BSF Beam Control System

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Components of the control system can be divided into:

(1) control desk

(2) programmable sequence controller

(3) timing system

(4) computer

(5) television system

(6) access control system

(7) gate monitor

Fig. 1 shows the schematic diagram of the hardware interconnections.

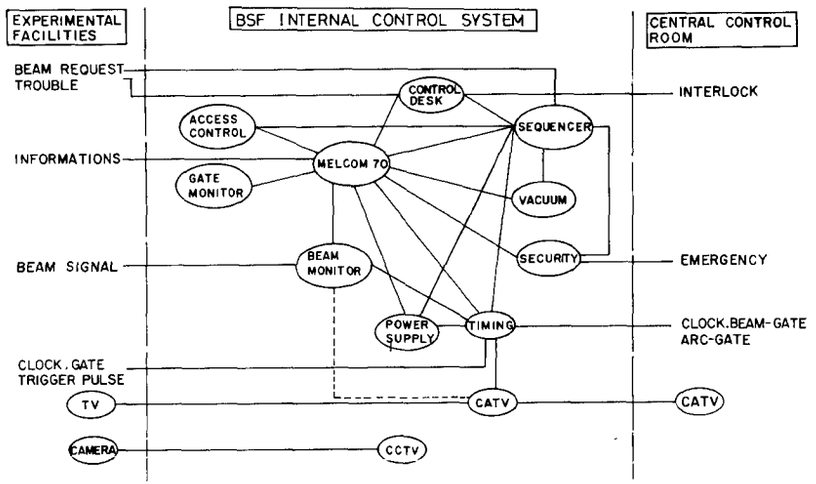

Fig.1 Simplified schematic diagram of the hardware interconnections

1. Control Desk

A BSF operation mode such as NORMAL, DUMP and MAIN RING INJECTION is selected at the control desk. Each operation mode means the following case:

(1) "NORMAL", where the booster beam is injected into the BSF beam channel.

(2) "DUMP", where a power supply B-2 is turned off and the beam goes down to the beam dump.

(3) "MAIN RING INJECTION", where power supplies B-2 and PB-1 are turned off and the booster beam is used for main ring injection only.

In the NORMAL mode, the beam switch of the control desk plays the most important role of the beam ON/OFF control. The conditions for beam injection directly interlock the beam switch by hardwiring (relay logic). If the interlock chain is broken the beam switch turns off and the beam is inhibited at the ion source of the preinjector.

2. Programmable Sequence Controller

5TI-1023 programmable sequence controller (TEXAS INSTRUMENTS INC., hereafter called a sequencer) is used for sequence control. The response of the sequencer is within 30.5 msec in a 50 Hz operation. According to the BSF operation mode the sequencer selects the doors which are allowed to be opened and signals the choices to an access control system. Beam request status from users is READY/PRESET/PAUSE/REJECT and each facility sends one of these requests. The sequencer accepts these requests and decides the beam delivery mode. After checking all conditions for the beam delivery it sends

"BSF ready" signal to the control desk if all conditions are satisfied. The "BSF ready" signal interlocks the beam switches on the control desks both in the BSF control room and the central control room (CCR).

3. Timing System

A beam-gate, clocks and trigger pulses are transmitted from the CCR. The beam-gate is a gate pulse of about 1.9 sec in width which corresponds to an excess of the booster beam pulses over the main ring injection. In this gate we can choose the beam pulses in any form of a pulse sequence by using a "BSF-programmer". Beam selection is made following the beam dilivery signal from the sequencer. The selected beam gate signal (arc-gate) is sent to the CCR and fed into the arc-triggering system for the preinjector. Timing clocks, trigger pulses are used for synchronizing pulsed operating devices to the booster cycle. Triggering a pulsed switching magnet, taking beam profile data, rotating a neutron chopper etc. should be in synchronization. These clocks and pulses are distributed to each facility.

4. Computer

The computer to be used is a MELCOM-70 mini-computer (M-70) made by MITSUBISHI ELECTRIC CORPORATION. Fig. 2 shows the constitution of the M-70 system. The software system is based on the real-time disc operating system RDOS and batch disc operating system BDOS. In the present system RDOS supervises 14 levels of tasks in the foreground and does not include a background job because of a limitation of the core memory size. The batch processing program is executed under the supervision of BDOS.

All the magnet power supplies are controlled by the M-70.

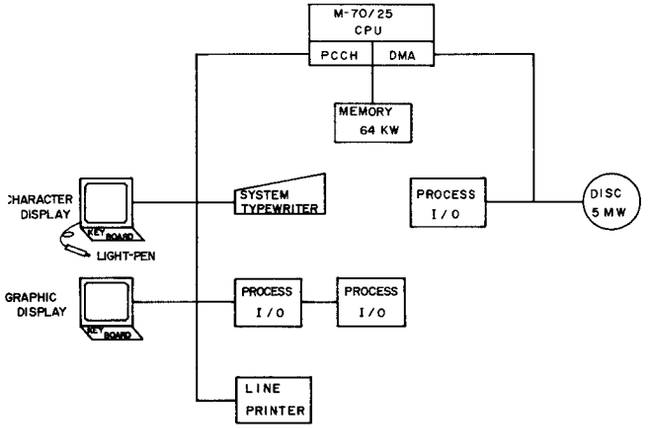

Fig.2 Constitution of the MELCOM-70 system

The control of ON/OFF, UP/DOWN and switching of polarity is performed. Beam profile data are taken through DMA synchronizing to the beam injection and are shown on a graphic terminal. Fig. 3 shows beam profiles on a graphic display. The beam line tuning is made by watching the screen and controlling the magnet power supplies.

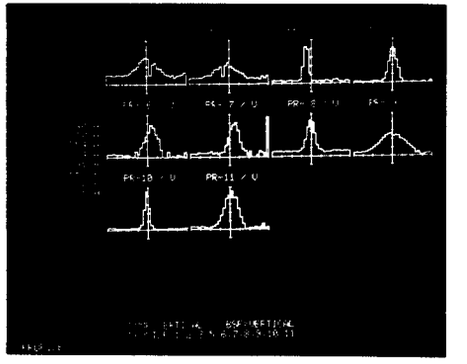

Fig.3 Beam profiles along the BSF beam line in a vertical direction. Each horizontal step corresponds to 2.5 mm in width. Beam profiles in a horizontal direction are the similar ones.

Beam current monitor output is fed into a sample/hold module and integrated with an ADC and counter module. The M-70 takes these integrated values by an external synchronizing signal and displays on the character terminal or the control desk in units of protons per pulse or counts per second.

Any other informations on the beam channel, experimental facilities and the safety status are gathered and displayed on the character terminal. Surveillance program checks these data. When it finds an incorrect status or a value out of tolerance, an alarm bit is generated. According to the alarm bit, the character on the screen which shows the item concerned changes its color so as to inform an operator of the accident. The alarm message is also printed out on a system typewriter for recording. Operation, access and contamination records are accumulated in a disc file of the M-70 and these data can be always read out and printed out in an arranged form.

5. Television System

Closed-circuit television CCTV is required for the purpose of surveillance of the access points, the beam channel and experimental areas especially around the neutron and the meson target. Video signals are connected to a multiplexer and displayed on the access and control consoles. Video informations on the BSF operation and the beam delivery mode are transmitted to the CCR. The signal is modulated and distributed anywhere in KEK by means of cable television (CATV) system. It is scheduled to transmit the beam profile data together with the informations described above.

6. Access Control System

Beam lines, a cable pit, experimental areas and a transfer tunnel are all controlled areas for radiation safety. Access to these areas is restricted and it depends upon the BSF operation mode which is selected at the control desk. According to each mode, access to the following areas is possible.

(1) NORMAL : neutron scattering experimental area and meson experimental area

(2) DUMP : all areas except for a primary beam line

(3) MAIN RING INJECTION : all areas

All doors of these controlled areas are electrically locked. One who wants to open the door has to, for the first time, contact the control room by means of an interphone placed inside/outside the door. On condition that the door is allowed to be opened, the power of the door control panel placed inside/outside the door can be switched on from the control room. The electric lock is released by performing a key operation on the door control panel. Entering or leaving is made under TV surveillance from the control room. For the access to the primary beam line, it is necessary to use a particular key which is reserved on a personal keyboard. When these kies are removed from the keyboard it becomes impossible to turn on the beam switch and the relevant magnet power supplies such as PB-1 and B-2. Removing or replacing the key is recorded by the M-70 as the personnel entering or leaving the primary beam line.

7. Gate Monitor

The radioactive contamination of whole human body surface

and equipments is checked by a gate monitor which is located at the entry gate to the primary beam line. Gas flow counters (helium + isobutane) and NaI scintillation counters are used for checking human body surface and equipments respectively. A detection sensitivity for body surface is within 7×10^{-6} $\mu Ci/cm^2$ calibrated by U_3O_8 β-ray and for equipments within 10 nCi calibrated by C_s γ-ray. If the contamination is found at either some portions of body surface or equipments, the personnel can not pass through the gate. In the case it is required to cool down the radioactivity of the equipments in the beam line tunnel and/or to clean the body surface. The contamination data are recorded by both the M-70 and a recorder provided for the gate monitor.

This work is made by the collaboration with the staff in the KEK accelerator department, the BSF and the radiation and safety control division with outside help.