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THE VERTICAL VAN de GRAAFF TELEMETRY SYSTEM

JEFF GRAY

GROUP P-9

LOS ALAMOS NATIONAL LABORATORY

Since the installation of the vertical Van de Graaff accelerator at the Los Alamos Ion Beam Facility in the early 1950s, the IBF staff has tried many different ways of controlling and monitoring the ion source parameters that sit atop the 7MV machine. In the early days control functions were accomplished using nylon strings that were run up the column structure to operate variacs, potentiometers, valves, etc... Over the years several different systems using line of sight optical communications have been used. These systems provided control or "uprun" signals to the ion terminal as well as sending monitor or "downrun" signals to the operator in the control room. The acquisition of a new ion source from General Ionex in the early 1970's made the early telemetry systems obsolete as they simply could not provide the versatility necessary operate the new source. A new system, based on solid state technology, was designed and built and did provide an adequate number of control and monitor channels. However, this system proved to be extremely susceptible to activity in the machine. This problem severely limited the ability to run the machine at its maximum potential or to condition the machine to higher potentials because of a high risk of telemetry system failure every time the machine sparked. These failures usually resulted in a tank opening to repair the telemetry causing several hours of downtime.

With the push on to take the machine to higher and higher potentials (it has been above 13MV without the accelerator tubes installed), it quickly became apparent that the existing telemetry system was simply not acceptable. Therefore, in 1988 a new multichannel telemetry system was specified for bid. The new system was to provide a control interface for the operator in the control room connected via fiber optic cables to three remote I/O devices located on two different (electrically isolated) decks on the ion terminal. The system was received in early 1989 and is based on the General Electric FANUC Division's Series One Plus programmable controller (GE FANUC was recently bought out by Texas Instruments who now offer the Series 305 programmable controller which is the same as GE's Series One Plus). A simplified block diagram of the entire system is displayed in Figure 1.

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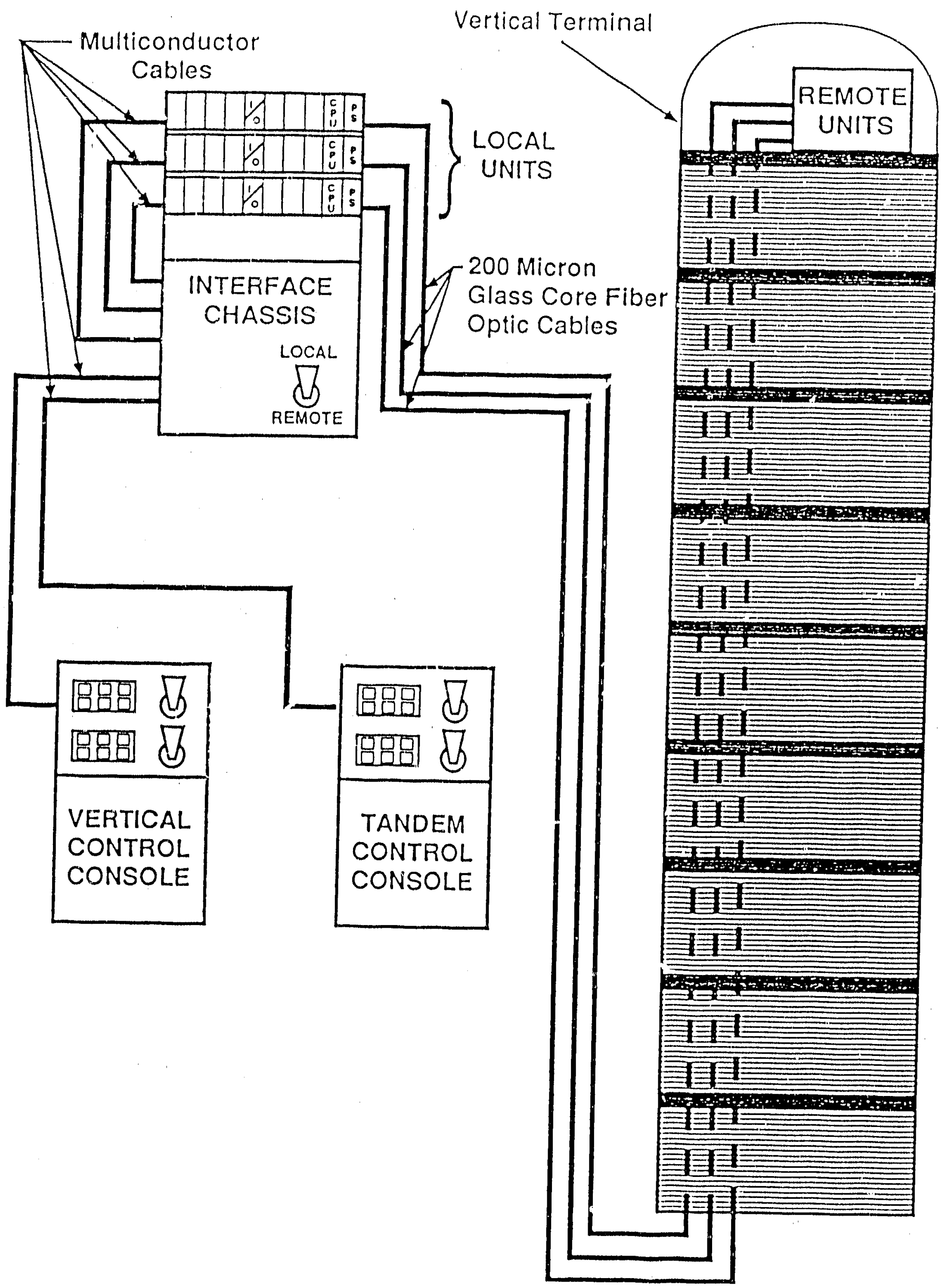


Figure 1 - Simplified block diagram

The delivered system is made up of three local units each having a corresponding remote unit. The three systems operate independently of one another. A major advantage of the programmable controllers is the flexible modular I/O device system. The modular design allows for easy repair as each subassembly is readily replaceable. Visual indication of channel activation is provided along with self diagnostics to aid in troubleshooting should a problem arise. There are also a broad range of I/O devices that are commercially available. In addition the programmable controller can be interfaced to a remote controlling or monitoring computer. A hand held programmer is also available to simplify remote operation and troubleshooting.

Each of the three systems are customized with the I/O modules needed to accomplish the control and monitor functions required to properly operate the ion source. Block diagrams of each of the three systems are provided in Appendix A.

The modules used in these systems include the CPU, local and remote I/O controllers, digital input modules, digital output modules, analog input modules and analog output modules in both 8 and 16 channel versions. Each system is set up around the CPU module. It is fully programmable (using ladder logic programming) and controls all functions of the local and remote racks. The digital input modules can be set, by jumper placement, to accept either sink or source inputs. In a similar manner the digital output modules can also be set to either normally open or normally closed. The analog input modules can be set, by jumper placement, to accept either current or voltage inputs, for unipolar or bipolar operation, for 10V or 20V span, at gains of 1, 10, 100 or 1000. The analog output modules are factory set for either unipolar or bipolar outputs with the output span being set by jumper placement.

The I/O controller modules located in both the local and remote racks provides the communication link between the two locations. The communication modules' outputs are RS-232 and are fed into a fiber optic modem made by Honeywell. The local and remote units are connected by 200 micron glass core fiber optic cables. The fiber optic cables have only the single layer cladding in the sections that span the column structure while the sections from the control room to the base of the pressure vessel have the full clad and jacket. It was determined that the jacket seemed to trap moisture and therefore cause breakdowns in the cables when the machine was up to voltage. However the unjacketed cables seem to stand off the voltage rather well. The cables are attached at 10 evenly spaced points along the column structure to help in grading the voltage across the cables. The pressure feedthru for the fiber optic cable was made by sliding a stainless steel capillary tube over the cable and then filling it with epoxy to form a seal between the fiber and the tube. A compression fitting with standard pipe threads was then used to seal around the capillary tube. The fiber optic terminations are made with Amphenol Series 906 SMA type connectors.

The local racks are packaged in 19" rack mount enclosures that take up approximately 30" of vertical space in the rack. They connect to a master panel that provides the interface to two meter-control panels-- a local panel in the vertical control console and a remote panel in the tandem control console used for three-stage operation. A switch closure or "sink" input activates the digital input channels which in turn activates corresponding digital output channels that control 24Vdc isolated functions in the machine.

The remote units are packaged in double shielded enclosures with a single point ground and RFI gaskets on the covers. All inputs and outputs on the remote unit have EMI/RFI suppression filters and surge suppressors at both the outer and inner boxes that provide double stage protection for the remote I/O devices. A diagram of the signal filtering scheme is shown in Figure 2.

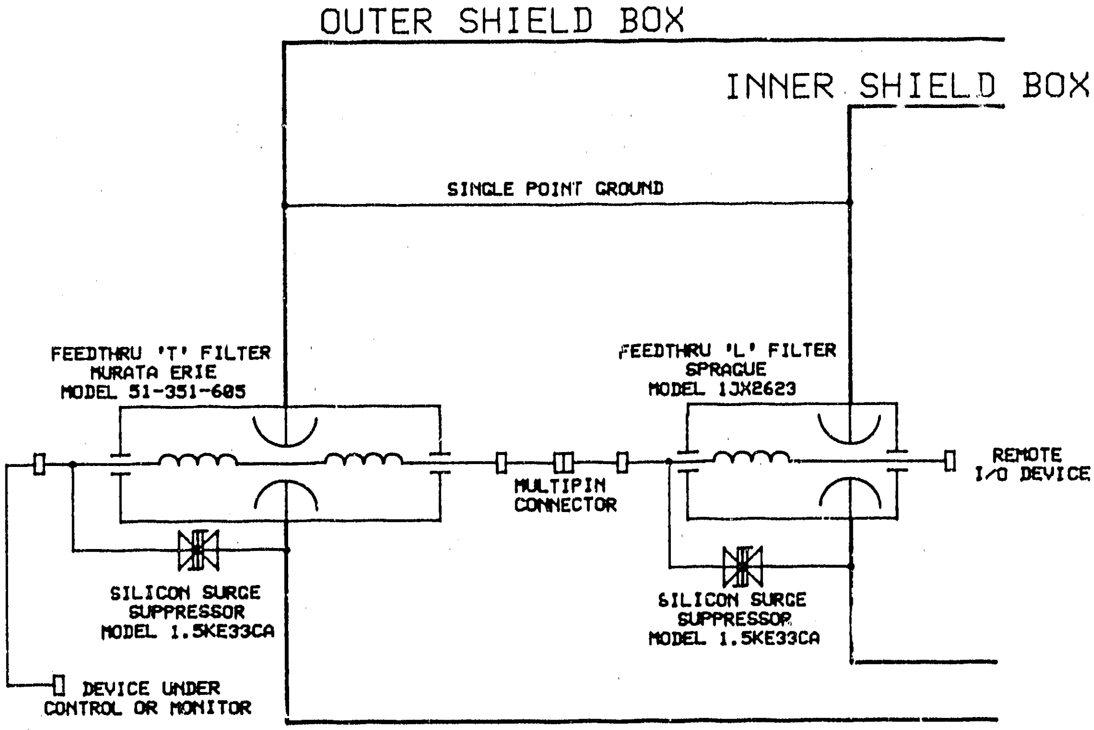


Figure 2 - Remote signal filtering

All air and fiber optic penetrations have a 10:1 hole length to diameter ratio. The monitor functions accept +/-10Vdc in the machine and output a corresponding +/-10Vdc at the local unit to drive digital panel meters. The overall system was delivered with provisions for 72 control channels and 72 monitor channels, however, the actual system requires only 68 control channels and 56 monitor channels.

The units in the control room (local racks) are powered from 120Vac 60 Hz. The units in the machine (remote racks) are powered from a 24Vdc power supply located between the outer and inner shield boxes. The 24Vdc supply is powered from the 120Vac 400Hz from the 5kW generator driven by the charging belt.

The entire system was installed in February 1990. Several problems were encountered during the checkout and installation. The first of which being that the remote systems would not start-up reliably. GE FANUC provided some literature (in Japanese) that showed tremendous start-up currents are required by the 24Vdc racks that are used in the remote units. It was determined that the Z80 processor in the remote I/O controller was trying to reset before the 24Vdc power supply had a chance to stabilize and was causing a communications failure between the two racks. Since the I/O controllers are equipped with self diagnostics that indicate errors via LEDs on the face of the module, it was decided that the solution was an automatic reset circuit that would continually try to reset the processor until the RUN LED came on indicating that communications had been established. A diagram of the automatic reset circuit is shown in Figure 3. No starting problems have been observed

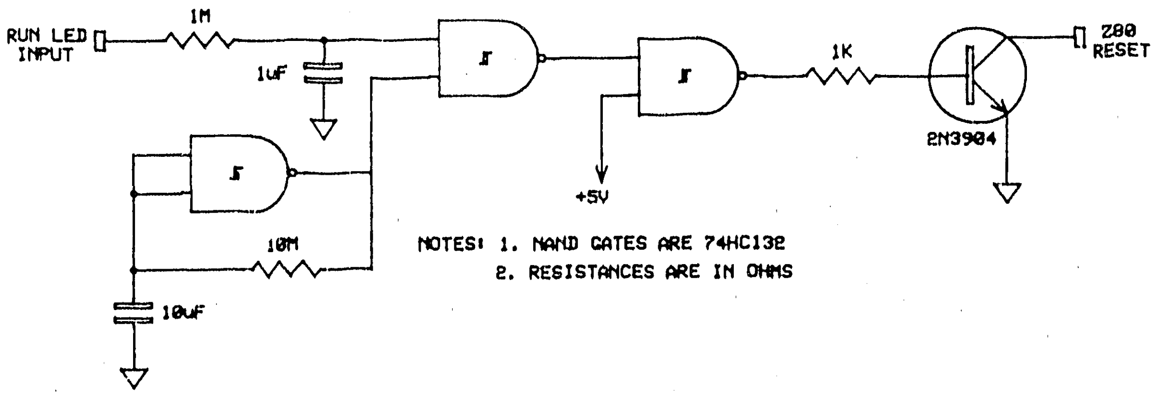


Figure 3 - Automatic reset circuit

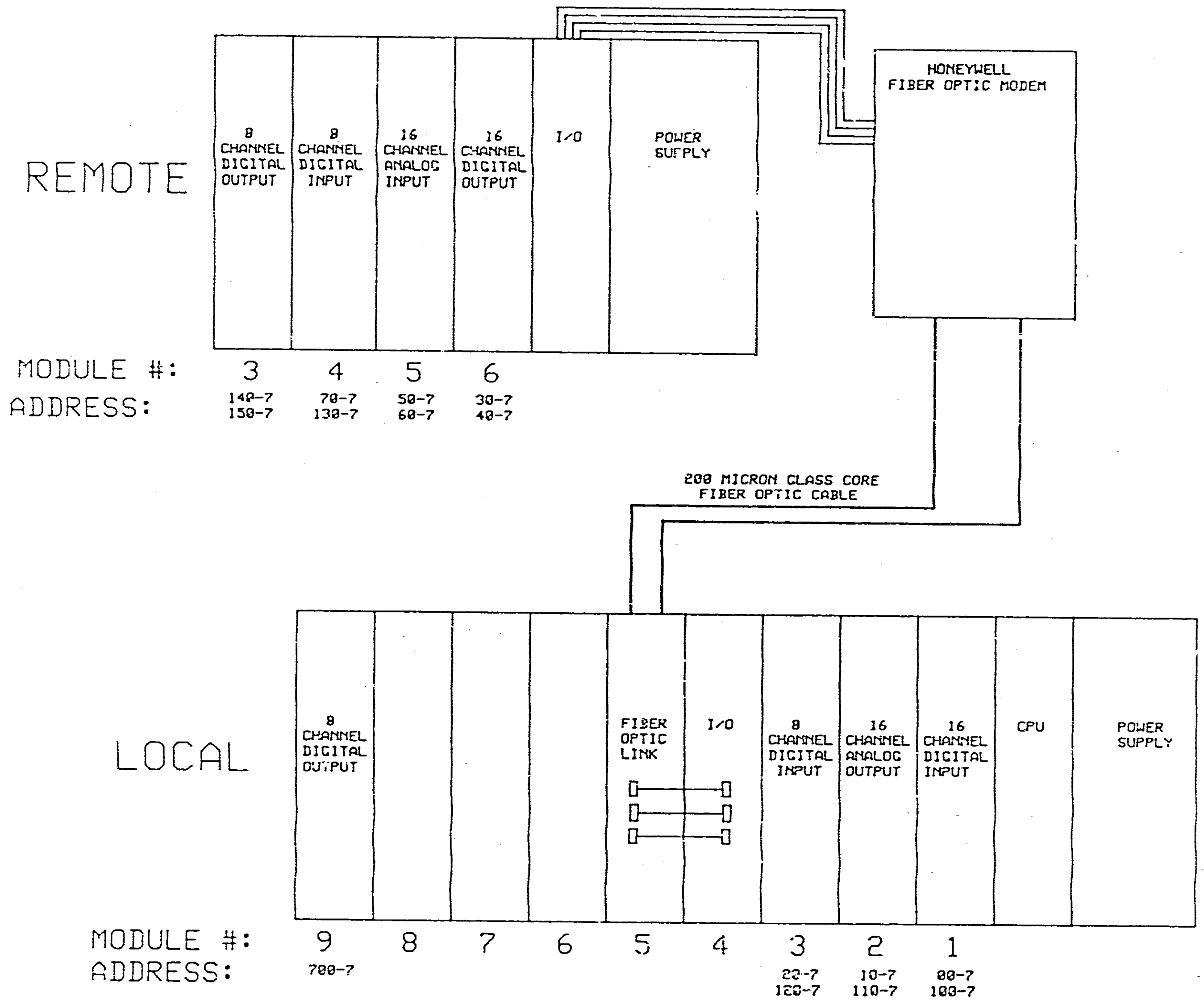
since the automatic reset circuits have been installed. The other problems encountered were mainly due to poor workmanship on the part of the vendor. These problems ranged from cold solder joints to unipolar surge suppressors on bipolar signals. However, each of the remote boxes, the meter-control panels, and the interface chassis have been completely rewired by the IBF staff.

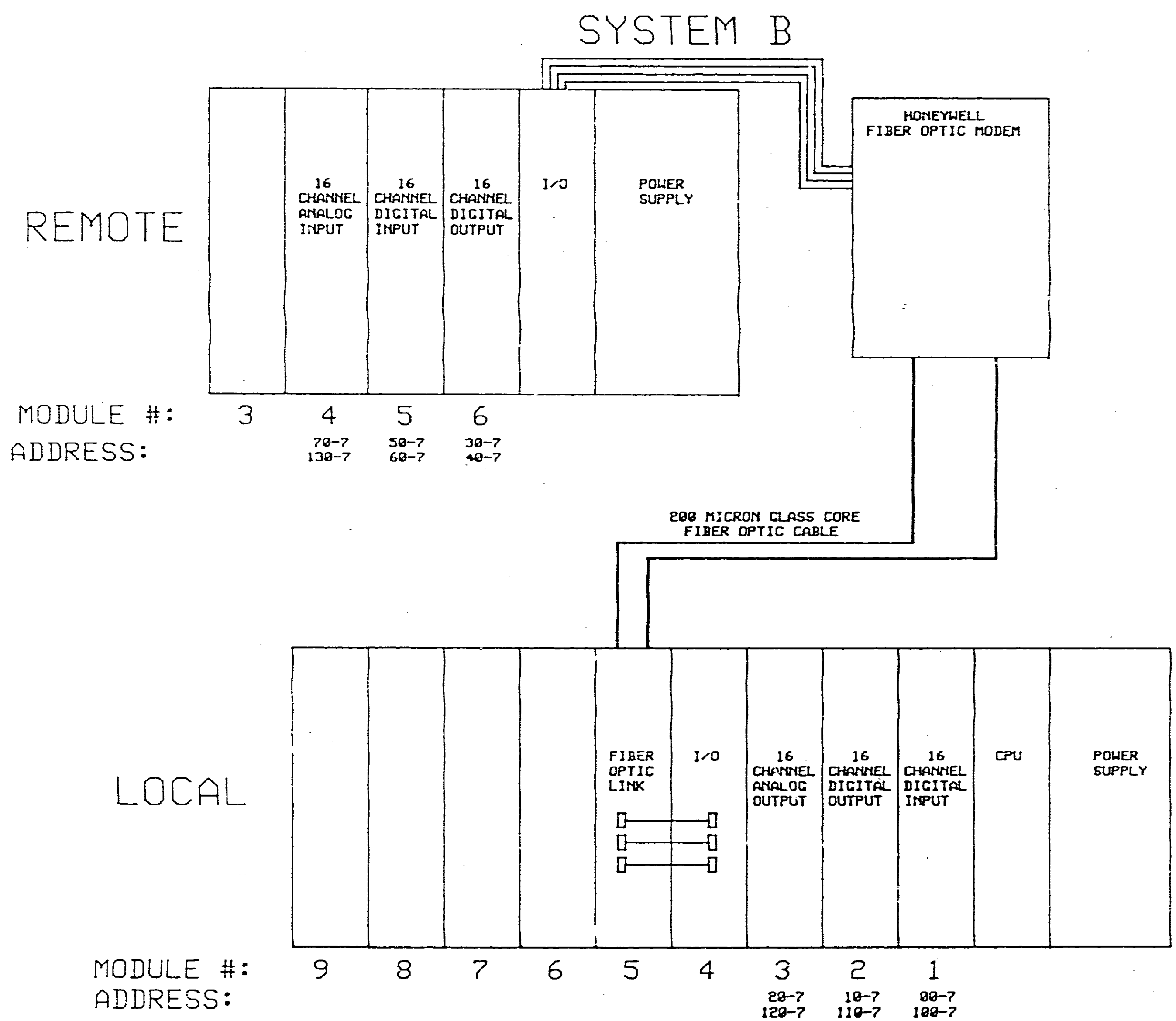
To date, the machine has been in operation approximately 800 hours with the new telemetry system installed. The machine has been conditioned over 7MV with countless tank sparks and column sparks with not one spark-related telemetry system failure.

APPENDIX A:

SYSTEM BLOCK DIAGRAMS

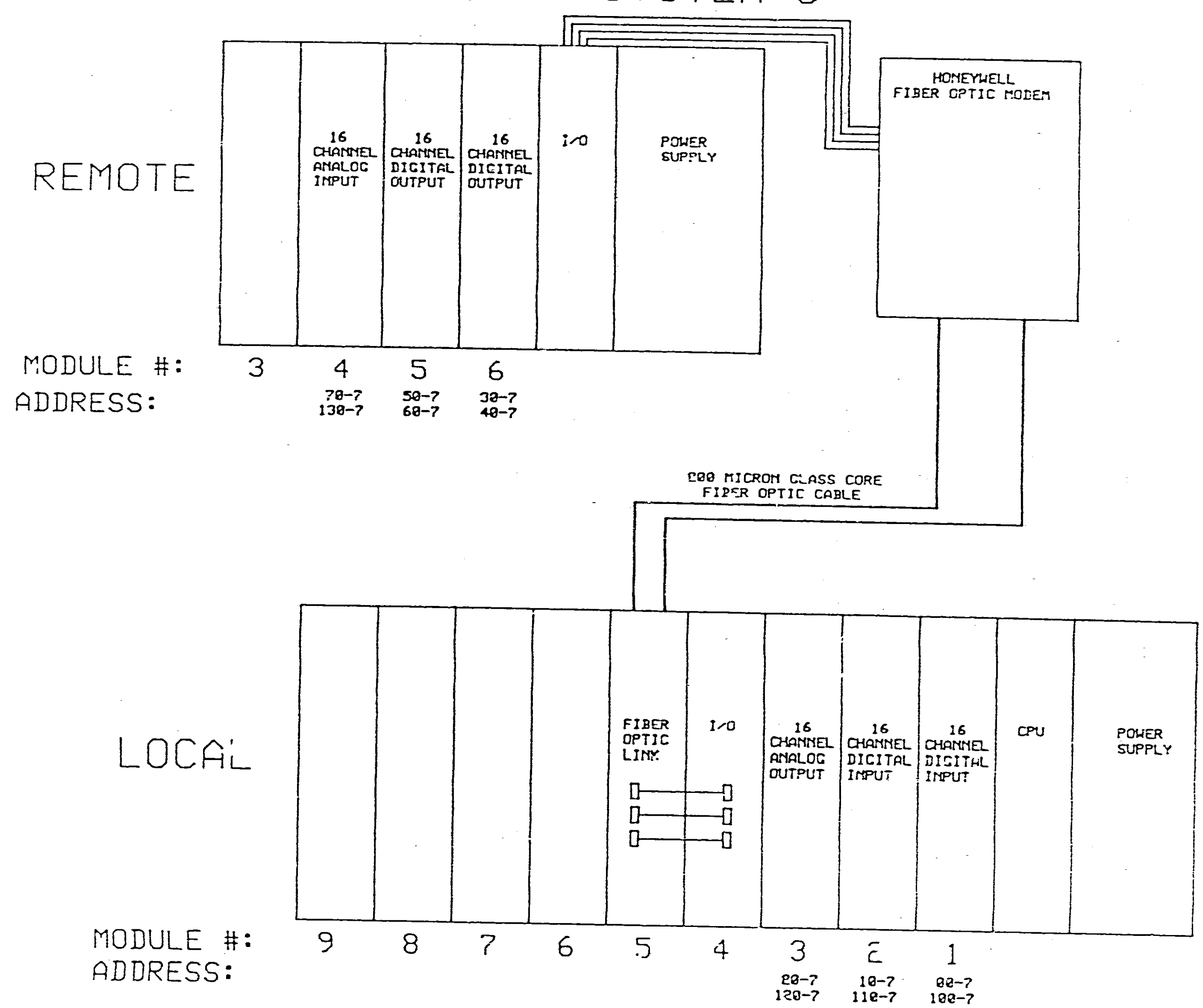
SYSTEM A


REMOTE
8 CHANNEL DIGITAL OUTPUT
8 CHANNEL DIGITAL INPUT
16 CHANNEL ANALOG INPUT
16 CHANNEL DIGITAL OUTPUT
I/O
POWER SUPPLY
MODULE #: 3 4 5 6
ADDRESS: 140-7 150-7; 70-7 130-7; 50-7 60-7; 30-7 40-7
HONEYWELL FIBER OPTIC MODEM
200 MICRON GLASS CORE FIBER OPTIC CABLE
LOCAL
8 CHANNEL DIGITAL OUTPUT
FIBER OPTIC LINK
I/O
8 CHANNEL DIGITAL INPUT
16 CHANNEL ANALOG OUTPUT
16 CHANNEL DIGITAL INPUT
CPU
POWER SUPPLY
MODULE #: 9 8 7 6 5 4 3 2 1
ADDRESS: 700-7; 20-7 120-7; 10-7 110-7; 00-7 100-7



SYSTEM B
REMOTE
16 CHANNEL ANALOG INPUT
16 CHANNEL DIGITAL INPUT
16 CHANNEL DIGITAL OUTPUT
I/O
POWER SUPPLY
HONEYWELL FIBER OPTIC MODEM
MODULE #: 3 4 5 6
ADDRESS: 70-7 130-7 50-7 60-7 30-7 40-7
200 MICRON GLASS CORE FIBER OPTIC CABLE
LOCAL
FIBER OPTIC LINK
I/O
16 CHANNEL ANALOG OUTPUT
16 CHANNEL DIGITAL OUTPUT
16 CHANNEL DIGITAL INPUT
CPU
POWER SUPPLY
MODULE #: 9 8 7 6 5 4 3 2 1
ADDRESS: 20-7 120-7 10-7 110-7 00-7 100-7

SYSTEM C



REMOTE
16 CHANNEL ANALOG INPUT
16 CHANNEL DIGITAL OUTPUT
16 CHANNEL DIGITAL OUTPUT
I/O
POWER SUPPLY
HONEYWELL FIBER OPTIC MODEM
MODULE #: 3 4 5 6
ADDRESS: 70-7 130-7 50-7 60-7 30-7 40-7
200 MICRON GLASS CORE FIBER OPTIC CABLE
LOCAL
FIBER OPTIC LINK
I/O
16 CHANNEL ANALOG OUTPUT
16 CHANNEL DIGITAL INPUT
16 CHANNEL DIGITAL INPUT
CPU
POWER SUPPLY
MODULE #: 9 8 7 6 5 4 3 2 1
ADDRESS: 20-7 120-7 10-7 110-7 00-7 100-7

END

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