ROCKET DYNAMICS AND CONTROL FACILITY

B-3

NASA-Lewis Research Center
Plum Brook Station
Sandusky, Ohio

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ILLUSTRATIONS

ROCKET DYNAMICS AND CONTROL FACILITY

"B-3"

1. Introduction

The "B-3" Test Facility, Figure 1, located at the NASA-Lewis Research Center, Plum Brook Station, Sandusky, Ohio was designed for the performance of non-nuclear altitude tests on various components of large second generation nuclear rocket engines. The "B-3" Facility was originally designed for two specific types of projects:

a. Propellant system research

b. Turbo pump research

The propellant system research capability was used for altitude startup tests on a NERVA (Nuclear Engine for Rocket Vehicle Application) engine. A vacuum was pulled on the nozzle discharge and the complete startup sequence was established and tested up to the point where reactor start would be initiated.

The test stand was also designed to do research on the dual turbo pump Pheobus engine. The Pheobus is the second generation nuclear rocket engine. These pumps are driven by hydrogen gas and have a total pump discharge of up to 200 lb/sec of LH_2. Tests were performed on one pump of the type that will be used for the Pheobus engine.

The facility has no provisions for hot firing tests.

The test stand was also used for some flight qualification tests on the Centaur Standard Shroud (CSS). The CSS is a set of insulation panels for the Centaur vehicle and a variety of payloads. The Centaur liquid oxygen tank was filled with liquid nitrogen and the liquid hydrogen tank filled with liquid hydrogen. This simulated the ground hold phase of flight operations and was maintained for several hours. After the ground hold tests, the shroud ordnance was fired and the shroud was partially jettisoned into a set of catch nets.

A series of structural load tests were also performed to verify the structural integrity of the shroud. These tests involved putting loads into the shroud, a simulated payload, the shroud hydrogen vent fin, and the shroud hinges. The loads were generated by a number of hydraulic cylinders located throughout the facility.

2. Summary of Specifications for "B-3" Facility

2.1 "B-3" Test Stand

a. Test level clear volume	26 ft. wide x 32 ft. long x 40 ft. high with run tank installed or 100 ft. high without run tank

b. LH_2 run tank capacity — 40,000 gal. (at 85 psig design pressure)

c. Test stand dimensions — 50 ft. wide x 50 ft. long x 200 ft. high

d. Exterior crane capacity — 65 ton

e. Shop utility crane capacity — 5 ton

f. Elevator capacity — 3 ton

2.2 Altitude Exhaust System

The "B" Complex altitude exhaust system is utilized. The system performance is shown below:

a. Vacuum capability (no flow conditions) — 0.5 psia in 45 seconds

b. Maximum run time — 6 minutes

c. Turn around time (to recharge accumulators) — 3 hours

d. 2 stage steam ejector system steam rate — 416 lbs/sec

e.

Engine Exhaust Nozzle Exit Pressure - lb/in^2	Ejector Pumping Capacity Dry Air Equivalent - lb/Sec
1.5	50
4	100
8	165
14.7	265

2.3 Data Acquisition System

400 channels of digital data

200 channels of continuous analog data

3. Description

3.1 "B-3" Facility Arrangement

The following major elements, Figure 2, comprise the "B-3" facility:

a. "B-3" test stand

b. Test stand support areas

c. "B-3" Boiler House

d. Burn-off system

e. Gaseous and cryogenic supply system

f. Data Acquisition System

g. "B-3" Control Area in "B" Control Building

The "B-3" Facility utilizes the B Complex altitude exhaust system.

3.2 "B-3" Test Stand

3.2.1 General

The "B-3" Test Stand, Figures 3 and 4, consists of a vertical tower 200 ft. high with a 50 ft. square base. The test stand is enclosed above the 74 ft. level and has the following electrically operated roll-up doors which are opened during testing to provide ventilation:

a. East Side

1 door 22 ft. wide x 64 ft. high

1 door 22 ft. wide x 37 ft. high

b. West Side

Same as on East side

c. South Side

1 door 25 ft., 9 in. wide x 112 ft., 2 in. high

The single door on the South side facilitates use of the 65 ton crane.

The partially enclosed lower elevations house the elevator shaftway, stairwell, and pipeway.

All electrical equipment located in the upper portion of the test stand is of explosion proof design. All cabinets in the upper levels are pressurized.

Overall dimensions of the support areas at the base are 86 ft. long x 80 ft., 8 inches wide.

The upper enclosed areas of the test stand are provided with a tempered air supply during cold weather.

Stairs extend from ground level to the 8th level, 168 ft. above grade.

A servo valve cabinet and a control terminal cabinet are located on the 4th level 94 ft., 6 inches above grade. A mechanical vacuum pump is located on the 6th level.

3.2.2 Research Package Mounting Provisions

The research package is normally mounted on the third level (73 ft., 6 inches above grade) or on the fourth level (94 ft., 6 inches above grade). Various mounting schemes may be employed including the use of a carriage mounted on tracks. Clear floor area on the third level is approximately 26 ft. x 32 ft.

This clear area can extend up to 100 feet above the third level. Also, complete working levels can conveniently be added at the fourth level, 21 feet above the third level, and at the fifth level, 42 feet above the third level. The run tank is normally installed at or above the fifth level.

3.2.3 "B-3" Test Stand Support Areas

3.2.3.1 General

A concrete shelter, Figure 5, at the base of the test stand houses the Forward Instrumentation Rooms, and Terminal Room. These two areas are air conditioned and pressurized. The Manifold and Purge Control Room, Mechanical Equipment Room and Shop Area are sheet metal structures.

3.2.3.2 Manifold and Purge Room

The Manifold and Purge Room is 12 ft., 10 inches wide x 22 ft., 9 inches long and houses a Control Terminal Cabinet and control panels for the N_2 and H_e purge systems.

3.2.3.3 Forward Instrumentation Rooms

Equipment located in the 12 ft., 6 in. wide x 24 ft., 4 in. long Forward Instrument Room and the 15 ft., 4 in. wide x 24 ft., 4 inches long addition includes a 400 channel S.E.L. Submultiplexer, 400 channel scanner and other signal conditioning equipment.

3.2.3.4 Terminal Room

The 10 ft., 7 in. wide x 15 ft., 9 in. long Terminal Room houses the following equipment: control equipment cabinet, test stand control terminal cabinet, test stand relay cabinet, control power panel, PAX and intercom cabinet and Ohio Bell Telephone equipment and terminal cabinet.

3.2.3.5 Mechanical Equipment Room

A lighting panel, electrical distribution panel, and motor control center, are located in the 14 ft., 4 in. wide x 29 ft. long Mechanical Equipment Room.

3.2.3.6 General Shop

The General Shop Area is 29 ft. wide x 49 ft. long. A 5-ton capacity crane is located in this area.

3.2.4 "B-3" Test Stand Services

A 65-ton capacity moving crane is located approximately 176 ft. above grade on the south side of the test stand. The crane rails are cantilevered out from the test stand so that the crane may be centered over a railroad car on the siding adjacent to the facility.

The test stand is serviced by a 3-ton capacity elevator with a floor area approximately 6 ft., 4 in. x 8 ft. Service is provided from the ground level to the 7th level 147 ft. above grade.

3.2.5 LH_2 Run Tank

The LH_2 run tank can be mounted inside the test stand with the bottom of the tank approximately 115 ft. or more above grade and 42 ft. or more above the research package mounting level. The tank has an actual liquid capacity of 40,000 gallons. The tank was removed and is presently in storage at ground level.

The tank consists of two coaxial vessels with 12 inches of foam glass insulation on the outside of the inner vessel. Liquid hydrogen discharge is thru a 12 inch diameter outlet at the bottom of the tank. The space between the 2 vessels is kept under GHe pressure to keep out moisture. The tank is filled through a 3 inch diameter vacuum jacketed line. Gaseous hydrogen is used to pressurize the LH_2 run tank thru a 3 inch diameter line. The capability exists for installation of four viewports (2 each on the top and bottom) for observing the behavior of the contained fluid. Viewports consist of 2 thicknesses of 1-3/4 inch thick quartz with a vacuum space in between.

The inner vessel consists of a 21 ft., 8 in. diameter x 8 ft. 4 in. high cylindrical section, a 2:1 elliptical head and a lower conical transition section terminating in a spherical surface at the lower end. Overall height of the inner vessel is 23 ft., 9-7/8 inches. Materials are 304 and 304-L stainless steel varying in thickness from ½ inch on the cylindrical portion to 3/4 inch on the elliptical head and lower sections.

Design pressure for the inner vessel is 85 psig with a test pressure of 106 psig. The inner vessel is designed for full vacuum.

The outer vessel consists of a 23 ft., 9¼ inch diameter x 13 ft., 5-7/8 inch high cylindrical section, a 3 ft., 3-5/16 inch high hemispherical head, and a conical lower section. Overall height is 24 ft., 10-5/8 inches. The material is 0.1875 inch thick A283-C steel. Design pressure for the outer vessel is 3 inches of water pressure.

3.2.6 Exhaust Duct

A 54 inch diameter exhaust duct extends downward from the third level (at 73 ft., 6 in. above grade) to the ground level. At ground level, a 90 degree elbow redirects the exhaust to the first stage steam ejector located approximately 400 ft. distant.

3.3 "B" Complex Altitude Exhaust System

3.3.1 General

The purpose of the altitude exhaust system (Figure 6) is to simulate altitude pressure conditions in the exhaust duct during an engine firing. The exhaust system includes steam boilers, accumulators, valves, and ejectors capable of evacuating the 30,000 cubic feet of "B-3" exhaust duct to a pressure of 0.5 psia in approximately 45 seconds under no flow conditions. With a 265 lb/sec. dry air equivalent flow from an engine under test, the exhaust system can produce a back pressure of 15 psia. The five accumulators have sufficient steam capacity for an engine firing run of 6 minutes. Turn around time to recharge the accumulators is approximately 3 hours utilizing four boilers.

3.3.2 Boiler House

Four boilers are located in the boiler house (Figure 2) and each has a capacity of 28,000 lbs. per hour of 500 psig saturated water. Approximately 25,000 lbs. per hour per boiler are available for charging the accumulators. The remaining 3,000 lbs. per hour per boiler are used for preheating feedwater and fuel oil and driving the turbines used in conjunction with the water pumps. The boilers are set up for continuous operation.

3.3.3 Accumulators

The five accumulators provide storage of 500 psig saturated water. The accumulators are capable of supplying 28,900 lb. of steam each when discharging from 500 psig saturated water to 200 psig saturated steam. The accumulators are cylindrical in shape and are 12 ft. OD x 53.5 ft. in length and have

3 inches of insulation. They are fabricated of 2-3/16 inch plate thickness and have a usable storage of 42,000 gallons of saturated water at 500 psig.

3.3.4 Ejectors

Two steam jet ejectors (Figure 4) are driven by steam supplied from the accumulators which are blown down through a pressure regulating system located in the valve house. Control of the steam system is accomplished remotely from the "B" Control Building. Steam service lines to the first and second stage ejectors are 16 inch and 30 inch diameter pipes respectively. The ejectors pump down the exhaust duct to simulate altitude conditions. Pumping capability of the two-stage steam ejector system is shown in Figure 7.

The first stage ejector has a throat area of 34.45 square inches; the second stage ejector 134.46 square inches. The total steam weight flow at 150 psig regulated inlet pressure is 416 pounds per second. The pumping capacities of the ejectors are 50, 100, 165 and 265 pounds per second dry air equivalent with exhaust nozzle exit pressures of 1.5, 4, 8, and 14.7 pounds per square inch respectively.

An interstage condenser is installed in the exhaust system but is not operational.

3.3.5 Flares

Six equally spaced continuously burning natural gas flares are mounted at the exit of the second stage ejector to dispose of the hydrogen in the exhaust system. The flares are ignited by the propogation of a flame initiated from the valve house and passing up a tube.

3.4 Burn-Off System

The "B-3" Facility burn-off stack is located approximately 315 ft. southeast of the test stand. The burn-off system is used to dispose of hydrogen during research hardware chill down and run cycles. It has a capacity of 200 lb/sec of hydrogen. An 8 inch line runs from the research hardware to ground level where a 14 inch type 304 stainless steel exhaust line connects the "B-3" test stand to the burn-off system. The discharge of the burn-off stack is 30 ft. above grade. A natural gas flare is used at the top of the stack.

3.5 Gaseous and Cryogenic Supply

3.5.1 General

All gaseous and cryogenic supplies, Figure 2, are stored at ground level in compressed gas cylinder semi-trailers, fixed compressed gas storage bottles, mobile liquid dewars, stationary storage tank, or railcars.

Parking space and unloading facilities are provided adjacent to the "B-3" test stand on the northwest side for the following service trailers:

a. 8 GH_2 tube trailers with a capacity of 70,000 SCF each at 2400 psig.

b. 3 or 4 LN_2 roadable dewars with a capacity of 6,000 gallons each.

c. 7 or 8 GN_2 tube trailers with a capacity of 70,000 SCF each at 2400 psig.

   Three LN_2 and 8 GN_2 or 4 LN_2 and 7 GN_2 trailers can be accommodated simultaneously.

d. 4 GH_e trailers with a capacity of 70,000 SCF each at 2400 psig.

The railcar area located adjacent to "B-3" on the south side provides facilities for handling up to 6 railcars as follows:

a. 2 gas railcars with a capacity of 780,000 SCF at 5000 psig each. These can be used for either hydrogen or nitrogen gas.

b. 2 liquid hydrogen railcars (receiver) with a capacity of 34,400 gallons at 100 psig each.

c. 2 helium gas railcars with a capacity of 300,000 SCF at 3500 psig each.

A gaseous nitrogen bottle farm is located adjacent to the test stand on the southeast side consisting of 200 nitrogen bottles with a total capacity of 300,000 SCF at 2400 psig. This system can be used to inert the exhaust duct, as a backup system for valve operating pressure, or as additional storage for the main GN_2 system.

A 200,000 gallon LH_2 storage dewar is located approximately 400 ft. northwest of the "B-3" test stand and supplies LH_2 to facility.

3.5.2 Nitrogen System

The following list shows some of the uses for the gaseous nitrogen system as shown in Figure 8:

a. Purges the LH_2 burn-off system.

b. Provides purge gas for hydraulic pump reservoirs.

c. Supplies pressure regulator loaders.

d. Provides gas ballast for vacuum pump.

e. Purges research hardware.

f. Valve actuation.

g. Pressurizes hydraulic accumulators.

h. Purges exhaust duct.

The liquid nitrogen system, Figure 8, supplies nitrogen for liquid nitrogen test runs or for pre-chilling the run tank on liquid hydrogen test runs. A liquid nitrogen pump rated at 270 GPM at 140 psi is used to transfer from the dewars to the run tank.

3.5.3 <u>Helium System</u>

The following list shows some of the systems purged by the helium system as shown in Figure 9:

a. LH_2 run tank

b. H_2 pressurizing line

c. H_2 supply line

d. Burn-off system

e. Research hardware

f. LH_2 vent stack

g. Camera viewing window (to prevent frost buildup)

h. LH_2 run tank insulation.

3.5.4 <u>Liquid Hydrogen System</u>

3.5.4.1 <u>General</u>

Liquid hydrogen is stored in a self-pressurizing 200,000 gal. LH_2 storage tank approximately 400 ft. from "B-3". The hydrogen is transferred to the test stand thru a 3 inch diameter vacuum jacketed line. The maximum transfer rate is 800 gallons per minute.

The 200,000 gallon tank also serves as a Plum Brook Station central collection point for LH_2. LH_2 may be transferred from this tank to roadable LH_2 dewars or to railcar dewars without opening the line to the "B-3" Facility.

3.5.4.2 LH_2 Storage Tank

The 200,000 gallon capacity (plus 10% ullage) LH_2 storage tank consists of 2 coaxial vessels with Linde 5A molecular sieve filling the annular space to absorb hydrogen leakage and maintain the annular space vacuum. The vessel is insulated by means of 9 inches of a quilted multilayer insulation (Linde Sl-10) applied to the outer surface of the inner shell. The design normal evaporation rate is 0.053% per day based on 200,000 gallon capacity. The spherical outer shell is 43 ft., 4 inches in diameter, is constructed of A-285-C Firebox material 0.76 inches thick, and weighs approximately 183,000 pounds. The spherical inner shell is 38 ft., 4 inches in diameter, is constructed of A-240 Tp 304 material, 0.437 to 0.456 inches variable thickness. Inner shell weight is approximately 90,000 pounds. All piping and nozzle attachments to the inner vessel are of A240 Tp 304.

3.5.5 Gaseous Hydrogen System

There are two independent gaseous hydrogen systems in the test stand as shown in Figure 10. A 3-inch diameter manifold runs from the trailer pad area to the upper levels of the test stand. This manifold was used for pressurizing the 40,000 gallon run tank. A 5-inch diameter manifold runs from the railcar area to level 4 where the manifold tees into two 3-inch diameter lines. Each 3-inch line can be connected to a turbopump for turbine drive gas supply.

There is also a 3-inch diameter branch line running from the 3-inch manifold on the trailer pad to the railcar area. The railcar area has four separate connection stations. By manipulating the hand valves at the railcar area, one to three of the stations can be opened only to the 5-inch manifold, one to three of the stations can be opened only to the 3-inch manifold, or the two manifolds can be made common. Any combination of trailer stations and railcar stations can be used when the manifolds are common.

3.6 Hydraulic System

Two identical hydraulic pumping systems with 60 gallon reservoirs and 30 GPM, 3000 psi variable displacement pumps are located on the third level of the test stand. A small, 5 GPM, 3000 psi hydraulic pump is located next to the two larger systems. This pump is used for standby operations or for tests where low flow rates are required.

A $1\frac{1}{2}$ inch diameter supply manifold and a $1\frac{1}{2}$ inch diameter return manifold extend from level 3 to a point above level 7. Several sets of bosses at each of the working levels allow relatively short tubing runs to any desired location. This system is used for loading cylinders, back pressure vent control systems, and flow control systems.

3.7 Vacuum System

A single stage, 720 CFM mechanical vacuum pump is located on the sixth level of the test stand. The pump is used for inerting the gaseous hydrogen and the liquid hydrogen transfer systems before introducing any hydrogen. The pump is also used for inerting the turbopump and 40,000 gallons LH_2 run tank when applicable. Alternate evacuation and helium gas purge cycles are used to inert the hydrogen systems. The pump is capable of evacuating the systems to 1 TORR or less.

3.8 Electrical Service

Electrical service at the "B-3" Facility has the following capacity:

a. 480 volt 3 phase delta system - 300 KVA

b. 208/120 volt 3 phase wye system - 112 KVA

3.9 Boiler House

The "B-3" Boiler House is located approximately 160 ft. north of the "B-3" test stand. Two natural gas fuel hot water generators provide hot water for heating the "B-3" Facility.

3.10 Safety System

Standard gas analyzers and fire detectors are utilized to detect hydrogen leaks or fires at stragetic locations throughout the test stand. These detectors are connected to Safety and Annunciator panels in the "B" Control Building. In addition, the oxygen level in the exhaust duct is monitored after inertion and prior to research operation by means of an oxygen analyzer.

3.11 "B" Control Building

During a test run, all personnel are evacuated from the "B-3" Facility. The test is controlled from the "B" Control Building. This building is a reinforced concrete structure located approximately 2600 ft. west of the test stand (Figure 1). Signals from "B" Control Building actuate relays at the test stand which apply test stand power to the device being controlled.

The following underground cables connect the "B-3" test stand with the "B" Control Building:

a. Nine 125 conductor externally shielded #16 AWG cables used to operate all subsystems including the liquid hydrogen storage tank.

b. Five 50 pair individually shielded #18 AWG cables connect cabinets on the test stand 95 foot level to the "B" Control Building for servo valve operation.

c. One 125 conductor externally shielded, one 60 conductor externally shielded, and one 25 pair individually shielded cable connect the "B" Control Building to the valve house to control the steam system.

The "B-3" control room, located in the "B" Control Building (Figure 11), is approximately $29\frac{1}{2}$ ft. wide x 34 ft. long. Forty rack type cabinets are arranged in a "U" shape with the main test conductor control panel located in the center. The facility major subsystems control panel is on the left and the steam system control panel is on the right of the test conductors panel.

The following equipment is located in the "B-3" Control Room:

a. Wind speed and direction indicator

b. Closed circuit TV monitors

c. Gas and propellant permissive panel

d. Gas and propellant control panel

e. Gas and propellant graphic panel

f. Annunciator panels

g. Research equipment main test conductor graphic panel

h. Research equipment main test conductor control panel

i. Steam and purge permissive panel

j. Steam and purge graphic panel

k. Paging, phone, base radio equipment

l. Servo-control panel

m. 15 spare cabinets.

There are provisions for closed circuit TV coverage of all levels of the test stand and trailer areas. Five TV cameras have pan and tilt control. Information on any of the TV monitors in the "B-3" control room can be recorded by selective switching onto any one of three video tape recorders.

Motion picture photography provides documentary coverage of a test run when desired.

The annunciator system monitors key safety limit parameters and will initiate a warning or shutdown.

The graphic panel indicates the condition of the test run at all times.

3.12 Control and Abort System

3.12.1 Computer System

A control and abort system automatically controls all events during the autosequence portion of the test. This system consists of a Xerox Data Systems, Inc. XDS 910 computer and various peripheral gear. The block diagram for this gear is shown in Figure 12. The autosequence portion of the run can run from a few seconds up to several minutes or more. The sequence can include a major part of the facility pre-run set up and post run system cleanup if desired. The computer sequences commands through its output relays, to the various test article and facility control circuits. It also can monitor up to 96 channels of hardwired critical test parameters during the autosequence. It will abort the sequence if any parameter exceeds its pre-determined limit.

3.12.2 Abort Monitor

A software Abort Monitor is also available to monitor prime data for abort purposes. This Abort Monitor consists of a XDS CF-16A minicomputer. It can monitor up to 400 channels of data being recorded on the main Data Acquisition System. This system can also be used to give only an alarm signal if desired. The alarmed signals are displayed on a CRT display in the control area. On any particular data channel, this system can give an abort only, an alarm only, or an alarm at one level and an abort at a second level.

3.12.3 Run Status Display

The computer system can also indicate the status of an autosequence throughout the test run by displaying messages on a CRT. For pump performance tests, this might include the time remaining before pump shutdown. For structural load tests, it might indicate the load level desired and whether the load is being ramped to that level or holding at that level. The CRT will also display messages at the end of a run indicating a normal shutdown or, if an abort occurs, which parameter and limit caused the abort.

3.12.4 Data Record Mode

When desired, the computer can be used in a slow speed data record mode by using the relay multiplexer system. This mode is particularly useful for safety monitoring during relatively long standby periods when conditions are fairly stable. The Central Recording System does not need to be on line during this mode of operation. Depending on analog data requirements in the control room, this system can be used to record up to 200 channels of data for B-3.

3.12.5 Arbitrary Function Generator

A ten channel Arbitrary Function Generator (AFG) is available for generating synchronized command signals for the facility control systems. The AFG can be driven by a prepunched paper tape or by stored programs in the XDS 910 computer. Using the computer to drive the AFG allows the course of the test to be altered by using on-line data.

3.12.6 Analog Computer System

There are also one EAI TR-48 and two EAI TR-20 analog computers in the control building. These computers allow pre-run checkout of the facility gear by using simulated signals for any equipment not on line. These computers can also be used to patch in any special on-line circuitry needed for any particular test run.

3.12.7 Automatic Timer System

An automatic timer system is available for simpler, less critical autosequences.

3.13 Data Acquisition System

3.13.1 General

The "B-3" Facility data acquisition system equipment, Figures 13 and 14, is located in five areas as follows: Test Stand (test level), Test Stand Forward Instrument Rooms, Data Computer Room in B Control Building, "B-3" Control Room in "B" Control Building, and "B" Control Building Terminal and Instrument Repair Room.

The "B-3" data acquisition system is part of the Plum Brook 30KC primary data system located in "H" Building. All prime data is transmitted from the "B-3" test stand to "H" Building for recording and processing. Analog signals go through a patchboard in "H" Building from which they are patched into analog recording equipment.

3.13.2 "B-3" Test Stand (Test Level)

Instrument cabinets located at the test level contain the following equipment:

a. Thermocouple ovens - 288 channels.

b. Deflectormeter signal conditioners - 96 channels

c. Liquid level gaging systems - 3 channels

d. Gas analyzer systems - 5 channels

e. Accelerometer signal conditioners - 32 channels

f. Strain gage balance panels, ½ bridge type, for strain measurements - 324 channels.

3.13.3 "B-3" Forward Instrument Room

The following equipment is located in the above area:

a. Strain gage signal conditioners - 64 channels

b. Frequency to dc converters - 16 channels

c. Platinum Resistance Thermometers - 24 channels

d. Scanner Signal monitor, 400 channels, digital volt-ohm meter, printer, scope.

e. Patchboard - 4896 points

f. Amplifiers - 64 channels

g. Sub-multiplexer system consisting of: 400 channel multiplexer, analog to digital converter, transmission unit, decimal readout, digital to analog converter, memoscope display.

3.13.4 "B" Control Building Data Computer Room

Located in the above area are instrument cabinets which contain "B-3" Facility switching equipment and the "B-3" 4896 point patchboard. The XDS 9300 data computer is also located in this room.

3.13.5 "B" Control Building - "B-3" Control Room

The following equipment is housed in cabinets located in the "B-3" Control Room:

a. Two X-Y plotters

b. "B-3" Analog Data Cable Switching Equipment Control Panel

c. Ampex tape deck, recorder electronics, speaker amplifiers, and speakers

d. Digital Frequency Counter and Printer

e. S.E.L. Recorder Control Panel

f. Remote Control of Scanner

g. Timer for auto seq.

h. Several cabinets for future instrumentation.

3.13.6 "B" Control Building - Data Display Area

The following equipment is housed in cabinets located in the Data Display area:

a. Six 8 channel strip chart recorders.

b. Three 50 channel direct writing oscillographs

c. Two 100 channel Events Recorders

d. Five channels of closed circuit TV monitors

e. One TV monitor for XDS 910 run status CRT

f. Five TV monitors for XDS 9300 data display CRT's along with associated control panels.

g. Three video tape machines with recording and playback capability from any of the TV monitors.

3.13.7 "H" Building

From the "B" Control Building the digitized instrumentation signals are sent via co-ax cables to the "H" Building for recording and processing. Analog signals terminate at a patchboard in the "H" Building from which they are patched into analog recording equipment.

The following equipment is available:

a. Two Central Record Trains to record prime digital data (can record up to 600 channels from a test site). Two 8-channel Brush Recorders are available for playback of digital data.

b. 3 F-M Recorders for recording 10 KHZ [illegible] analog data (42 channels total).

c. 10 Strip Chart Recorders

d. One Master Timing Generator

e. Two 36 channel Oscillograph Recorders

3.14 Data Computer System

3.14.1 Computer System

A data computer system is located in B Control Building. This system consists of a Xerox Data Systems, Inc. XDS-9300 computer, with a 32,768 word memory, and two XDS CF-16A mini-computers. This system is shown in the block diagram in Figure 12. The system can be used to display raw data and/or calculated data in engineering units. This can be done on line for test monitoring or immediately after a test run to enable Research engineers to quickly analyze data and make decisions for the next run.

Raw digital data for the computer is obtained directly from the Central Recording Systems in "H" Building. A time code, for data correlation, is obtained from the Master Timing Generator, also located in "H" Building.

3.14.2 Data Displays

The data can be displayed in several ways, including CRT's, printers, and plotters. On-line data is normally displayed on 3 CRT's. Each CRT can display various patterns of up to 88 channels of data, including transducer number and its output in engineering units. There can be up to 12 different display patterns in memory, with any one of the 12 patterns available to any CRT at any time. Any of the CRT images can be output to a line printer upon request. Other on-line data can be printed in engineering units on a digital line printer or plotted on a digital plotter. These same capabilities can be used immediately after the run by playing the data back into the computer from magnetic tape.

3.14.3 Instrument System Check Out

With some additional equipment modifications and some programming effort, the computer could also be used to help check out the site instrument systems. This would assure better accuracy, save manpower, and shorten setup time.

3.14.4 Computer Peripheral Equipment

Auxiliary equipment for the computer includes the following:

a. 4 tape transports

b. A 500,000 word Rapid Access Data (RAD) storage

c. 2 XDS CF-16A mini-computers, each with a 180,000 word RAD, interfaced with the graphic displays.

d. 3 Cathode Ray Tube (CRT) displays

e. 1 digital printer/plotter

f. 1 digital printer

g. 1 digital plotter

h. Absolute time data input

4. Operation

The "B-3" facility operating procedure varies depending on the nature of each particular research program. The following is a typical sequence of events for a liquid hydrogen pump test.

In preparing the facility for a test run, some 25 engineers, mechanics, and technicians are required for a two-day countdown. During this time, all instrumentation is checked and calibrated, all supporting system operations are verified, high pressure gas trailers and liquid dewars brought into position, and the computer program is loaded and checked out.

Prior to loading liquid hydrogen in the propellant tank, the transfer lines and tank are evacuated and inerted with helium, and the exhaust duct inerted with nitrogen.

At this point the "B-3" test stand is evacuated and all operation is from the "B-3" control room in the "B" Control Building.

The run tank is filled with liquid hydrogen.

With all systems in a ready condition and precooling of pump and feedline accomplished, the steam driven ejector system is brought on line.

When the exhaust duct pressure reaches 2 psia, the computer starts the test run.

After the test is completed, any remaining hydrogen in the run tank is back transferred and necessary procedures for securing the facility are carried out.

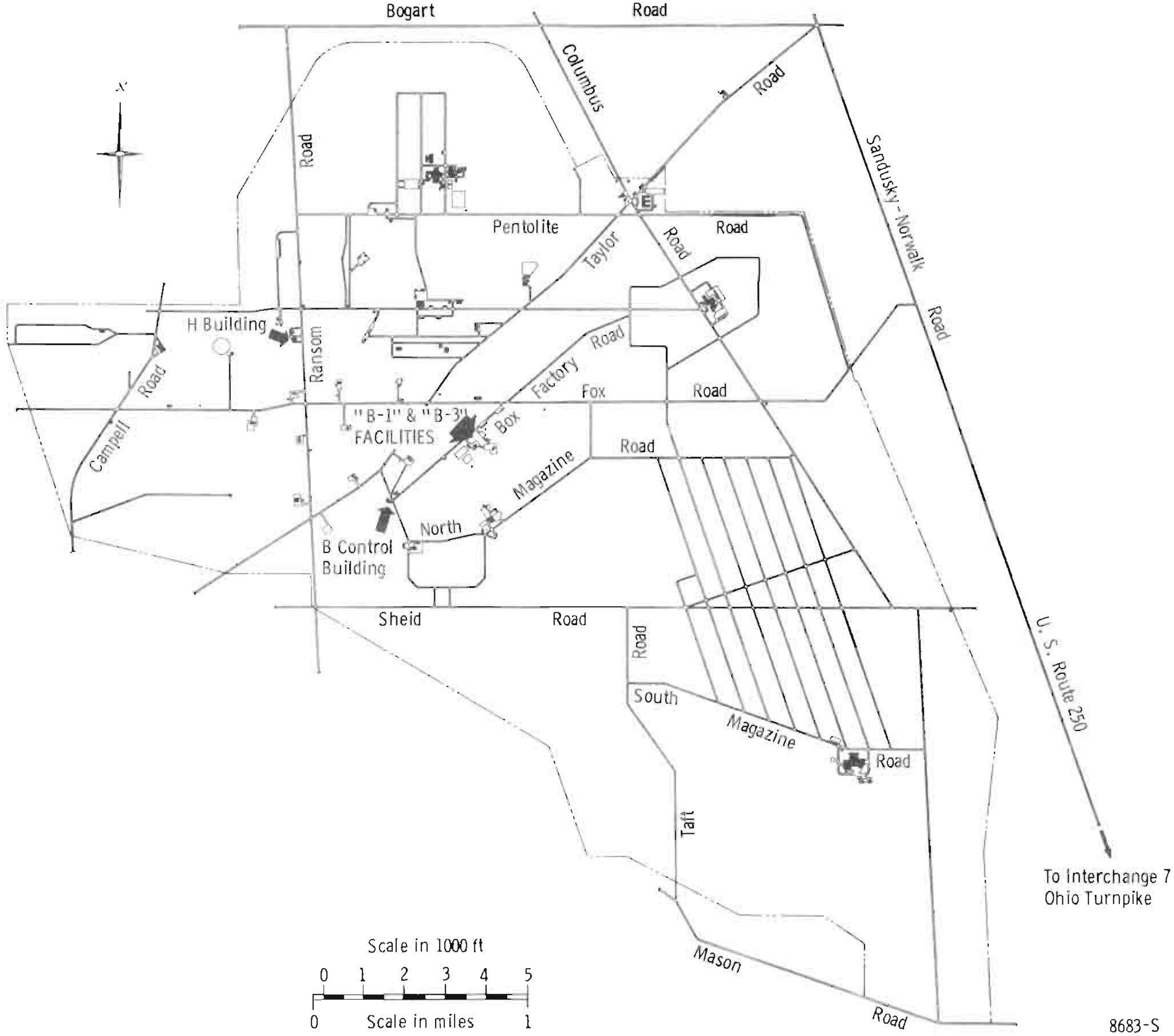

Figure 1. - Plot plan of Plum Brook station showing location of "B-1" and "B-3" facilities.

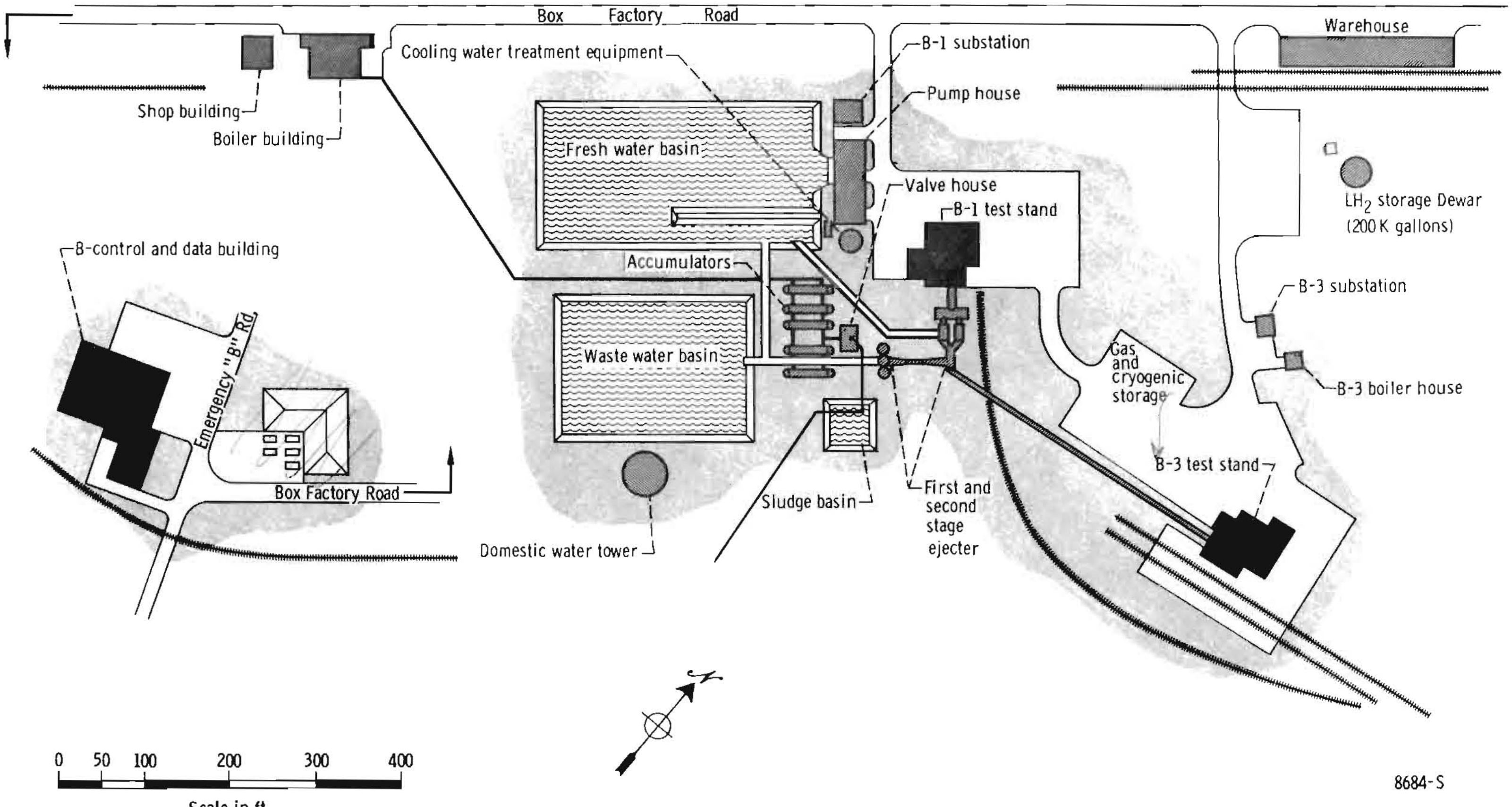

Figure 2. - General site plan of "B-1" and "B-3" facilities.

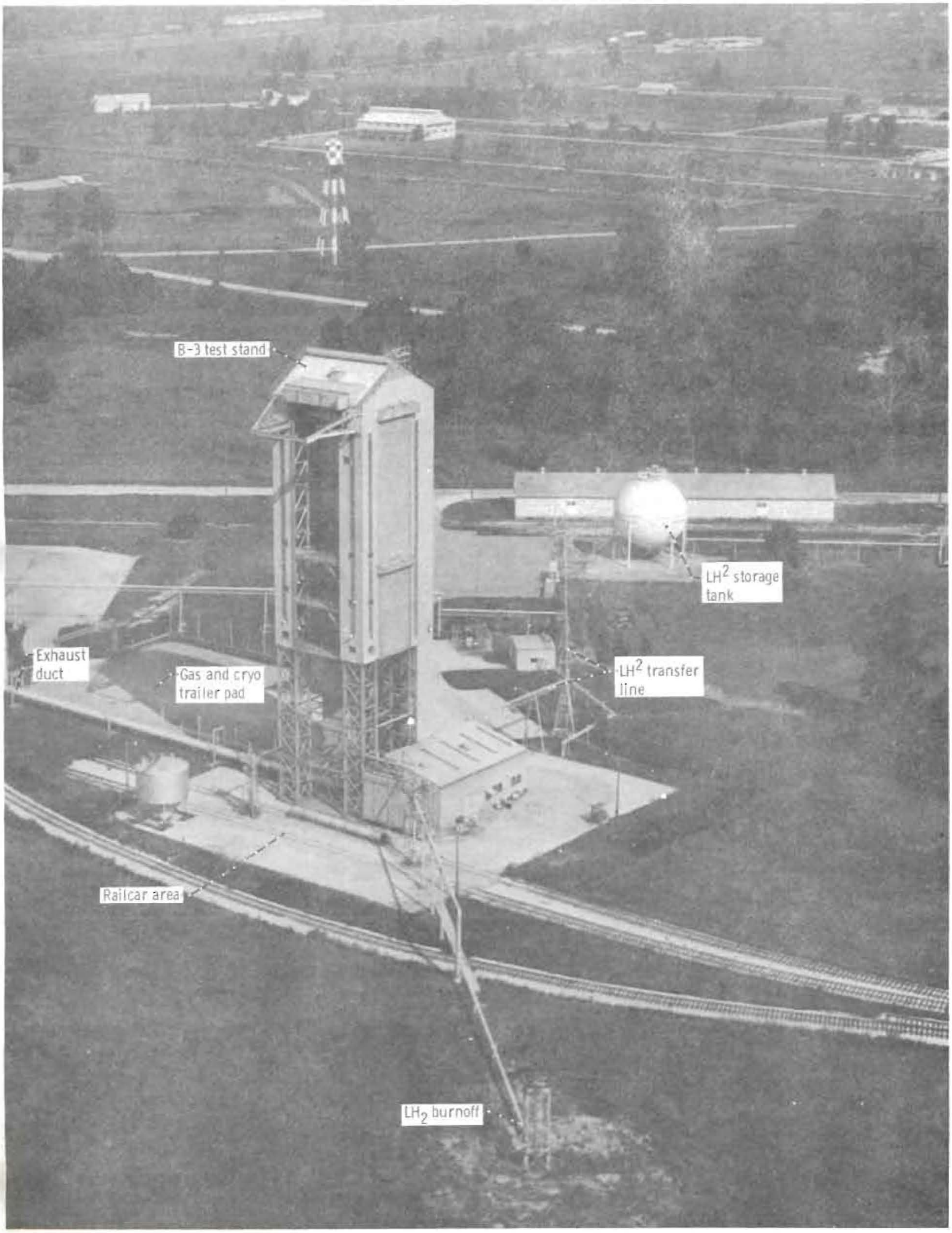

Figure 3. - Aerial view of "B-3" test stand.

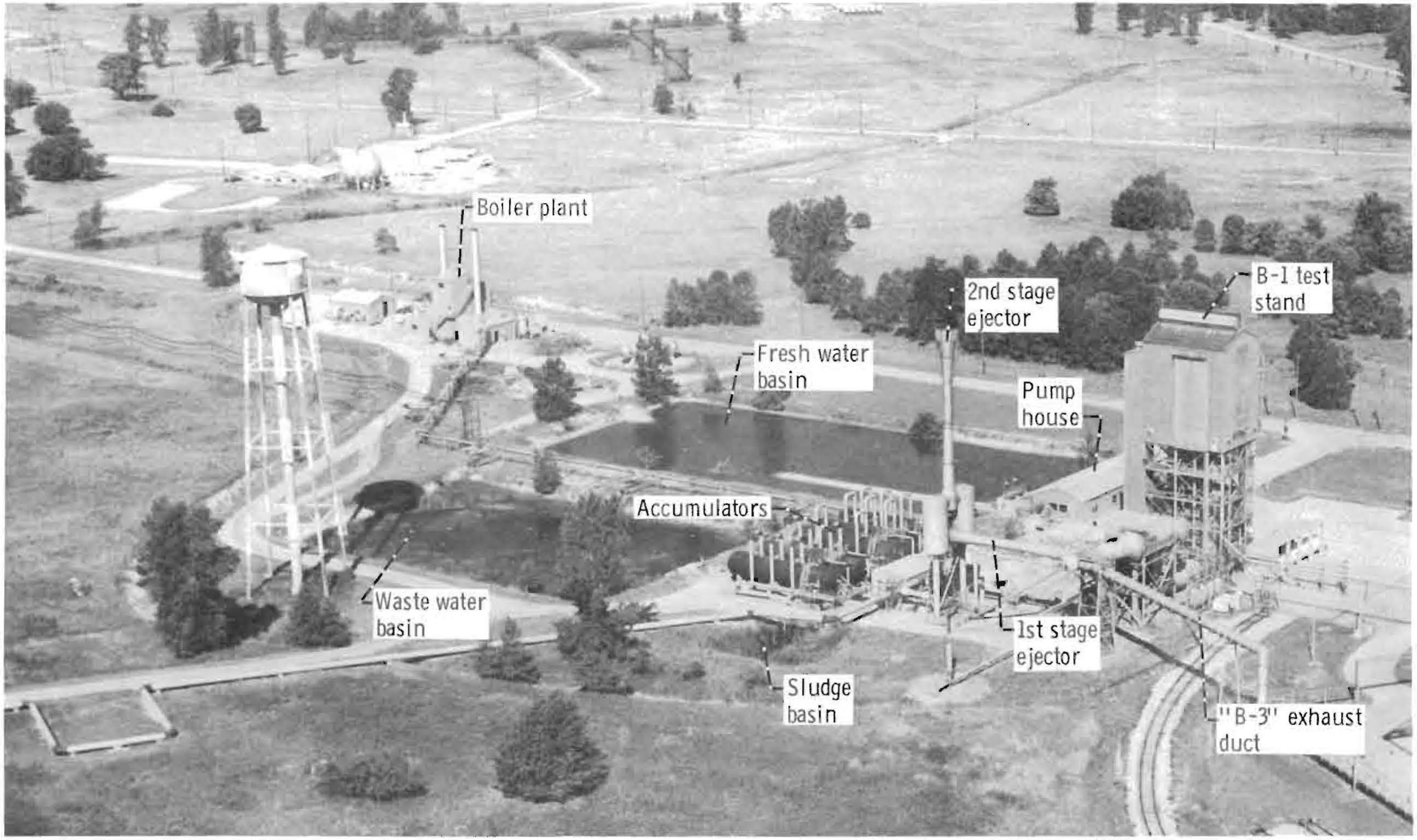

Figure 4. - B complex altitude exhaust system.

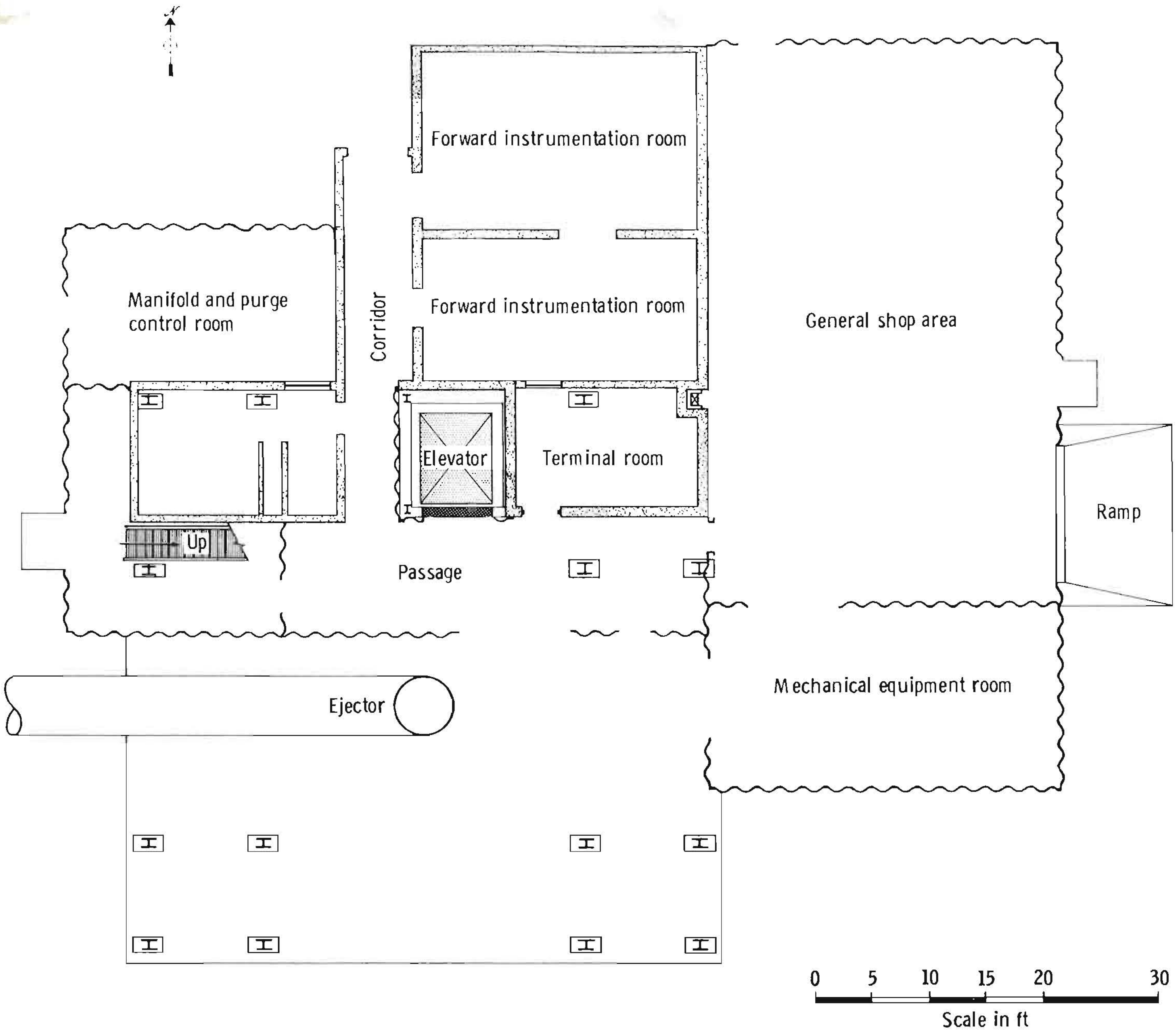

Figure 5. - "B-3" test stand ground floor plan.

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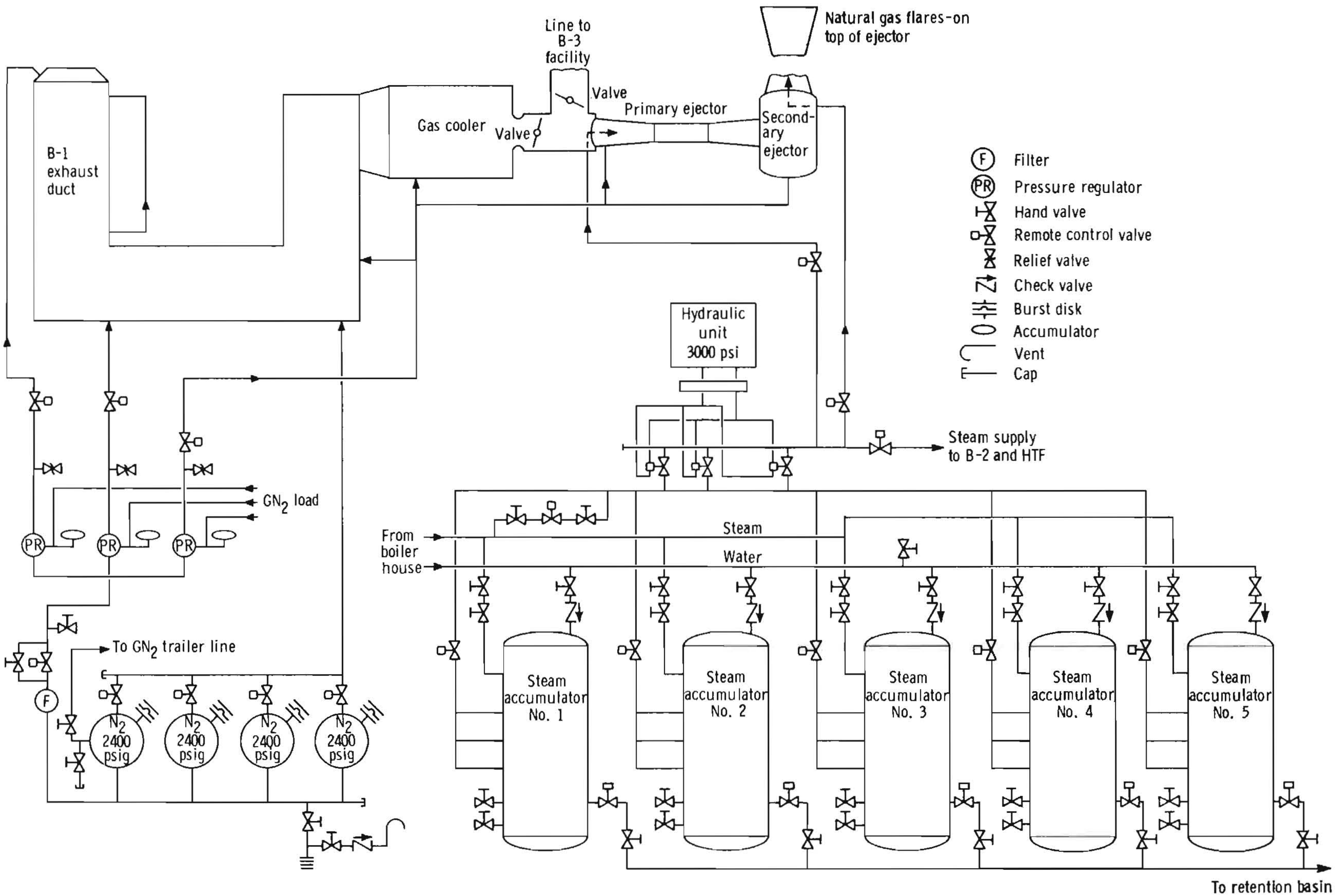

Figure 6. - B-complex altitude exhaust and bottled nitrogen systems.

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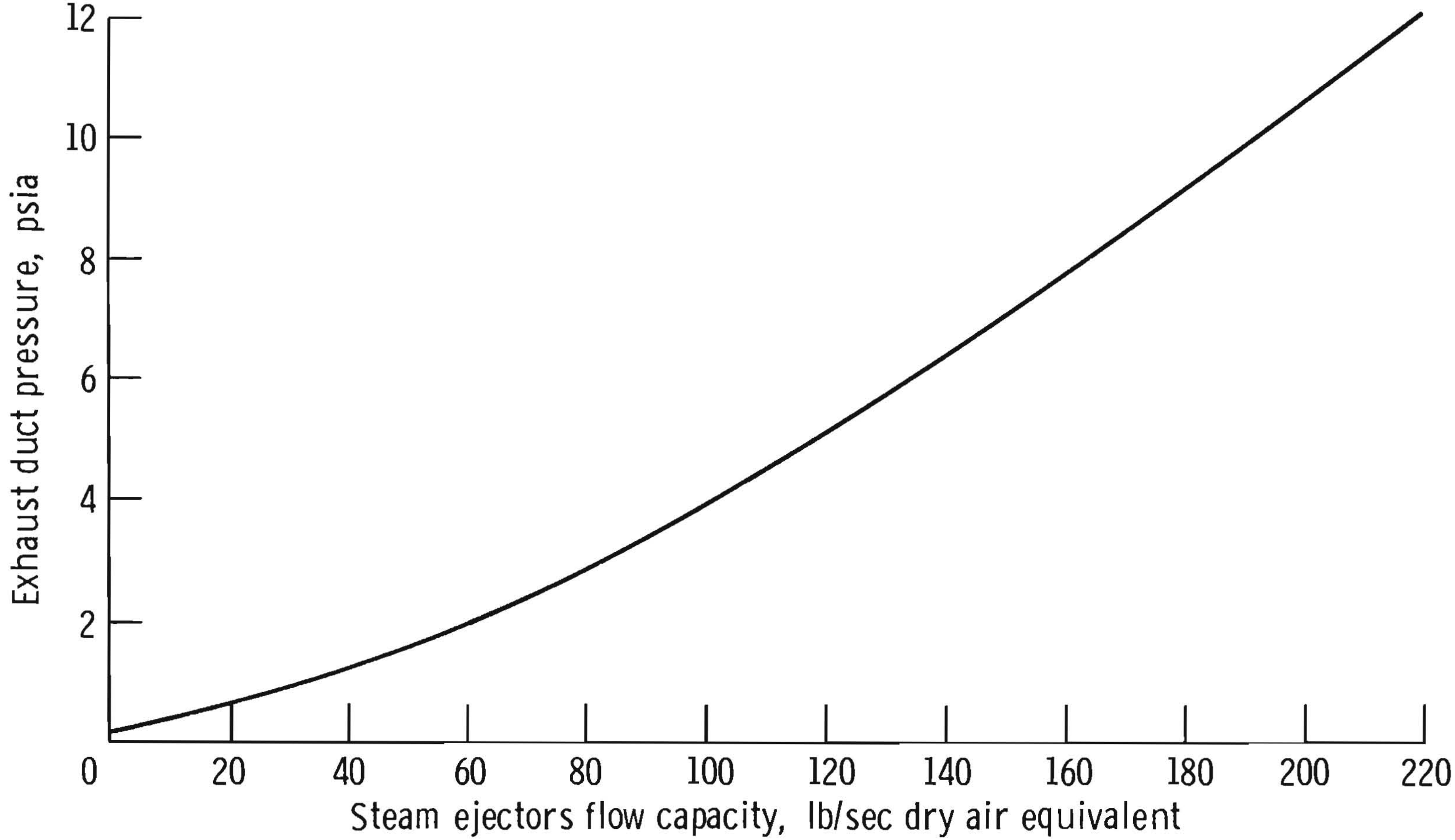

Figure 7. - B complex steam ejectors flow capacity vs exhaust duct pressure at inlet to first stage ejector.

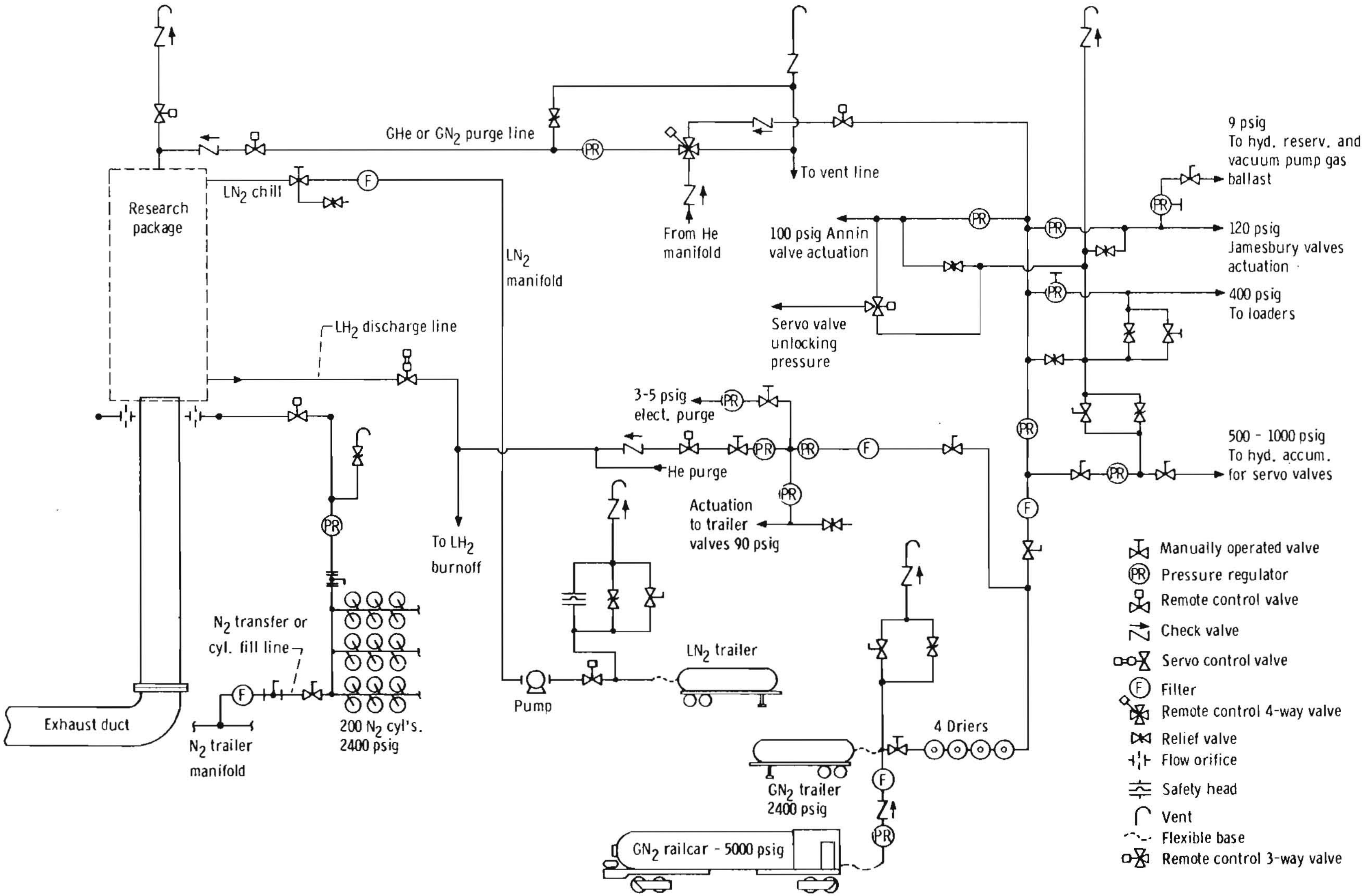

Figure 8. - B-3 nitrogen systems.
Typical - more GN_2 branch systems exist.

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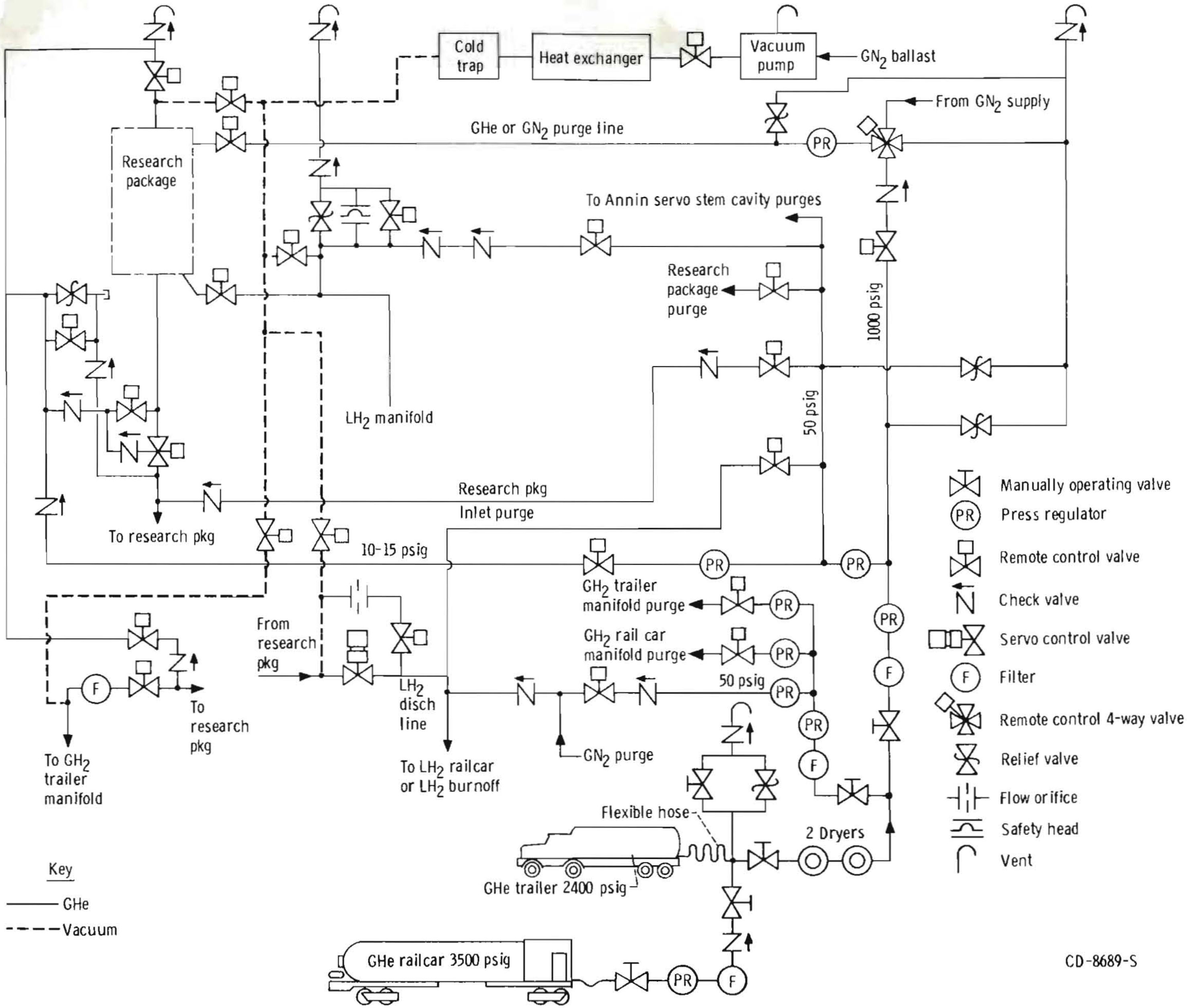

Figure 9. - B-3 helium system and vacuum system. Typical - more GHe branch systems exist.

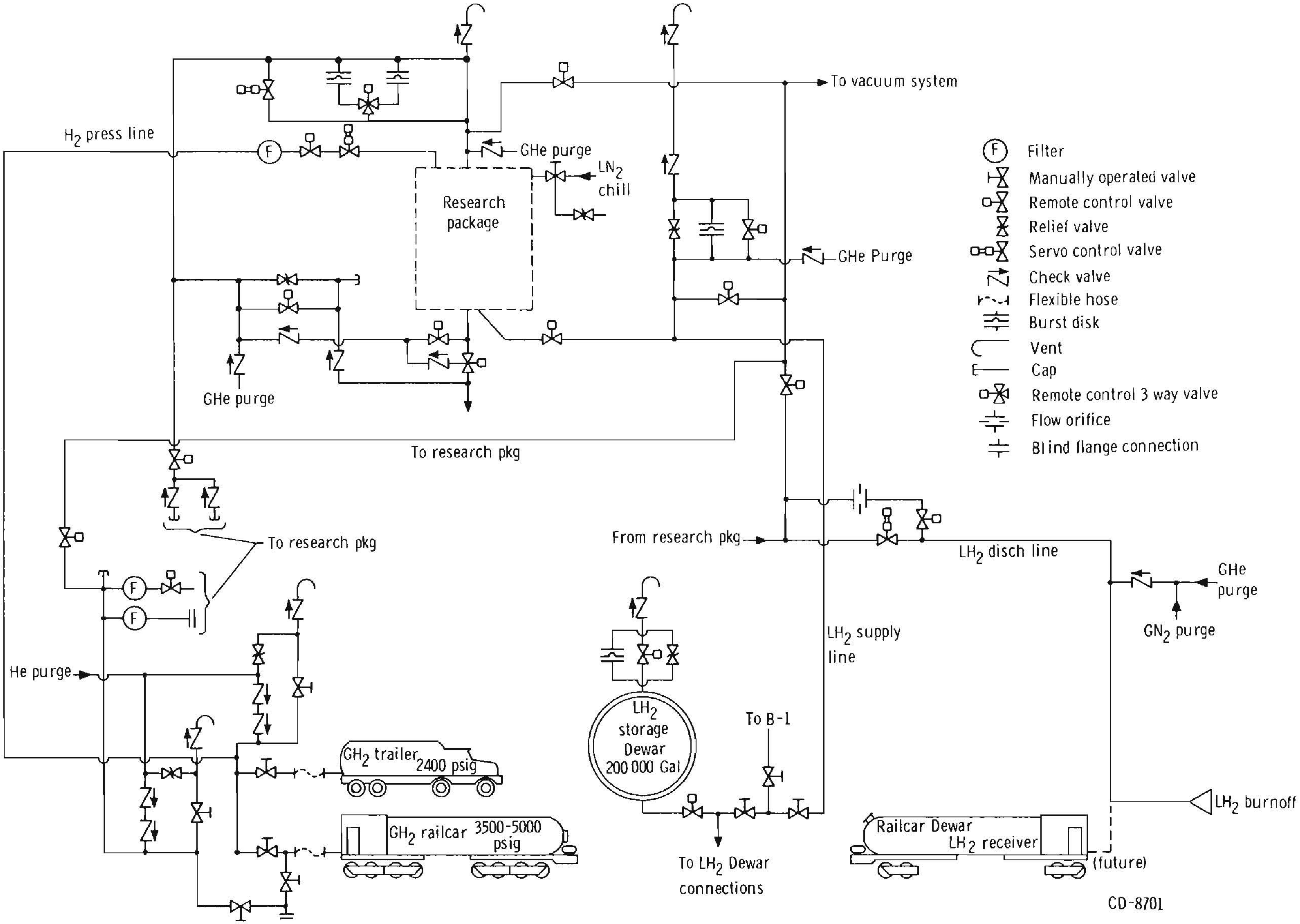

Figure 10. - "B-3" hydrogen system.

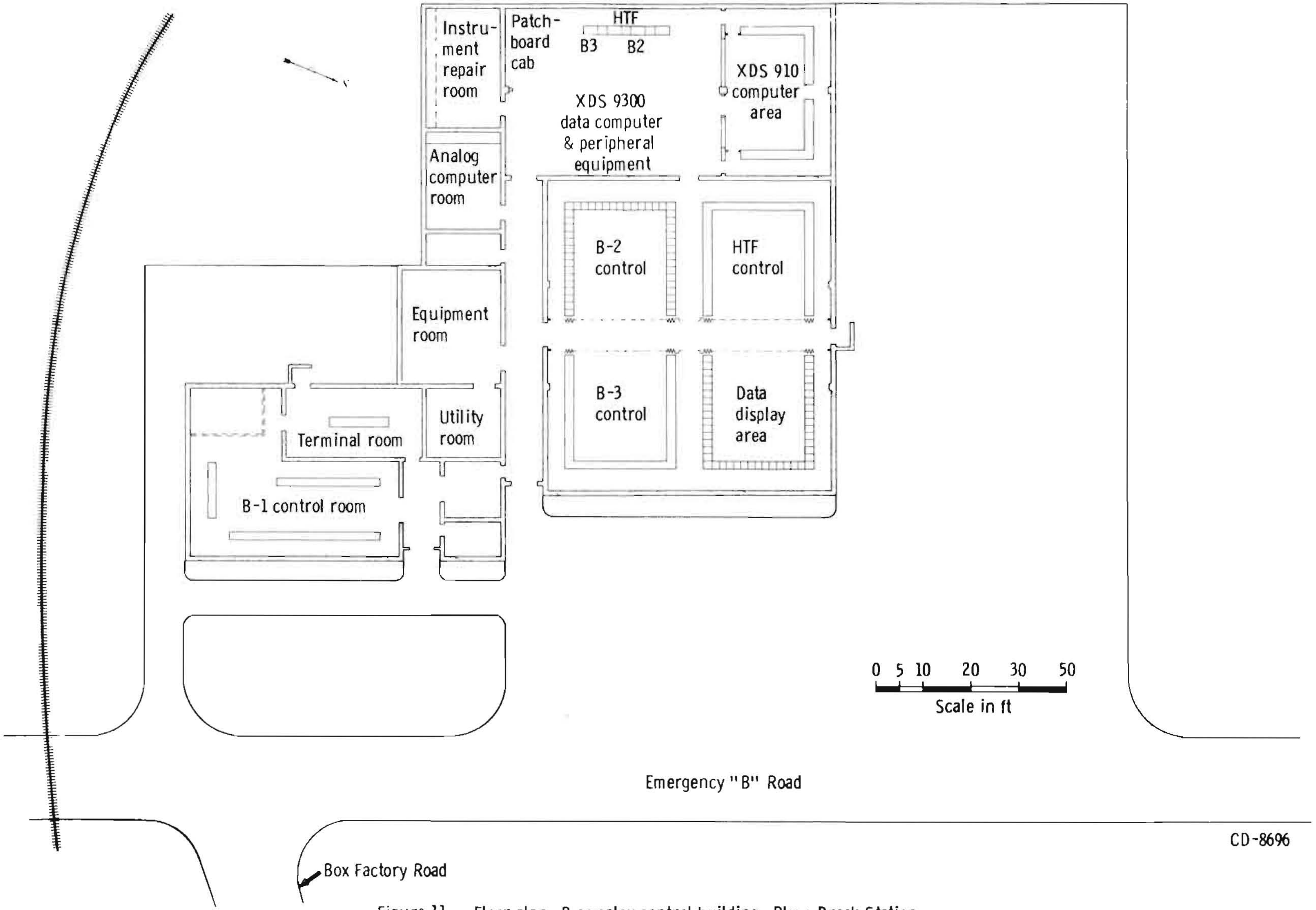

Figure 11. - Floor plan, B complex control building, Plum Brook Station.

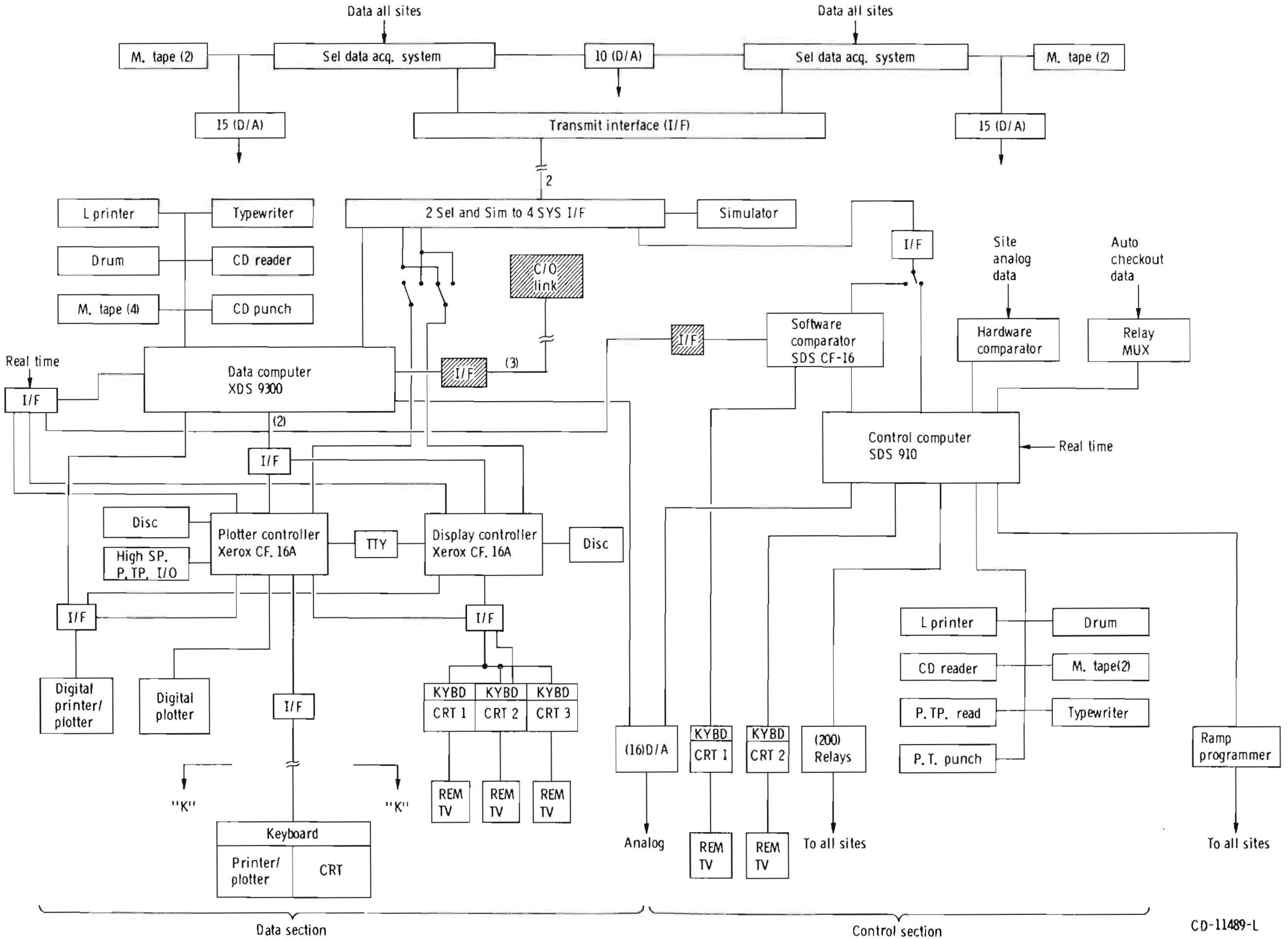

Figure 12. - B-control digital computer facilities.

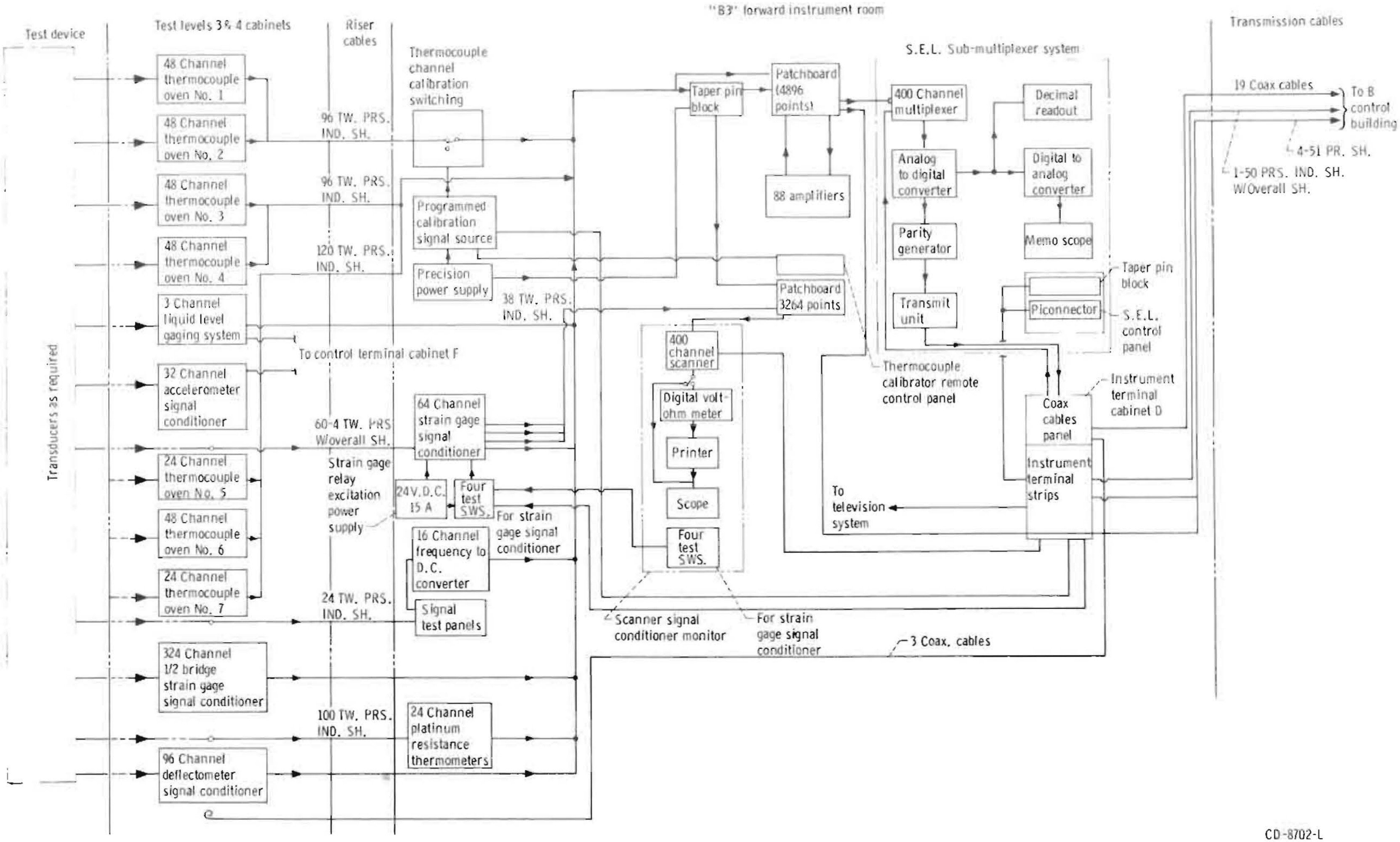

Figure 13. - "B-3" acquisition system - "B-3" test stand.

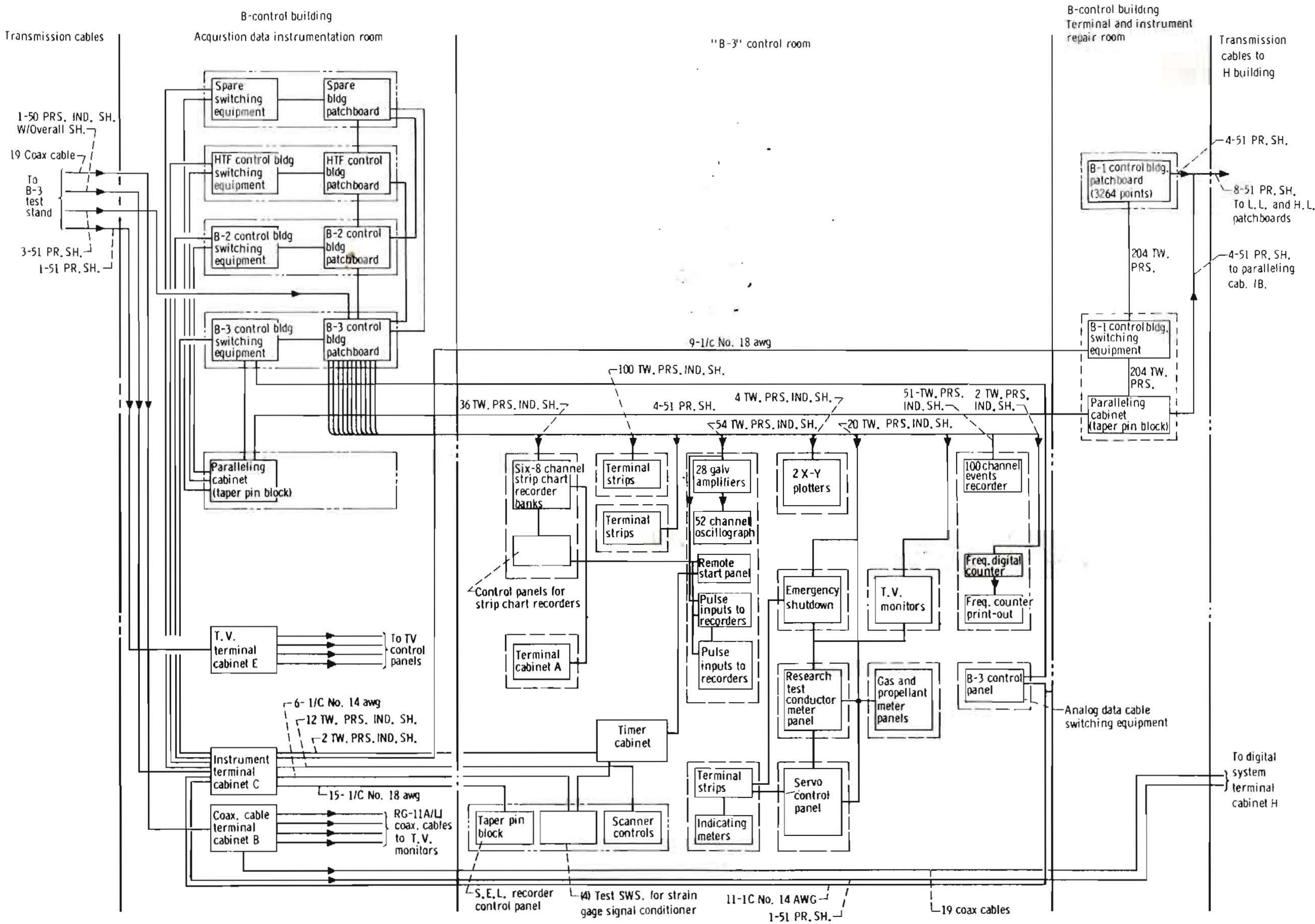

Figure 14. - "B-3" data acquisition system - B control bldg.

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