Conf-8204141--1

CONF-8204141--1

DE83 017225

NEUTRAL BEAM DATA SYSTEMS AT ORNL*

There are two distinct approaches to neutral-beam line data acquisition systems at the Oak Ridge National Laboratory (ORNL) Fusion Energy Division (FED).

The first one is the beam test stands which are used strictly for neutral-beam-source development and the second is the neutral-beam injectors attached to the Impurities Studies Experiment (ISX-B) tokamak type device. First, I will discuss the neutral-beam-development data-acquisition systems and then conclude with a discussion of the approach used on the ISX-B neutral-beam-injector data acquisition and control systems.

There are three neutral-beam test stands at ORNL: the High-Power Test Facility (HPTF); the Medium-Energy Test Facility (METF); and the Negative-Ion Test Facility (NITF). All three use a set of software tools collectively called the Oak Ridge Beam Analysis System (ORBAS)

The neutral-beam test-stand data-acquisition systems all have some subset of the hardware shown in Figure 1 and are essentially similar. All three systems have PDP-11s[1] with 128K words of memory and use the RSX11M[1] operating system. The data-acquisition front-ends are B_1R_a[2] systems Micro-programmable parallel Branch Drivers (MBDs). The data are all acquired via Computer Automated Measurement And Control (CAMAC) interfaces, either directly or indirectly through the NEFF[3] programmable gain analog to digital converter.

---

*[illegible] of Fusion Energy (OFE), U.S. Department of Energy under contract W-7405-eng-26 with the Union Carbide Corp. [illegible]

[1] Digital Equipment Corporation, Maynard, Massachusetts.

[2] B_1R_a Systems, Alberquerque, New Mexico.

[3] Neff Instrument Corporation, Monrovia, California.

ORNL-DWG 81-2369R FED

BEAM STAND DATA ACQUISITION SYSTEM

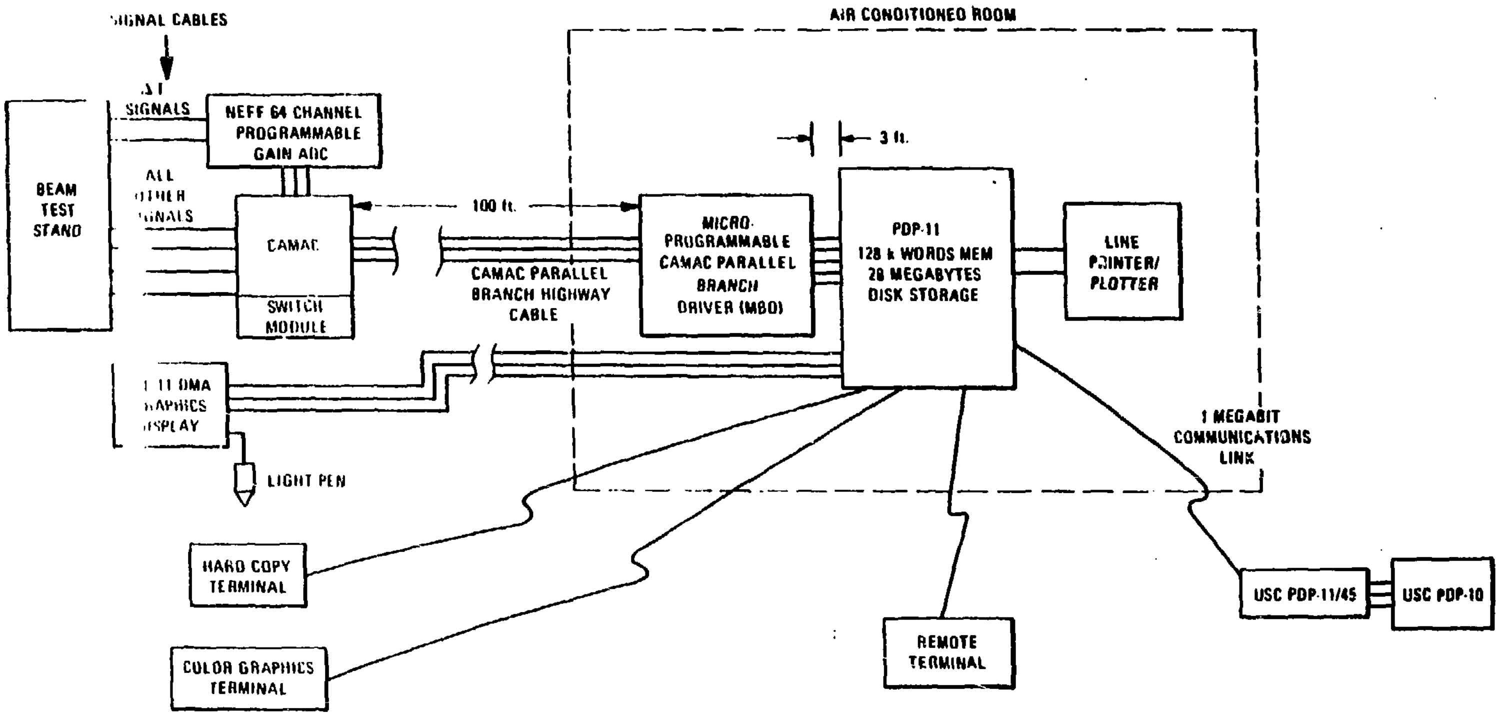


Figure 1

The MBD data acquisition front-end micro-computer is downloaded with its operating system by the host PDP-11 prior to the start of data acquisition. Figure 2 is a flow chart of the system from the point of view of the MBD. The MBD operating system is driven by a 500 hz CAMAC clock. Each MBD task is called every clock tick. That particular task then decides first if it has any data samples remaining to be taken and second, if enough time has elapsed since the last sample was taken. When a new task is added to the MBD software, its name is added to the list of tasks to be called when the clock ticks.

Figure 3 is an overview of the system as it appears to the PDP-11.

PDP-11 Software

The data acquisition systems are parameter file driven. All three beam test stands use the same parameter file format, the only difference being the contents of the parameter files.

The parameter file contains the information needed for labeling the acquired data and converting it to engineering units. Also, the gain values for the NEFF programmable gain analog to digital convertor. The format of the parameter file and the data acquired is such that physical data channels are predefined as taking certain classes of data. The experimenter can define a data channel by following a four step process.

1. The experimenter selects a free channel taking the class of data desired.
2. Connects the signal transducer to that channel on the data input patch panel.

FLOW CHART FOR MBD PROGRAM

ORNL-DWG 81-2359 FED

TYPICAL TIME BETWEEN PULSES IS 10-20 SECONDS

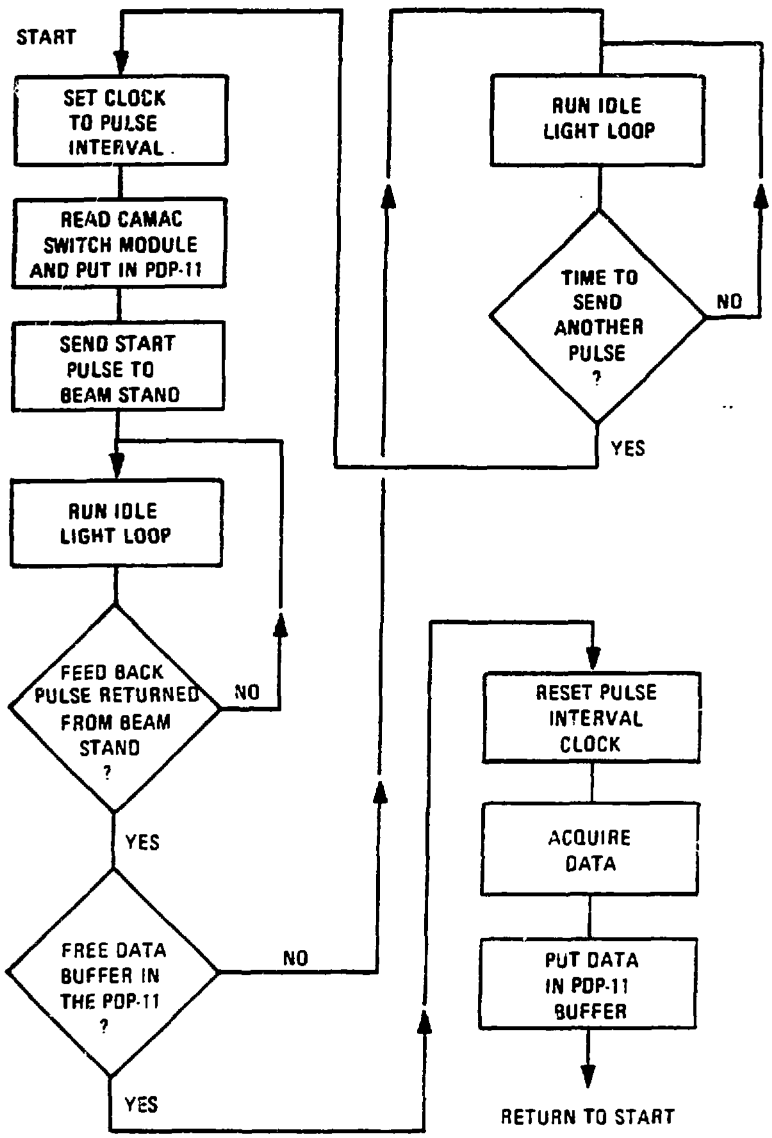


Figure 2

BEAM STAND PDP–II
DATA ACQUISITION SYSTEMS

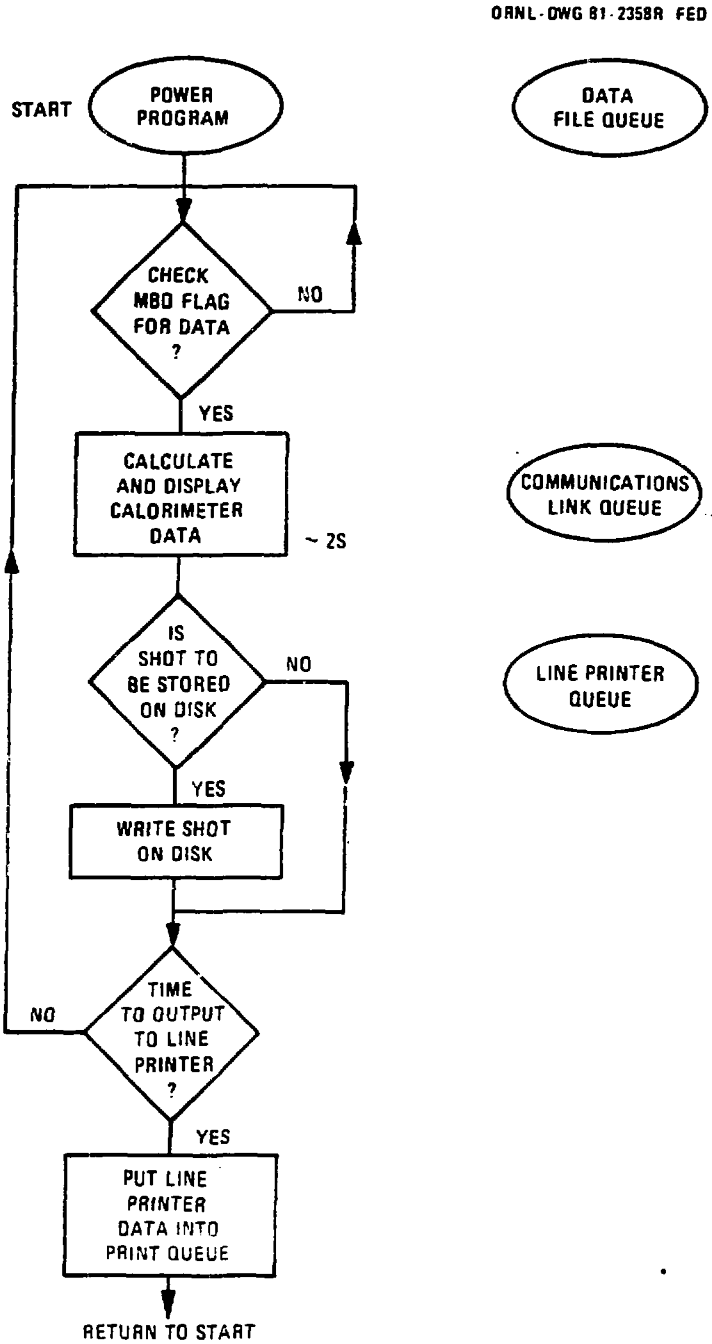


Figure 3

3. Puts the proper parameters for that channel into the parameter file.

4. Starts data acquisition.

When data acquisition is started, the PDP-11 program reads the parameter file from disk and downloads the MBD with its program, which contains the data acquisition parameters. These parameters consist of the pulse interval, the time between samples for the wave form data, and the programmable gain values for the NEFF ADC channels.

Next, a copy of the parameter file for that experiment is transmitted to the PDP-10. Each data file sent to the PDP-10 has the name of its corresponding parameter file embedded in it, thus the PDP-10 has all the information needed to analyze the data.

The PDP-11, upon finding valid data in one of its memory buffers, then optionally displays, prints, and transmits the data to the USC PDP-10. The preceding options all may be turned off or on depending on the CAMAC control switch positions selected by the experimenter. The beam power distribution profile appears on the display <2S after the data are acquired. Figure 4 is a flow chart of the PDP-11 data display and analysis program.

USC PDP-10 Software

Software exists on the USC PDP-10 for permanently storing 'SHOT' data files on magnetic tape, putting the shots into data bases, and further analyzing the data.

Typically, an experimenter would acquire data pre-analyze it in the PDP-11 and transmit his data to the PDP-10 via the communications system. Once the results of the experiment are on the PDP-10, he would probably put the entire experiment into a data base and possibly also store it on magnetic tape. The experimenter has software tools available on the PDP-10 for plotting, printing, and analyzing his data according to his own requirements.

See Table 1 for a partial list of the programs available on the PDP-10.

Conclusions

The ORBAS system gives the experimenters a complete system with which they can acquire data automatically, classify it by experiments, store it on magnetic tape and/or further analyze it. The use of the same parameter file structure and identical data acquisition software on all three systems reduced software costs. The ORBAS system allows a common approach to the solving of similar, but not identical, data acquisition problems.

TABLE 1

A Subset of the Beam data Analysis Programs on the USC PDP-10

1) Perveance

   a) Single perveance curve
   b) Percent power loading vs. perveance
   c) Transmission perveance

2) Reliability - Generates bar chart

   a) Joules/shot
   b) Kilowatts/shot
   c) Pulse length

3) Percent Power Loading

   a) Percent power loading vs. decel voltage
   b) Percent power loading vs. beam current
   c) Percent power loading vs. beam voltage
   d) Percent power loading vs. perveance

4) Voltage and Current vs. Time

   a) Beam voltage and current vs. time
   b) Decel voltage and current vs. time
   c) Arc voltage and current vs. time

The ISX-B tokamak experiments are directed primarily toward investigating high beta plasmas. A fundamental part of these experiments is the neutral beam injection system, which supplies additional ion heating to the plasma.

Continuous conditioning of the arc chamber and proper control of the source parameters are necessary to maximize the extracted beam power and to optimize the beam optics. These and other items such as switching between conditioning the beams and injecting the beam into the tokamak and recording the current and parameters after each shot, require the operators total attention.

A computer based system was designed to handle most of these tasks.

Hardware

The system uses a CAMAC crate interfaced to a PDP-11[1] via a serial data highway and a Jorway[2] 411 CAMAC branch driver.

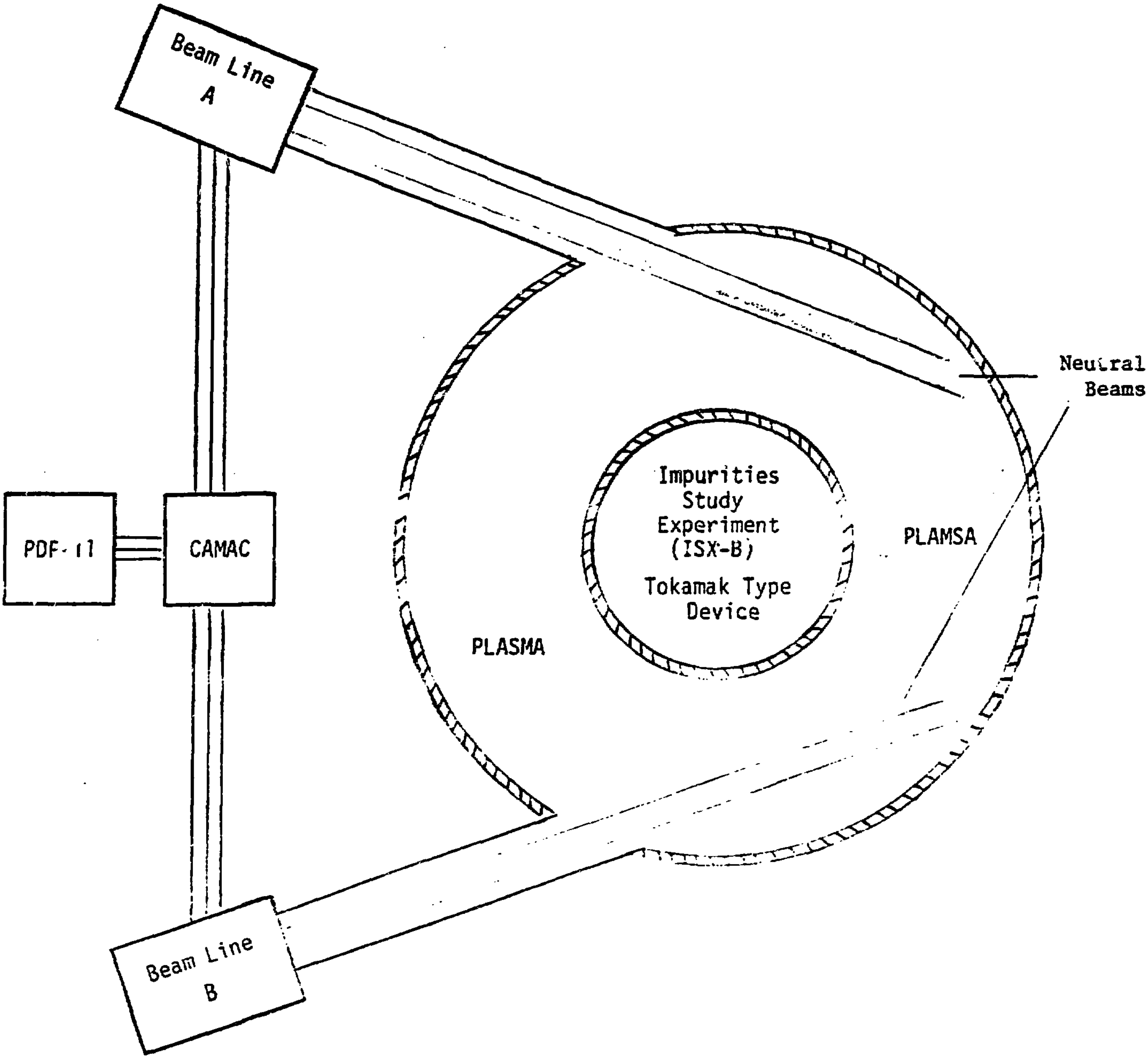
Design Requirements

The beam line system at ISX-B consists of two beams which operate completely independently of each other with the exception of the trigger producing timers which are in a master/slave configuration so that the beams fire together. For this reason the computer has to be able to monitor and control each beam line separately. The two beam lines also react differently to the same parameter settings so that the system must be tailored for each beam line individually.

---

[1]Digital Equipment Corporation, Maynard, Massachusetts.

[2]Jorway Corporation, Westbury, New York.



Beam Line
A
Neutral
Beams
Impurities
Study
Experiment
(ISX-B)
Tokamak Type
Device
PDF-11
CAMAC
PLAMSA
PLASMA
Beam Line
B

FIGURE 1

In order to have any control of the beam lines, monitoring and data acquisition must be done to provide a basis for decisions. Arc current, arc voltage, beam current and beam voltage comprise the needed information. Another facet of the data acquisition system is to record these parameters for every tokamak injection shot, along with the time and date and the corresponding tokamak shot number.

The parameters which govern the beam line and thus need to be controlled by the computer are the arc drive voltage, the gas density, the magnetic strength, and the accel voltage level. For safety, and efficient operation, the human operator must be able to effect changes in the values which the computer sets for these parameters or, if need be, switch from computer control to manual control very quickly. It is required that this system be able to automatically adjust these parameters in order to generate a beam with a specified power level. This includes conditioning away breakdowns and sweeping around the beam current/voltage perveance curve to improve the beam optics.

The final requirement of the system is that it recognizes which beam or beams are to be injected and at the correct time moves the calorimeters and switches the timers to inject mode. This also involves switching back to conditioning (test) mode after a shot or a timeout (shot cancelled).

Software

The software was developed completely in Fortran with calls to existing CAMAC subroutines. It is broken up into a number of small tasks which are outlined below. These tasks all access a Fortran common area so that data can be shared.

AUTOBM - Initialization.

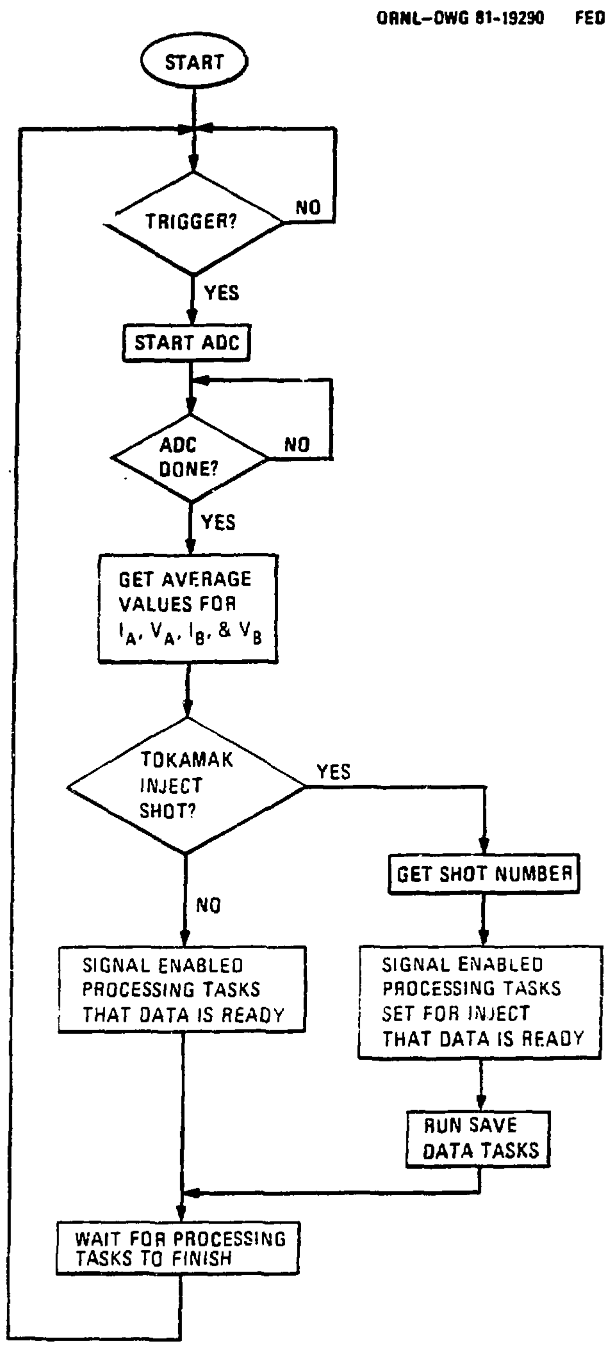
Initializes variables and CAMAC modules. Also displays initialized variables to the operator and allows changes to be made.

BLC - Operator interaction routine.

Allows the operator to change parameters which the computer has set. The operator also uses this routine to inhibit or enable a beam line and to signal that a beam line should inject when the tokamak fires.

WATCHT - Watches for triggers.

Waits for triggers to occur and starts the digitization of the parameters. When the ADC is finished, WATCHT signals the appropriate processing routines that the data is valid. (See Flowchart 1)



Flowchart 1 - WATCHT

SAVDAE or SAVDAW - Save data.

After a tokamak shot with beam injection these tasks are started in order to save the parameters from that shot to disk.

RECALE or RECALW - Recall data.

These tasks are run by the operator when he wants to see the data on the disk. Data can be accessed by shot number or by the date of the shot and can be displayed or printed.

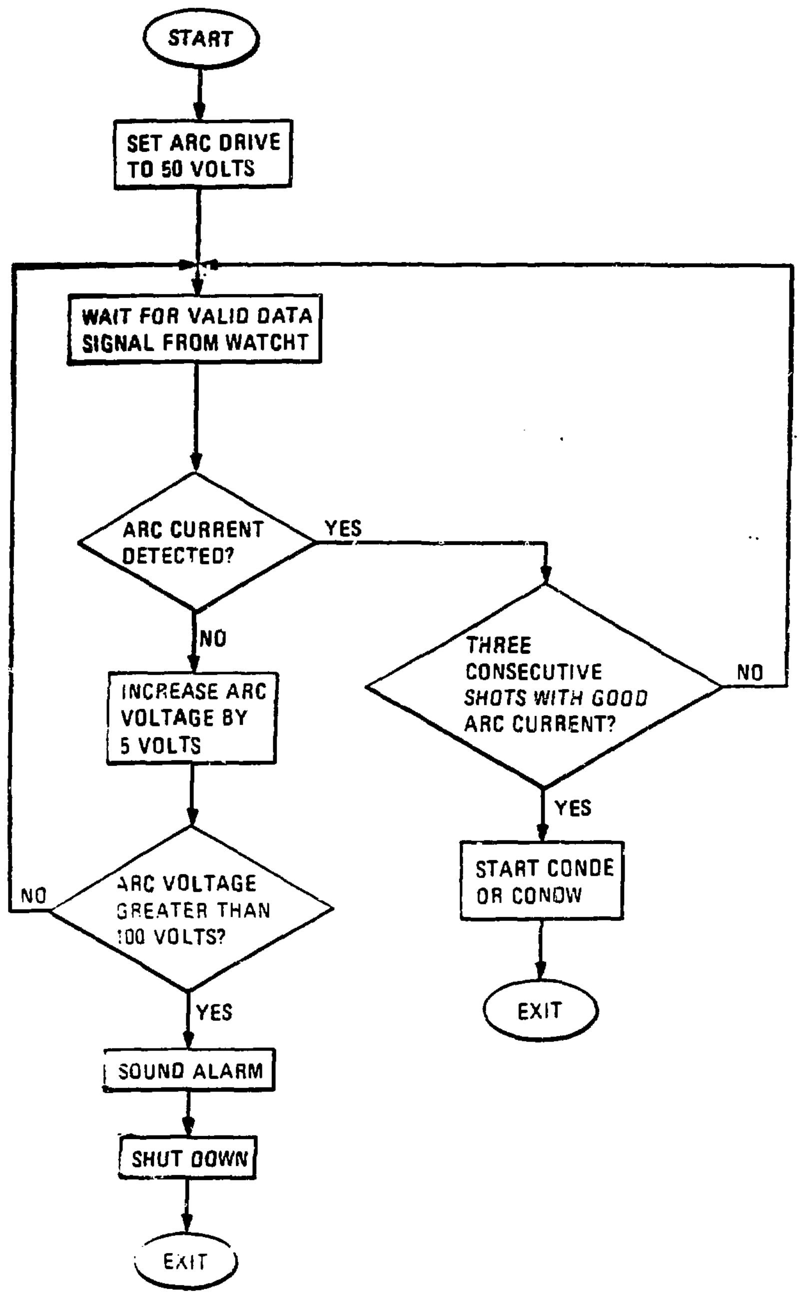
INITE or INITW - Initialize the arc current.

More of a safety feature than anything else. This routine waits for WATCHT to signal that the data is valid and then looks for a good arc current. It verifies that an arc is established before the arc voltage exceeds 100 volts or it shuts down. If the arc current is established, this routine starts CONDE or CONDW and exits. (See Flowchart 2)

CONDE or CONDW - Condition arc and beam.

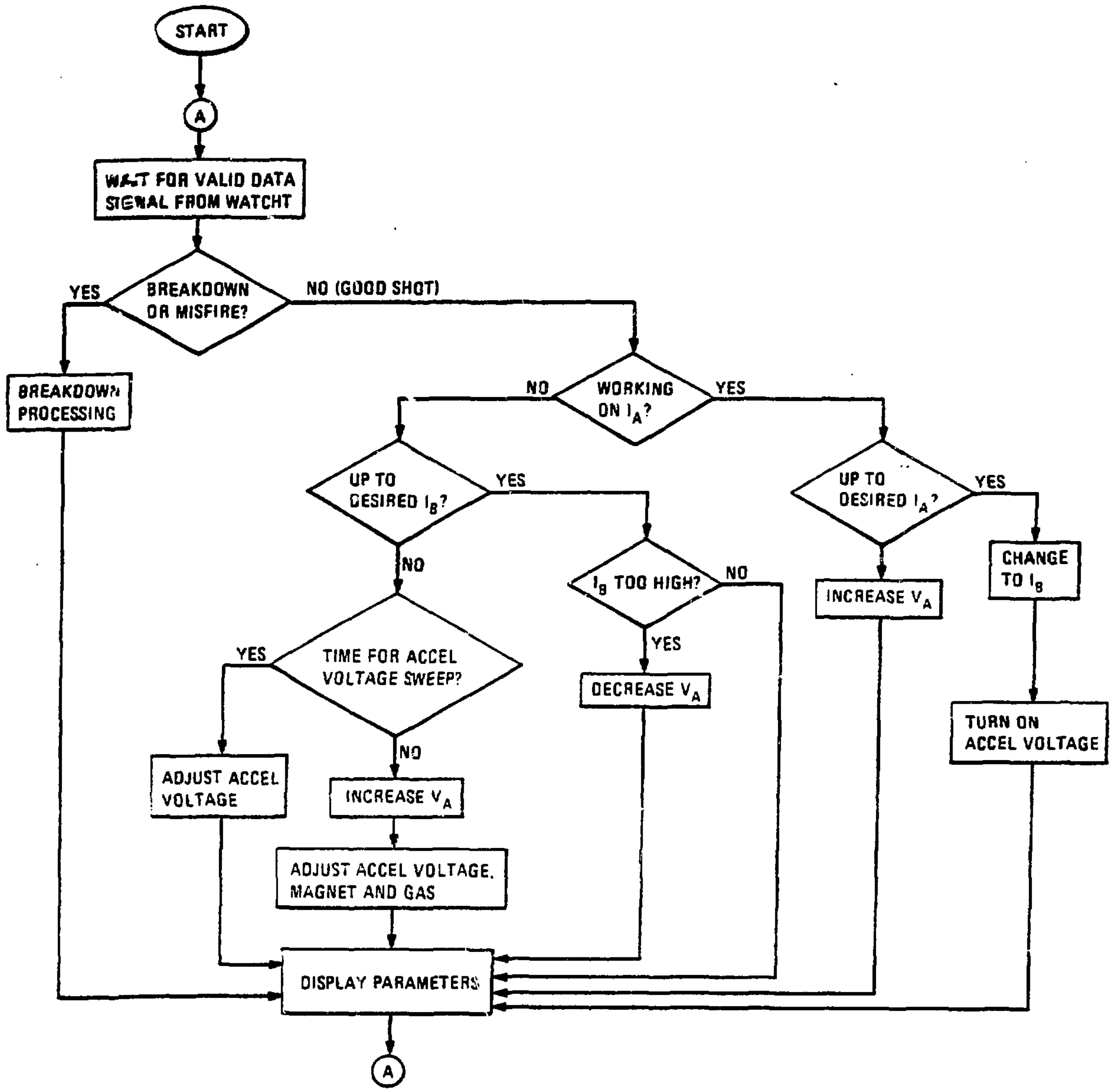
This routine brings the arc up to a specified current and then turns on the beam and brings it up to the specified current level. It handles all breakdowns, as well as high voltage sweeping, waiting to clear up numerous breakdowns, and switching between test and inject modes. (See Flowchart 3)

ORNL–DWG 81-19291 FED



Flowchart 2 – INITE or INITW

ORNL-DWG 81-19292 FED



Flowchart 3 - CONDE or CONDW

Future Improvements

The first priority seems to be more electrical noise immunity. This may involve work on both the computer software and the existing beam line controls.

The operator interface is being redeveloped to include a display with lightpen interaction. This display is updated automatically and the operator can make changes by simply touching the screen with the light pen.

The existing calorimetry system which provides power measurement will be incorporated into this system so that these values will be available to the operator.

Conclusions

A control system for neutral injection beam lines has been designed, implemented, and used with much success. Despite the problems with very high power levels this system is very successful in relieving the operators burdens of slow conditioning, data recording, and mode switching. The use of computer control with multiple beam lines now appears very promising.

Acknowledgments

I would like to acknowledge the help of P. C. Hanna and J. E. Francis in the preparation of this paper and the work they did on the projects. Also, the encouragement and advice given me by C. E. Hammons.