BNL-28035

XI INTERN. CONF. ON HIGH ENERGY ACCELERATORS, GENEVA, SWITZERLAND, JULY 7-11, 1980

CONF-800740--23

THE ISABELLE CONTROL SYSTEM*

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ABSTRACT

Design principles for the Brookhaven ISABELLE control intersecting storage ring accelerator are described. Principal features include a locally networked console and control computer complex, a system wide process data highway, and intelligent local device controllers. Progress to date is summarized.

I. INTRODUCTION

The ISABELLE control system enables a single human operator to direct a large, complicated, and fragile collection of accelerator devices and systems. It both performs commands and collects data in coordinating the activity of many thousands of components. This paper illustrates the overall control design principles. It surveys the features by which an operator in the control center directs, monitors, or operates any of the individual devices of ISABELLE.

As with most accelerators, ISABELLE is organized as a combination of a number of relatively self contained contributing systems. The ISABELLE control system unifies the operation of each. The control system itself includes three rather distinct elements. A closely linked network of adjacent computers communicates with widely distributed, intelligent controllers via a process data highway.

Figure 1 shows a block diagram of this conceptual control system. Figure 2 amplifies this diagram. Each of the three elements - network, process data highway, and controllers will be discussed in more detail in the following pages.

II. THE CONTROL CENTER

Operators interact with ISABELLE as a system at the control center. The center is a common resource of computers and control consoles in a single location. Most computers of the ISABELLE system will be placed in the control center. These computers aid in a number of rather distinct functions:

1. Control console support
2. Simulation and modelling/accelerator data base
3. Program development
4. Program library
5. Alarms and access
6. Subsystems (power supplies, vacuum, cryogenics, etc.)
7. Sextants

MASTER

Of these, we will discuss only the console and modelling computers.

At ISABELLE, computers will be heavily embedded in the control console, as is now the custom in the accelerator business. Consoles must support at least two kinds of accelerator operation. These are stable beam collision production for physics experiments, and a more active accelerator study and development kind of operation. In development running, the operator may be trying to repair the machine, to get around some inconvenience, to surmount an unforeseen technical limitation, or to do new accelerator development. This kind of operator is most likely exploring changes, and examining the basic properties of

*) Work performed under the auspices of the U.S. Department of Energy.

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the machine itself. The second running mode emphasizes stability, and beam luminosity for the particle physics experiments, and depends upon the experience produced by the accelerator development studies. Control systems must thus provide flexibility for the exploratory periods of operation, and stability for both, especially the routine periods. Flexibility in design seems to be an essential ingredient in improving performance as machines mature, but it also leads to a certain amount of commotion in earlier budget tugs of war as well.

The control center of ISABELLE will contain more than just the computer control system. Operators will need information from the beam monitoring and rf accelerating systems to run ISABELLE. Much of this information is analogue in nature. Some may be obtained from information processing equipment too expensive or too bulky to duplicate at every control console. Networking methods will make it possible to share most instrument readings among the various console displays. Experience with other accelerators indicates that it would be quite useful to have the low level rf system, the beam monitor analyzers, and the control consoles in a single area or in contiguous rooms. The ISABELLE control room will be located close to the ring and cable runs between the control room and this instrumentation (pickup electrodes for longitudinal and transverse Schottky scans, beam current monitors, etc.) will be kept short.

The modelling computer will let us model ISABELLE in both a predictive and a historical sense. This facility will perform accelerator simulations in real time. It may be a linked combination of a 32 bit or larger computer within the ISABELLE control computer network and an outside scientific computing facility. The modelling computer in the control network would be used for doing simpler calculations, such as verifying the safety of machine setting changes. This is also the natural place to locate the accelerator data base. More complicated simulations could be done on the larger machine elsewhere.

The phenomenological models of the accelerator will need operational experience before they can become reliable aids in the running of ISABELLE. There will be a natural interplay between the models and the measured properties of the accelerator as the models are refined. The models should help with determining various surveillance limits for accelerator devices. The design of the models will require adequate care that they do not degrade the performance of the system unduly.

As designers at CERN have shown so convincingly, the choice of computer languages is important to the success of a control system. Users of the ISABELLE control system may write programs in either FORTRAN or NODAL. The ISA Controls Group is now using PASCAL as a program development language to design and define system software. We are creating a NODAL design document in PASCAL and are likely to adopt a version of NODAL. The choice of final language to be used to implement these system and library programs designed in PASCAL is still an open question, and depends somewhat upon eventual computer selection.

III. CONTROL SYSTEM COMMUNICATIONS

It appears practical to separate ISABELLE control system data communications into two parts, a local computer network, and a process data highway. These are shown on Figure 2. It is desirable to seek commercial software for these links whenever it appears suitable. A number of maturing procedures in the commercial control and computer industries are now available to support local computer to computer networking. The speeds and techniques of these networking endeavors are rather well suited to the types of function which will be distributed among the console and central complex of control computers. The traffic on this first part of the system should be mostly block data transfer as console commands are interpreted and programs and display arrays are shuffled about. The second part of the system is in the nature of a process data highway, which links a multitude of outlying devices with the central complex. The traffic here under normal operating conditions is most likely to be very short messages and commands routed to individual device controllers. The adoption of intelligent device controllers tends to relax demands on control data movement, and leads to ways to engineer more robust overall systems. This strategy combines rather naturally with the results of other activity in the industrial control fields which has produced very reliable and flexible data highway examples.

The ISABELLE process data highway will consist of a common distribution cable, stations which tap the cable at a number of places on the ring, and branch lines which radiate from the stations to connect local equipment controllers. The system divides itself more or less by decades. Perhaps ten computers in the central complex discourse with about 100 stations along the cable. These 100 stations talk with 1000 controllers, which tie to some tens of thousands of control or monitor points placed on accelerator devices.

The projected ISABELLE process data highway is a member of a class called "Ethernet" or "Contention" networks. The name Ethernet belongs to a specific minicomputer communications system developed during the past six years at the Xerox Palo Alto Research Center. Ethernet systems are characterized as a number of stations sharing a common passive communications medium (usually coax cable) of a wide range of bandwidth, 1-20 megabits/sec. Under normal conditions, any station (A) which wishes to send a message to any other station (B) first senses the coax cable (the ether). If the ether is quiet, A broadcasts his message and B receives it. If the ether is in use, A waits. Because of large separations along the ring, two or more stations might find the ether to be inactive, and hence try to broadcast at the same time. Such simultaneous messages will collide somewhere on the cable. This situation is called contention. In general, the method of collision detection and contention resolution differentiates systems of this class. The ISABELLE contention resolving technique uses cable TV directional couplers to implement a priority by position scheme. During the brief intervals in which contention can occur, down stream senders yield to upstream ones. We give the highest communication priority to the control center.

Stations on the main line handle transmission, reception, buffering, etc. We show the ISABELLE site plan on Figure 3. Stations will be located in the service buildings, intersection area support buildings, and eighteen equipment alcoves around the ring to help control nearby devices. The present census includes 3 stations per alcove, 6 stations per support building, and 20 stations for the service building, for a total of 110 stations.

As is typical of a large accelerator, ISABELLE will have approximately 30,000 monitor and control points. Thus, each station must service a number of monitor and control points on a short-distance local bus, which we call a branch line. We plan to use IEEE-488 (IEC-625-1), also known as the General Purpose Interface Bus. Each branch line will have a bus controller. One option is to make branch lines specific to particular subsystems, such as magnets. This will allow the branch line to be disconnected from the main line and operated locally during periods of down time. This feature will be useful for assembly, maintenance, and testing.

IV. DEVICE CONTROLLERS

The functional parts of the accelerator will couple to the control system by means of intelligent local device controllers. To the operator, these outlying devices are the accelerator. The components and instrumentation which direct or monitor each device will be connected via conventional transducers to these local controllers. In some cases, such as power supplies, the microprocessor based controller may be embedded in the supply equipment. Some of the vacuum instrumentation data will be gathered from high radiation sites in the tunnel using tone sensing and other low frequency line techniques. A microprocessor controller manages a number of such units from within a sheltered alcove. The many varied controllers will interface to local branch lines with standard bus plugs.

V. PRESENT STATUS

Design of the control consoles is scheduled to begin next year. A first draft specification for computers is written, and will be further developed. Detailed design and analysis of the proposed process data highway is underway. Power Supply and Vacuum Sector controllers have been designed, built, tested, and reviewed. An evaluation of the IEEE-488 General Purpose Interface Bus has been done, and techniques to remedy its deficiencies are being studied. We are evaluating computer languages, and an implementation of NODAL is underway.

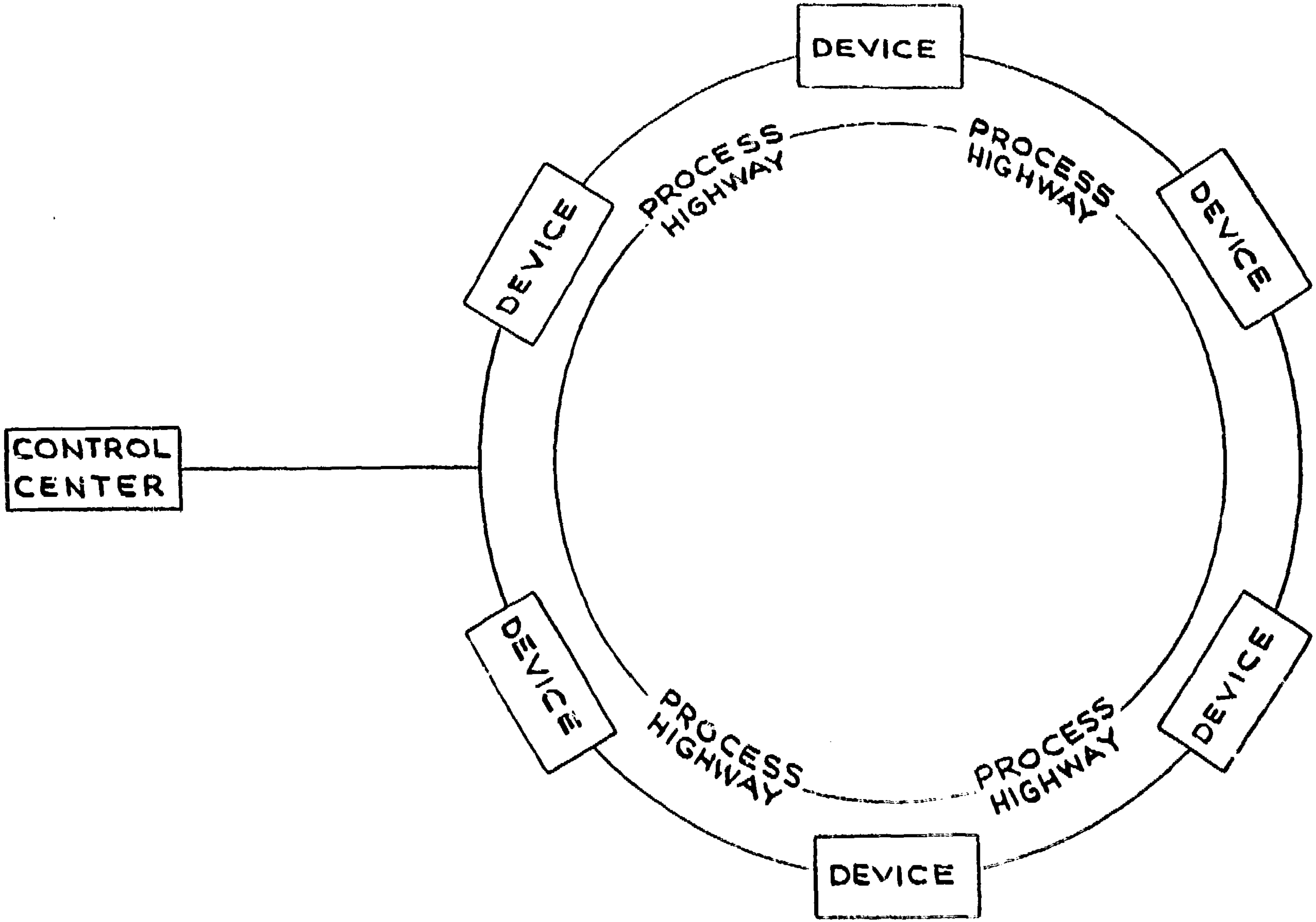


FIG 1
BLOCK DIAGRAM OF CONCEPTUAL CONTROL SYSTEM

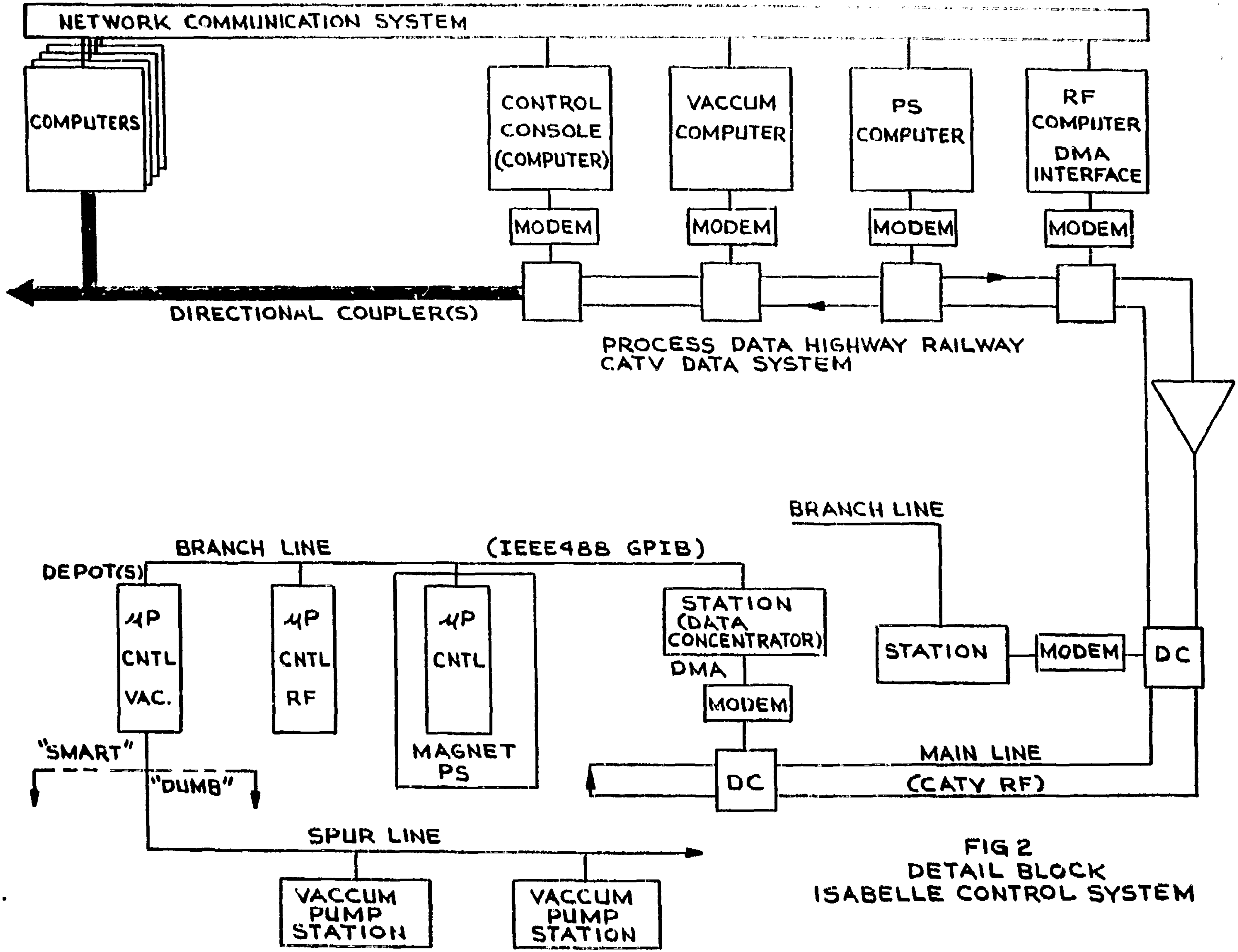
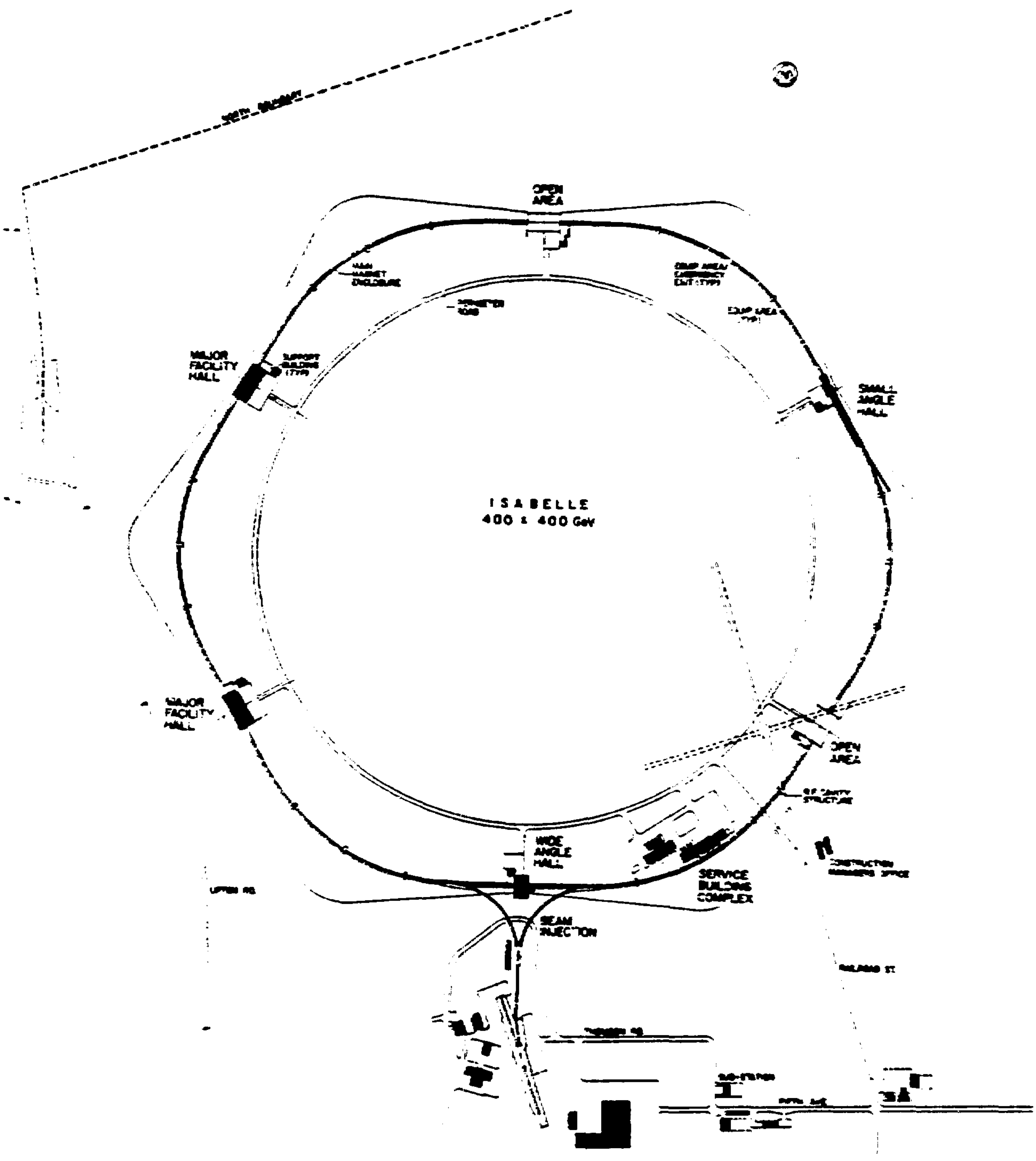


FIG 2
DETAIL BLOCK
ISABELLE CONTROL SYSTEM


OPEN AREA
MAJOR FACILITY HALL
SMALL ANGLE HALL
I S A B E L L E
400 x 400 GeV
MAJOR FACILITY HALL
OPEN AREA
WIDE ANGLE HALL
SERVICE BUILDING COMPLEX
BEAM INJECTION