JAERI-Research
98-001

DEVELOPMENT OF INTEGRATED CONTAINMENT AND SURVEILLANCE SYSTEM FOR FAST CRITICAL FACILITY FCA
-PORTAL AND PENETRATION MONITORS-

January 1998

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編集兼発行　日本原子力研究所
印　　刷　㈱原子力資料サービス

Development of Integrated Containment and Surveillance System for Fast Critical Facility FCA - Portal and Penetration Monitors -

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(Received January 5, 1998)

Manpower and radiation exposure problems, accompanied by frequent Non Destructive Assay (NDA) based inspections at the Fast Critical Facility FCA of Japan Atomic Energy Research institute (JAERI), are a burden for both the inspectorates and the facility operator. In the hope of alleviating these burdens, the development of containment and surveillance measures for the FCA was initiated in 1979.

The integrated containment and surveillance system consists of a portal monitor and a penetration monitor. The reactor building provides an ideal containment measure because of its explosion-proof, airtight structure and limited number of penetrations. The function of the portal monitor is to detect undeclared removal of nuclear material from the reactor building through the doorway. The penetration monitor is designed for surveillance of diversion routes through containment boundaries, and of safeguards related activities for bypassing the portal monitor.

The combination of monitoring by the penetration monitor of containment boundaries and all their penetrations except for the doorway, and monitoring by the portal monitor, provides complete coverage of realistic diversion routes.

The development of the system was completed in 1988 and the field trial test was conducted for the period of twelve running months. The final report on the field trial was

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concluded on January 1990. The major conclusion of the report was that the system is effective, reliable and efficient.

Following this successful conclusion, the International Atomic Energy Agency (IAEA) accepted the system for meeting its safeguards goals at the FCA on condition that an independent IAEA authentication equipment is provided.

The development of the authentication equipment is accomplished as an separate Japan Support Programme for Agency Safeguards (JASPAS) task.

Keywords : FCA, Fast Critical Facility, Containment, Surveillance, C/S, C/S System, Portal Monitor, Penetration Monitor, Inspection, Safeguards

高速炉臨界実験施設の封じ込め・監視装置の開発
― ポータル・モニター と ペネトレーション・モニター ―

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(1998年 1月 5日受理)

日本原子力研究所の高速炉臨界実験施設 FCA は、保障措置上非常に機微な金属ウランや金属プルトニウムを保有する。このため、高頻度で直接検認する査察を実施しているが、国際原子力機関(IAEA)及び国(科学技術庁)と施設の3者に大きな負担となっている。
査察に係わるマンパワーと被爆の増加及び実験に対する制約を、効果的・効率的に軽減する事を目的として1979年に本システムの開発を開始した。

本システムは、ポータル・モニターとペネトレーション・モニターの互いに補完する二つのモニターで構成されている。システムの開発は1988年に完了し、引き続いて12ケ月の現地認証試験を実施した。
1990年1月のIAEA 最終報告書は、保障措置上の目標基準を達成する査察機器として受諾した。
但し、データ真正性の担保手段を条件とした。

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1. Introduction

Because of the amount and quality of its nuclear material, the Fast Critical Facility FCA of Japan Atomic Energy Research Institute (JAERI) is considered to be among the most sensitive of facilities from the safeguards viewpoint. Thus, inspection activities are quite frequent. Manpower and radiation exposure problems, accompanied by frequent Non Destructive Assay (NDA) based inspections, are a burden for both the inspectorates and the facility operator. In the hope of alleviating these burdens, the development of the integrated Containment and Surveillance(C/S) measures for the FCA was initiated in 1979.

This document describes the C/S system, the field trial test and the inspection procedures for the C/S system for meeting part of the International Atomic Energy Agency (IAEA) safeguards goals at FCA.

2. Concept of C/S Application to the FCA

A great part of the nuclear material in the FCA Facility is located inside the reactor containment building. The rest of the material is outside the reactor containment building under IAEA and State seals. The main effort of the IAEA inspection is directed towards the verification of the inventory of non-sealed material inside the reactor containment building using NDA techniques.

The reactor building provides an ideal containment measure because of its explosion-proof, airtight structure and the limited number of penetrations, most of which are seldom opened. Only the personal doorway is frequently used. Therefore, the combination of monitoring by penetration monitor of containment boundaries and all their penetrations except for the doorway, and monitoring by portal monitor, provides complete coverage of all realistic diversion routes. The assurance that the integrity of the containment itself remains unimpaired is provided by reviewing the operation record of the monitor.

The C/S System is designed to replace the monthly NDA measurements on fuel in the Reactor Room which are required to achieve the timeliness goal.

The C/S System at FCA consists of the following sub-systems:

1. The Portal Monitor (P/M) System.
2. The Penetration Monitor (PN/M) System.
3. IAEA and STA seals.
4. An Authentication System for the P/M and PN/M Systems.

The P/M and PN/M Systems are Operator-designed and manufactured and are the first fully automatic, unattended, operator-provided systems for routine use. The Authentication System was therefore designed to provide the IAEA with independent and reliable means of authenticating the data and records produced by the P/M and the PN/M Systems.

The function of each of the four sub-systems of the C/S System at FCA is as follows:

P/M

The P/M System is designed to detect the unauthorized passage of metallic fuel plates out of the Reactor Containment Building to the working area via the normal access route.

PN/M

The PN/M System is designed to detect an attempt to remove fuel from the Reactor Containment Building either by routes other than those used for normal access, or alternately in a form other than metallic.

Seals

The IAEA and Japan Nuclear Safety Bureau (JNSB) seals are used to supplement the P/M and PN/M Systems such that certain existing penetrations (relatively less difficult diversion paths) under surveillance by the system are redundantly covered (e.g. Fuel Transfer Tubes, Emergency Exit). Seals are also used to ensure the integrity of the P/M and PN/M and Authentication Systems equipment, by sealing their electronic enclosures.

Note: A list of all the seals and their location is given as an Appendix. No further description of the seals which constitute part of the FCA C/S System will be given in this document.

Authentication

The Authentication System is designed to check and authenticate randomly the proper functioning of the sensors, the data transmission and the records of the P/M and PN/M Systems.

Details of the safeguards approach for FCA when using the P/M and PN/M Systems are given in document STR-175.

The overall concept of the C/S System at FCA is shown in Fig.1. The boundary of the C/S System is the boundary of the outer containment building and includes the P/M which provides the normal operator access to and from the building.

3. The Portal Monitor System (P/M)

It can be seen from Fig. 1 that the P/M, complete with integral Metal Detector (MD1), Space Sensors (SS1 to SS16), Beam Sensors (SB1 to SB6) and Video Cameras (TVC1, TVC2, TVC3), is located at the normal exit from the Reactor Room Containment. More details on the location of these various devices within the Portal Monitor are given in Fig. 2 and Fig. 3.

The Portal Monitor, shown in Fig. 4, provides the normal access to and from the reactor area in a manner that is not intrusive to free passage, while, at the same time, providing assurance that metallic fuel is not taken out from the reactor.

An emergency door for moving bulky equipment in and out of the reactor is provided as part of the P/M. Because this door by-passes the metal detector it is normally locked when the P/M is in service and its opening and closing is automatically monitored by the P/M System. Any opening of the emergency door and passage of personnel in a direction out of the reactor area when the P/M System is in service is considered a major anomaly.

In addition to the P/M metal detector (MD1) two metal detectors are provided (MD2 and MD3) which are for 'Operator use only'. These allow the Operator to ensure that they are 'clean' of metal prior to passing through the P/M metal detector thus avoiding unnecessary 'metal detected' alarms and potential major anomalies.

In addition to the various field sensors whose function is explained in 3.2, the P/M has the following additional tamper resistant features:

1. It is lined with a type of paper that if damaged by a newly made penetration is very difficult to repair without leaving traces of the penetration.

2. Most of the conduits and cables associated with the P/M installation are within view of the P/M video cameras.

3.1 P/M System Equipment Location

The sketch in Fig. 5 gives the general layout of the equipment for orientation.

As shown in Fig. 3 the P/M Metal Detector (MD1), Beam Sensors SB1 to SB6, Space Sensors SS1 to SS16 are located either in or above the P/M. Three Video Cameras, TVC1, TVC2 and TVC3 are also located at the P/M.

TVC1 views the MD1 entrance on the fuel handling side, while TVC2 views the MD1 entrance on the reactor side. Video Sensors VS1 and VS2 are associated with these two cameras.

A third camera, TVC3, is not used for recording, but provides the video signal for Video Sensor VS3 used in the logic to determine portal occupancy and direction of travel. None of the three video sensors are physically located in the P/M but because they provide contact actuations associated with sensing passage through the P/M they are shown in Fig. 3.

A sealed Junction Box (JB) is provided on the interior side of the metal detector housing for connections to the metal detector coils. A photo of the interior of the JB with cover removed is shown in Fig. 6.

A second sealed box, the Junction Unit (J.U.) is provided for:

1. Housing the metal detector amplifiers.
2. Terminating the field located P/M sensors, video wiring and other field wiring associated with receipt of signals from the computer.
3. Housing the data multiplexing and transmission equipment associated with converting the parallel field sensor data to a serial bit stream and transmitting to and from the central computer(C.P.U).

Fig. 7 shows the Junction Unit with its cover off.

The control and recording equipment associated with the P/M is located in the Safeguards Laboratory (SGL) of the FCA Facility. A front view of this equipment is shown in Fig. 8.

3.2 Detailed P/M System Description

For an overview refer to Figs. 3 and 9.

The basic function of the P/M System is to detect the undeclared removal of nuclear material (in metallic form) from the reactor building through the normal exit. To accomplish this the following features are provided:

1. A walk-through metal detector (MD1) for detecting metallic nuclear fuel.
2. Tamper indicating sensors to detect attempts to make new penetrations in the portal, or tamper with the video cameras or other system enclosures.
3. A video surveillance system to provide video confirmation of computer recorded events.
4. Hard copy recording of all significant digital and video events and anomalies under control of a centralized computer and video recording system.
5. A colour display system that facilitates review of system events and anomalies at the end of the inspection interval.

The basic functioning of the system is illustrated in Fig. 9.

Space Sensors

The Space Sensors (SS1 to SS16)mounted in the field are used to sense such activities as approaching too close to the walls, ceilings attic area or Emergency Door of the P/M.

Beam Switch Sensors

The beam switch sensors are used to detect the entrance and progress of persons in the P/M. They enable the software to determine such events as 'Multiple Occupancy' 'Timeover', 'Direction of Travel', etc. (see the Section on the CPU for the definition of these terms).

Metal Detector

The metal detector is the main item of the system and is designed to detect the passage of a single 2"x2"x1/16" fuel plate (or larger) in any orientation and at any grid location through the P/M.

Emergency Door Interlock

The Emergency Door Interlock (EMD) indicates when the emergency door is open, thus giving warning that the metal detector may be by-passed.

All of the above sensors are in the region of the portal monitor. Their associated relay contacts are connected individually to terminal blocks in the junction unit.

Data Transmission Equipment

The junction unit contains data transmission equipment including a converter for changing the parallel input field sensor relay contacts to a serial encoded bit stream, and a multiplex transmitter for sending the bit stream via a single fiber optic cable to the centrally located CPU.

The fiber optic cable by its nature provides a significant degree to tamper resistance.

The serial bit stream is converted back to parallel form by similar centrally located data transmission equipment at the Control Unit in the Safeguards Technology Laboratory (SGL), and read in parallel into the CPU via the I/O bus.

Central processing Unit (CPU)

The computer controlling the system is a PC/NEC 9801. The computer hard ware includes two 3.5" diskette drives, a display, a printer and an I/O interface. The CPU, through the interactive software, controls the P/M system hardware, provides Restart, Shut Down and Review Procedures and guides the operator through step-by-step instruction on the CRT.

The CPU collects and stores all data formatted for convenient retrieval and review.

The data is stored on:

1. Diskettes - Two Redundant 3.5" Diskettes
2. Random Access Memory (RAM)

The Diskettes contain all data collected during the inspection interval and each acts as a full back-up to the other.

The RAM provides full back-up to both diskettes.

The CPU can provide a print-out on request of all significant events that occur during the unattended inspection interval, for inspector review on his arrival. The inspector can also specify the type of print-out.

Normally the post inspection review is done on site using the diskettes.

The CPU software also provides an extensive selection of interactive visual displays on the colour CRT to aid the inspector in review, reporting of results, and system start-up and shut-down.

The software in the CPU also uses inputs from beam sensors SB1 to SB6 to detect the following:

1. Multiple Occupancy - more than one person simultaneously in the P/M (considered a possible indicator of certain diversion scenarios that require the presence of more than one person in the P/M at one time for their execution).

2. Timeover - too long a transit time through the P/M, or too long a time in a particular zone of the P/M. [Timeover is considered a possible attempt to take advantage of the Metal Detectors known insensitivity at low transit speeds. It is also an indicator that someone may be lingering in the P/M to make penetrations that would bypass the metal detector].

3. Direction A - travel into reactor area or

   Direction B - travel out of reactor area.

4. Return - an entrance into the P/M from either direction followed by a return to the starting point.

5. Monitoring of its own 'state of health' and logging of any "Troubles" or "Major Troubles" so discovered.

The CPU software also controls the following video recording functions:

1. Initiation of video recording on each significant event (e.g. on the activation of any sensor, emergency door interlock, etc.).

2. Initiation of random video recording in accordance with the inspector-set "average" random period.

3. Annotation of the video record with date, time, and the event that initiated the video recording.

4. Recording and annotating as in 3. of video line tamper and camera tamper attempts as indicated by video sensors located at the Central Control Unit.

Video System

The Video System functions are to:

1. Record any activities in the P/M.

2. Confirm such software indicated events as "Multiple Occupancy", "Timeover", "Metal Detected with a person walking through the P/M in a direction out of the reactor area" (MD-B), "Metal detected with no one present in the portal" (a ghost indication)(MD-C), etc.

The Video System basically consists of three cameras, TVC1, TVC2, TVC3 with an associated recording system. The images from TVC1 and TVC2 are recorded on two recorders VTR1 and VTR2, respectively (see Fig. 3 for camera locations). An additional recorder, VTRO, has a split screen and records the images from both cameras, thus providing some degree of redundancy.

TVC3 is not used for recording, but rather looks at the same area of the P/M as is covered by Beam Switch Sensor SB5, and Video Sensor Signal VS3 is derived from this view. VS3 provides a back-up to the beam switch sensor SB5 in the logic used by the CPU to determine P/M occupancy and direction of travel.

Similar Video Sensors (VS1 and VS2) are associated with cameras TVC1 and TVC2 and provide back-up in the logic for SB3 AND SB4, respectively.

3.2.1 Metal Detector

The metal detector is designed to detect the passage, in any orientation, of single 2"x2"x1/16" (or larger) uranium and stainless steel clad plutonium fuel plates. Although some FCA fuel plates are smaller in size than 2"x2"x1/16" these are only a small portion of the inventory.

The metal detector is of the walk-through type and consists of pairs of horizontal and vertical transmitter-receiver coils (as illustrated in Fig. 10).

The transmitter coils produce a magnetic field which induces a voltage in the receiver coils. Any introduction of metal within the volume encompassed by the magnetic field changes both the magnitude and relative phase of the voltage induced in the receiver coils. Electronic circuitry detects these changes and produces a "metal detected" signal when appropriate.

The transmitter and receiver coils have been carefully positioned to detect a fuel plate no matter what its orientation is to the metal detector magnetic field. Fig. 12 shows a sensitivity map for a stainless steel plate transported through the P/M in three different orientations with respect to the vertical plane of the P/M entrance (see Fig. 11 for an illustration of the various orientations).

In addition to orientation the metal detectors' sensitivity depends upon speed of transport of the plates through the detector, as illustrated in Fig. 13.; Because of the low sensitivity at low transfer speeds it is possible for a person walking slowly to take metal through without causing a metal detected signal. To counteract this potential diversion strategy the system software, using beam switches SB1 to SB6 as inputs, measures the time taken to pass through the various zones of the P/M. A time greater than six seconds in the metal detector portion (Zone 2) is logged by the computer as a "Timeover Zone 2" anomaly, which requires inspector follow-up (see Follow-up Procedures of Inspectorates).

Because of the relatively low metal detector sensitivity at high transport speeds, still other diversion scenarios become possible. One of these - throw - through of fuel plates from a person at the entrance to the metal detector to a second person at the exit - is countered again by the software. In such a case the software (using SB1 to SB6 and VS1 to VS3 as inputs) declares "multiple occupancy", which requires inspector follow-up.

A second "high transport speed" scenario - fast transfer of metal fuel coupons from a trailing hand to a leading hand by a single subject walking through the metal detector has been countered by the incorporation of a fast response amplifier.

It should be noted that, although the metal detector sensitivity shown in Fig. 12 and Fig. 13 has been generated using stainless steel test plates, tests with real U and Pu fuel plates have shown that their response is quite similar to stainless steel.

It should be further noted, that the metal detector is insensitive to U or Pu in oxide form or dissolved in solution. One of the functions of the Penetration Monitor System described later and in Reference (3) to record any activities that could be related to the conversion of metallic fuel to oxide or liquid form.

Metal Detector Self-Test

The metal detector is provided with a self-test circuit, which, when energized, unbalances the transmitter coils and thus effectively checks out the working state of the entire metal detector system.

The P/M software initiates this test during every system start-up. The normal result of the test is activation of the metal detector amplifier relays MD1A and MD1B, and logging by the CPU of their contact actuation. Failure of the test to do this is an indication of a faulty metal detector and is logged as "Trouble Metal Detector".

This same self-test circuit is also used by the IAEA Authentication System.

Any loss of AC power to the metal detector is also detected and logged by the P/M CPU.

3.2.2 Space Sensors

The Space Sensors (SS1 to SS16) are of two types, wide angle sensors Pulnix model PA-4010X, and vertical plane sensors PA-4030E, and are passive devices which are based on an infrared sensitive diode. Infrared radiation emitted by humans can be used to detect their presence in the P/M. Infrared radiation emitted in the volume covered by a particular space sensor impinges on the reflector of the space sensor, and is reflected onto an infrared sensitive diode. The resulting diode signal is amplified and operates the relay within the sensor enclosure and the ensuing relay contact closure is read by the computer.

The area of coverage of a particular sensor is adjustable and a red light comes on when infrared is detected.

Typical coverage capabilities are shown in Fig. 14.

3.2.3 Beam Sensors

The Beam Sensors, SB1 to SB6 are of two different types. Both SB1 and SB6 are Pulnix Model PH-50B and consist of a photo-electric transmitter and oppositely mounted receiver. Breaking of the photo-electric beam results in actuation of a relay in the receiver, and the resultant contact change-of-state is recorded by the P/M computer. The beam sensors for SB2 to SB5 are Pulnix model PR-10B and consist of an infrared transmitter-receiver and an oppositely placed reflector, that reflects the transmitted infrared back to the receiver, as long as the transmitting path is not blocked by persons or objects.

The basic function of the beam switches is to detect the presence and passage of persons through the P/M. They are installed redundantly (e.g. two SB1s, etc.) in the P/M at the locations shown in Fig. 3. SB3, SB4 and SB6, in addition, are backed up by Video Sensors VS1, VS2 and VS3, respectively.

The logic in which the beam switches and video sensors are used to determine such events as Dir.A, Dir.B, Return, Timeover, and Multiple Occupancy is given in the Time Chart and Sequential Logic in the Appendixes.

3.2.4 Surveillance

The scene inside the P/M is recorded on video tapes by means of closed circuit television. Recording is triggered by the passage of personnel, as indicated by the beam or video sensors, or at mean time intervals on a random basis as set by the inspector.

The Video System consists of three TV cameras Sony Model AVC-1150D, with associated recording system (see Fig. 3 and Fig. 15). The images from TVC1 and TVC2 are recorded on the two recorders VTR1 and VTR2 (Sony Model EVT-801/2), respectively. The third recorder, VTRO (the same model as the other two), records the images from both cameras on a split screen, providing some degree of redundancy.

The third camera, TVC3, is not used for recording, but rather provides a back-up to the Beam Switch Sensor, SB5, through the Video Sensor VS3. The Video Sensors VS1 and VS2 are associated with Cameras TVC1 and TVC2 and provide back-up in the logic for SB3 and SB4 to determine direction of travel, timeover, multiple occupancy, etc.

High resolution and high sensitivity TV cameras and time-lapse VTRs are used. The VTRs can be started instantaneously by the trigger signals without any loss of picture. The images are time and date annotated, and a code denoting the activation event is superimposed on the TV screen. A list of all code designations is provided in the Appendixes.

3.2.5 Data Transmission and Junction Unit

The data from the metal detector coils is received by the amplifiers in the small Junction Box (JB) directly adjacent to MD1. This JB is secured with an IAEA seal. The MD data together with the signals from the beam sensors and the space sensors are further transmitted to the Junction Unit where they are received in the metal detector amplifiers and the sensor terminal, respectively. This JU is also secured with an IAEA seal. A Converter and data multiplexing and transmission equipment convert the parallel data to a serial bit stream. This is then transmitted through a fiber optic link to the Control Unit. This technique of data transmission offers a certain degree of tamper resistance. The video signals from the CCTV units are transmitted directly to the control unit. Authentication of the video signals will be introduced as part of the IAEA overall video authentication programme.

3.2.6 The P/M Control Unit

The Control/Recording Unit (CU) of the P/M is shown in Fig. 8. The configuration of the various components in the Control Unit are shown in Fig. 16.

The entire P/M System is controlled by the computer in this unit. The computer hardware consists of the CPU, a hard disk, 2 floppy disk drives, a printer, a CRT display, an I/O interface, and a power supply.

The special interactive software (written in "C" language) contains all the instructions in screen formats necessary for controlling the system and for the Restart and

Review Procedures. The inspector reads the instructions on the CRT for every step of the operation. These will be described in detail in the section “6. The Inspection Procedures for the C/S System”.

The CPU formats and stores the data for inspector retrieval and review on two redundant diskettes and on the Random Access Memory. These act as back-ups to one another.

The CPU can also provide a print-out of all significant events that occur during the unattended interval period for inspector review on his arrival. The software also uses the inputs from the various sensors to detect multiple occupancy, direction of travel, timeover, return and 'state of health' of the system as described earlier.

4. The Penetration Monitor (PN/M) System

The PN/M System is designed to detect any attempt at removing nuclear material from the reactor area by any route other than the normal route of carrying metallic plates through the exit. The PN/M System therefore complements the P/M System by guarding against potential attempts at removing nuclear material through an unusual route or manner. The system is designed to counter all potential removal scenarios such as tampering with the containment, dissolution of plates, removal through the Emergency Hatch, the Fuel Transfer Tube or the conduits.

The entire C/S System and the role of the PN/M are shown in Fig. 1, Fig. 5 and Fig. 17. The measures chosen for safeguarding the potential penetrations or fuel conversion are a collection of motion-detection sensors coupled with CCTV surveillance cameras and seals. The layout of this system of measures is shown in Fig. 17. The layout is designed so that the collection of motion detectors cover the entire inner and outer building providing an indication of the presence of personnel. This in turn triggers the appropriate video tape recorder (VTR) providing surveillance for safeguards related activities to be reviewed by the inspector. Any attempt at tampering with the sensors or with the TV cameras will be recorded on the VTR. All penetrations through the reactor containment building wall are in addition secured by seals.

The PN/M consists of two systems, namely System A, which covers the reactor room inside the inner building, and System B, which covers the outer building up to the containment wall. Within each of these areas the closed circuit TV surveillance system enables the inspector, upon review, to follow the movements and activities of personnel from one section to another within the building.

The major characteristics of the PN/M System are described below.

4.1 PN/M System Equipment Location

Fig. 5 and Fig. 17 show the location of the various components of the PN/M System within the FCA Facility. These include the motion detectors, TV cameras and seals in Area A and Area B, the Junction Unit (JU) in the ground floor of Area B and the Control Unit (CU) located in the Safeguards Technology Laboratory (SGL) of the FCA facility.

As shown in Fig. 17, four TV cameras (C1I, C2I, C3I, C4I) with their associated motion detection sensors (S1I, S2I, S3I, S4I) are located in the four corners of the inner reactor-room. Additional sensors (S1IA, S1IB, S2IA, S3IA, S4IA) are further distributed along the wall to provide complete coverage of the inner reactor-room. Area B is covered with eight TV cameras and thirteen sensors. Five cameras with eight sensors (C10 with S10+10A, C20 with S20+S20A, C30 with S30, C40 with S40+S40A and C50 with S50+S50A). Three additional cameras with associated sensors cover the upper floor (C60 with S60, C70 with S70, and C80 with S80 and S80A). Seals are attached to the Junction Unit, the Fuel Transfer Tubes, the Emergency Hatch, the Ventilation Penetration, and the Control Unit.

The Junction Unit (JU) is located in the Outer Building. The data from the sensors are transmitted to this unit where data multiplexing equipment is used to receive and transmit the data via a fiber optic link to the Control Unit (CU).

The Control Unit which receives all the data from the sensors and the video cameras is located in the Safeguards Technology Laboratory next to the P/M Control Unit.

4.2 Detailed PN/M System Description

The function of the PN/M System is to detect any attempt at the undeclared removal of nuclear material in solution or in the form of an oxide through the P/M, or in metallic form through any other openings in the containment.

The sensors in association with the TV surveillance guards against any such potential activities required for dissolving or oxidizing the fuel coupons. In addition these also guard against any tamper activities for breaking through the containment. The seals secure against tamper with the data transmission equipment (in the JU) and removal through the various penetrations.

4.2.1 The Motion Detectors and the CCTV System

The schematic arrangement of the sensors and TV cameras, data transmission, signal recording and review are shown in Fig. 17, 18 and 19.

The sensors, cameras and VTRs are of the same type as those used in the P/M system. The video control switcher can handle up to four parallel video signal inputs and thus enables the recording of four video images on one VTR. In Area A the four cameras are fed into two

VTRs, only two images in each. This is done so because of the high activity in this area. For Area B four cameras are fed into each VTR since the activity in this area is limited. All TV systems are backed-up with a duplicate VTR providing partial redundancy. The data from 22 space sensors from Areas A and B are fed through multiple transmission equipment in the PN/M Junction Unit through a fiber optic cable to the Control Unit. This system is similar to the one used in the P/M system. The seal information is presently not transmitted to the Control Unit, since IAEA E-type metallic seals are being used. The provision is available to accept signals from electronic VACOSS-type seals, should these be used later.

4.2.2 The PN/M Control Unit

The Control Unit is shown in the photos in Figs. 20 and 21. In the photo in Fig. 20 the Control Unit cabinet is shown closed doors. Fig. 21 shows the inside of the Control Unit. The schematic diagram in Fig. 22 describes the component configuration.

The entire PN/M System is controlled by the computer in this unit. The computer hardware consists of the CPU, a hard disk, two redundant floppy disk drives, a printer, a CRT display, and I/O interface, and a power supply.

The special interactive software (written in "C" language) contains all the instructions in screen formats necessary for controlling the system and for the Restart and Review Procedures. The inspector reads the instructions on the CRT for every step of the operation. These will be described in detail in the section “6. The Inspection Procedures for the C/S System”.

In the review of the data the inspector must review the sensor alarms and the video recordings for any unusual activities in the building. These are described in the section “6. The Inspection Procedures for the C/S System”.

5. The Field Trial Test

5.1 History of the field trial

It was agreed at the outset that the Field Trial would extend over a period of 12 "running-months".

Because of the nature of the FCA experimental programme during the period of the field trial frequent core changes were required, with associated reactor shutdowns. Consequently, it took considerably more calendar-months to accumulate the required running-months experience than originally planned, and this experience ended up being attained in three phases.

The first phase, during which "4 running-months" was accumulated, extended over the calendar period Sept. '86 to May '87. During this period, in addition to gathering data and analyzing performance, a number of potential system defeat scenarios were attempted. The results from this first phase were reported in detail in Reference (5), along with suggestions for improvements. The overall conclusion was that "despite the problems detailed in this report, none has been uncovered so far that is not correctable by appropriate design or administrative effort".

Many of the recommended improvements resulting form operation during the first phase were made prior to the start of the second phase. These included:

1. Addition of an Uninterruptable Power Supply to prevent "major anomalies" caused by monthly diesel generator testing.

2. Modification of software to indicate "Metal Detected in Direction into Reactor" to eliminate the success of the system defeat scenarios described on figures 2 and 3 of Reference (7).

The second phase of the field trial started in July '87 and it was originally intended to mark the end of the field trial in October 1988, at which time the requisite 12 “running -months” operation would have been accumulated.

However, major problems arose with the 10 year old P/M metal detector in

May-June 1988 and a decision was made to terminate this second phase in June 1988. This phase of the trial resulted in "6 running-months" operation, extending over the calendar period July '87 to June '88.

It was decided, due to the promising performance in the first phase, to extend the field trial for a last 6 running-months period, after the metal detector had been rebuilt and retested, and base any final recommendations primarily on the outcome of this last phase (Reference (7)). It was further decided, that during this final 6 running-months, priority would be given to running the systems continuously, rather than with the shutdowns that marked the first two phases.

Consequently, the systems were restart in December '88 and ran almost continuously until mid June '89 at which time the target 6 running months had been accumulated.

5.2 The results of the field trial

The results is presented in Appendixes as the copy of the executive summary of final report on the field trial written by L. Watkins and E. Yellin of IAEA, SGDE.

5.3 The IAEA conclusion on the FCA C/S system based on the field trial.

The major conclusion of the report was that the system is effective, reliable and efficient.

Following this successful conclusion, IAEA accepted the system for meeting its safeguards goals at the FCA on condition that an independent IAEA authentication equipment is provided.

The attached in Appendixes is the copy of the letter from J. Jennekens, DDG-SG of IAEA, to J. Shibata of JNSB concerning the IAEA judgment for the FCA C/S system.

6. The Inspection Procedures for the C/S System

6.1 Inspection Procedures for the P/M System

#1 SYSTEM TAMPER AND FUNCTION CHECK

Upon each servicing of the P/M visual checks, seals check, sensor check and metal detector test should be carried out. The space sensor check and metal detector test shall be performed just after the P/M system has been started up for a new period.

#1.1 VISUAL CHECK

Examine visually the Portal Monitor area, sensors, cameras, detectors, cabinets for any evidence of tampering particularly:

at Fuel Handling area;

- Junction Unit (JU)
-Junction Box (JB)
-Emergency Exit Door (EMD)

-Video sensors zone at SGL Laboratory Room;

-Control unit (CU)

#1.2 SEAL CHECKS

Using Seals Listing check seal numbers and examine visually seals and the seal wires for any evidence of tampering. During Ordinary Extended inspection also replacement of 20% of seals chosen randomly.

Location of the seals and detection devices is presented in Appendixes.

#1.3 SENSOR CHECK

Space and beam sensors are used to detect the entrance and progress of people in portal monitor area. Video sensors are used to trigger TV recording.

Checking should be done before starting up the Portal Monitor for a new C/S period as follows:

Inspector unaccompanied by JAERI Staff should proceed through Portal Monitor into zone 3 and return along the same route, observing the sensor triggering lights when approaching sensors SS1 to SS16 and SB1 to SB6. When passing in front of the TV cameras he should look at it for later identification on the TV recording.

#1.4 METAL DETECTOR TEST

The metal detector is designed to detect the passage of a single 2"x2"x1/16" fuel plate in any orientation and grid location through the Metal Detector. Perform test as follows:

Carrying a metal test plate, proceed through metal detector into zone 3, then return along the same route.

Later check the computer records. In case of failure or anomaly proceed with the Follow up action (see Follow-up Procedures of Inspectorates).

#2 P/M DATA RETRIEVAL AND SYSTEM RESTART

#2.1 Remove the seals on the front P/M cabinet doors and record the seals number.

#2.2 Open the doors.

#2.3 Turn on CRT switch.

#2.4 Pull out keyboard and printer.

#2.5 Press GRAPHIC and view system status on arrival. Then press EVENT COUNT key and print by pressing COPY button on the keyboard. Particularly look for any indication of "emergency door open, Metal Detected or Major Trouble".

Note: If detailed review confirms these events the probable conclusion is "C/S Inconclusive", so detailed review of the PN/M records may not be necessary.

Follow instructions appearing on the screen.

#2.6 Turn on the TV monitor and confirm all cameras working.

#2.7 Press "END" key on keyboard to enter review mode. "Data now in Process of Printing" appears on the screen. Automatic print-out of "Anomaly Event", "Total Events by Day", and "Anomaly List" takes place.

IMPORTANT: System is now dead. Monitor can be used for visual surveillance.

#2.8 As instructed on the screen collect VTR tapes, printouts, video cassettes and the data floppy diskettes (step 323).

Note: Be sure to label all items with date, time and name, inspection number.

#2.9 Press RETURN key, then END. Check date and time when date and time display appears.

#2.10 Update date and time if necessary. Follow screen instructions (step 201).

Note: Normally P/M is serviced first. The PN/M time is set to the time indicated by P/M system.

#2.11 Before proceeding be sure that you have at least three 8mm video tapes and two properly formatted diskettes (3.5") that will be accepted by the system. (Diskettes may be formatted on the CPU in the UTILITY MODE option).

#2.12 Label all items with the IN date time, your name and inspection number. Follow screen instructions (step 203);

VTRs: Install new tapes, reset counters, check VTRs in alarm mode,
Printer: Load printer paper if needed, check printer "ON LINE",
CPU: Load new floppy discs in drivers 1 and 2.

#2.13 After completing all instructions, press RETURN key.
SYSTEM STATUS CHECK appears on the screen (step 205).

Note: If the sensors are working, the message "Under Check" changes to "OK" and the status is printed out. If "Trouble" shows during step 205 press RETURN key. Step 206 then appears on the screen and gives details on what the trouble is, and the troubles are printed out. Have JAERI clear up all "Troubles" before proceeding.

#2.14 Press RETURN key.

Note: System sensor status is then printed out. Step 207 appears on the screen for updating VTR random time. Customary VTR random period is 60 min. "Set-up Messages" appears (Step 209).

#2.15 Input set up date, inspectors name(s) and relevant message then press RETURN.

Note: "NOW ALL VTRS UNDER CHECK" appears on the screen (step 211). VTRs OK "All VTR are recording Mode". (If not OK follow instructions on cleaning up "Troubles" that would appear on the screen (step 212)).

#2.16 Press RETURN.

Note: Set-up data is now being recorded on all video tape recorders (Step 214). This takes 150 seconds. Use this time to label any tapes or floppies not labelled in step #2.12 if needed, "Summary of Set up Parameters" will be printed at end of this period (Step 215).

#2.17 Check that the VTRs are operating i.e. that VTR counters are moving from zero.

Note: The "REC" and "ALARM" lights should be on. When all the set-up data has been recorded set-up is then printed out. (If some equipment is not OK, contact JAERI).

#2.18 Press END key to proceed to monitoring process for next C/S period. (RUN MODE).

IMPORTANT !! "P/M RUN MODE" flashing on the screen is a confirmation that the P/M has started its monitoring for a new period.

#2.19 Press GRAPHIC key.

The display on the screen should be free of all "Trouble" or "Tamper" indications except for those door switches associated with any control cabinet door that is not yet closed.

WARNING !! It is possible to start up the system with "Troubles" existing that could render the system inoperative (e.g. "Power Trouble Interface", "Data transmitter Receive Trouble", etc.

ALWAYS CHECK THE GRAPHIC DISPLAY BEFORE SEALING.

#2.20 Make sure that the paper for the printer has been folded properly at the bottom tray. If not, take the printer off-line, press Form Feed, then put the printer back on-line.

#2.21 Just prior to seal-up perform the sensor check and the metal detector test (#1.3 to #1.4). When passing TV cameras, look at them for identification later.

#2.22 Having completed the tests, press EVENT COUNT. Compare recorded events with actual test.

#2.23 Seal-up cabinet doors.

#3 PORTAL MONITOR DATA REVIEW

Normally the initial review of the collected data is done at site using retrieved data diskettes and video tapes.

Note: If for any reason the writing of data onto diskettes has failed, the data in the CPU memory can be transferred to a diskette following procedure #4 below.

#3.1 If review shall be made using P/M CPU which is engaged in run mode press END to exit run mode.

#3.2 Load diskette to be reviewed into upper drive of the CPU.

#3.3 Press RESET on CPU front panel.

Black and white system messages will appear on the screen followed by menu display (Step 401, 402). A printout of " Events" will occur (Step 450).

#3.4 Select REVIEW MODE when menu appears. Follow instructions on the screen.

Look at the anomalies and confirm that the printout from step 450 is completed.

If not, call for a printout as per screen instructions.

#3.5 Select printouts "Total Events by Day" or "Daily Events" from menu to supplement data from "Anomaly Events" as necessary for conclusive comparison. “Exit Review Mode".

#3.6 At the end of your review, select "Return to Daily Events Menu", then "Return to Review Menu" and finally "Exit Review Mode".

Note: Failure to do so will prevent the data memory from being further used in run mode until "Exit Review Mode" is formally performed. When you “Exit” step 899 appears on screen.

#3.7 Press END key to finish and no continued review is desired.

#3.8 "End of Review Mode" appears on the screen. The system is now in run mode.

Note: The data obtained during the previous inspection period is still in the memory. The new data will be successively added while the old data is erased.

#4 COPYING DATA FROM CPU MEMORY ONTO DATA DISKETTE

The data diskettes contain all data collected during the inspection period and each acts as a full back-up to the other. If the writing of data onto diskettes has failed, data stored in the CPU memory can be copied onto a diskette using the procedure below.

#4.1 Press RESET button on CPU 0f P/M. "Utility Mode Menu" appears on the screen.

#4.2 Select option "Salvage data from RAM" from the menu using appropriate cursor keys. Then follow instruction that appears on the screen to copy onto a loaded diskette. The copying process is quite slow.

#4.3 When coping is completed use procedures #3 (P/M) or (PN/M) to review the data on the diskette.

#5 REVIEW OF P/M DATA USING VIDEO TAPES

Video tapes are used to confirm software indicated events as;

- Multiple Occupancy
- Timeover
- Metal detected with a person walking through the Portal Monitor

#5.1 Insert video tape into the recorder on review station.

#5.2 Put the MODE switch on the bottom module into BYPASS position.

#5.3 Play tape and compare recorded scenes against results obtained from the review of corresponding data diskettes.

#5.4 Confirm indicated events.

#5.5 Complete working papers.

In case of any troubles carry out the activities of Follow-up(see Follow-up Procedures).

6.2. Inspection procedures for PN/M

#1 TAMPER AND FUNCTION CHECK

Upon each servicing of the PN/M visual checks, seals check and space sensor checks should be carried out as described below. The space sensor check shall be performed just after the PN/M system has been started up for a new period.

#1.1 VISUAL CHECK

Examine visually the Penetration Monitor area sensors, cameras, cabinets etc. for any evidence of tampering in particular:

in Containment Annulus area;

- Junction Unit (JU)
- Cameras
- Space Sensors
- Transfer Tubes

in Reactor Building;

- Space Sensors
- Cameras

in SGL Laboratory Room:

- Control Unit cabinets (CU)

#1.2 SEALS CHECKS

Examine visually seals and the seals wires for any evidence of tampering. Check selected seal numbers against seals list obtained from T.R.O. or HQ. during Ordinary Extended Inspections also replace 20% of IAEA seals randomly chosen.

Allocation of the seals and detection devices is presented in Appendixes.

#1.3 SPACE SENSOR CHECK

The space sensors are used to detect presence and movement of the people within the monitored area.

To check space sensors proceed through the reactor room and containment annulus observing sensor triggering lights when approaching the 9 sensors in the reactor room and 13 sensors in the annulus. Passing in front of a video cameras look at the camera for later identification. Later compare with the computer and video tapes records.

#2 PN/M DATA RETRIEVAL AND SYSTEM RESTART

#2.1 Remove the seals on the front PN/M cabinet doors and record seal number.

#2.2 Open doors, allocation of equipment is presented in Fig. 22.

#2.3 Turn on CRT switch.

#2.4 Pull out keyboard and printer.

#2.5 Before entering review mode press GRAPHIC and EVENT LOG and note if any "Trouble" exists on system status on arrival.

Note: Computer door switches (D1C, D3C) are actuated by step #2.2 and will be registered on the "Graphic" display. Then press EVENT COUNT followed by COPY.

#2.6 Turn on TV monitor and confirm all cameras working by setting video switcher switches 1 to 12 auto position.

Note: Views will change from one camera view to the next at a rate determined by the setting of the video switcher "Timer" knob.

#2.7 Press END key on keyboard to enter review mode.

IMPORTANT !! System is now dead and remains so until step #2.17. However monitor can be used for direct surveillance.

Note: On CRT screen appears "Data now in process of Printing" (step 321) and automatically printout of the data accumulated since the last scheduled Daily Report Print-out occurs. When printing stops step 323 appears on the screen.

#2.8 As instructed in step 323 collect VTR tapes, printouts, and the data floppy diskettes.

Note: Be sure to all items with the date, time, your name and inspections number.

#2.9 Record the video tape recorder numbers.

#2.10 Press RETURN key.

"Ending Stage of Run Mode" appears on the screen. (step 399).

#2.11 Press END key.

Follow screen instructions. (Step 101 immediately followed by step 201 appears on the screen).

#2.12 Update date time to agree with time previously set in to P/M system (step 203 appears on the screen).

Before proceeding be sure that you have eight 8mm video tapes and two formatted diskettes that will be accepted by the system. (Brand new diskettes may be formatted on the CPU in the UTILITY MODE option). All these items should be labeled with the IN date, time, your name, and inspection number. Follow screen instruction for VTR, Printer, Floppy.

#2.13 Follow screen instructions (step 203) when finished press RETURN key. (step 204 appears on the screen).

#2.14 Press RETURN key.

Note: "Please Wait" appears on the screen (step 204), then "System Sensors Under Status Check" (step 205).

If the sensors are working the message "Under check" changes to "OK" and the status is printed out. If "Trouble" shows during step 205 press RETURN key to get screen indication and printout of which equipment is faulty. Step 206 then appears on the screen and gives details on what the "Trouble" is and the troubles are printed out. Have JAERI clear up all "Troubles" before proceeding System Sensor status is then printed out. Step 207 appears on the screen for updating VTR random time and/or print out time. Customary VTR random period is 30 minutes. Follow screen instructions until (step 209) "Set Up Messages" appears on the screen.

#2.15 Input set up date, Inspectors name(s) and relevant message. "Now all VTRs are Under Check" appears on the screen (step 211). If VTRs "OK", "All" VTRs are Recording Mode" appears (step 213). If not "OK" follow instructions on cleaning up "Troubles" that appear on the screen (step 212). If VTRs "OK" press RETURN. (step 214 appears) Setup data is now being recorded on the video tape recorders in service. This takes approximately 270 sec.

#2.16 Check that correct VTRs are in service and that their VTR counters are moving from zero.

Note: The "Rec" and "Alarm" lights should be on. When all the set-up data has been recorded step 215 appears. If some equipment is not OK contact JAERI. Set up parameter data is then printed (step 216).

#2.17 Press END key to proceed to monitoring process for next period ("Run" mode). At this stage "Under Preparation for Run Mode" flashes on the screen (step 301).

IMPORTANT !! "PN/M Run Mode" flashing on the screen is a confirmation that the PN/M has started its monitoring for the new period.

#2.18 Press GRAPHIC key.

The display on the screen should be free of all "Trouble" or "Tamper" indications except for those door switches associated with any control cabinet door that is not yet closed.

WARNING !! It is possible to start the system up with "Troubles" existing that would render the system inoperative (e.g. Data Transmitter Receive Trouble, Power Trouble Interface, etc.).

ALWAYS CHECK GRAPHIC DISPLAY PRIOR TO SEALING !

#2.19 Make sure that the paper for the printer has been properly folded at bottom tray.

#2.20 Prior to seal-up perform the space sensor check.

#2.21 After space sensor check walk-through press GRAPHIC to ensure that system is trouble and tamper free.

#2.22 Press EVENT COUNT then COPY.

#2.23 Seal-up cabinet.

#3 PENETRATION MONITOR DATA REVIEW

Normally the initial review of collected data is done at site using retrieved data diskettes and video tapes.

Note: If for any reason the writing of data onto diskettes has failed, a diskette copy of the CPU memory can be prepared using procedure 6.1 #4 above.

#3.1 Load diskette with PN/M data to be reviewed into upper slot of simulator computer (CPU).

#3.2 Press RESET on CPU

Black and white system messages appear on the screen, (step 401, then 402). A print-out occurs of all anomalies and "Total Events by Day".

#3.3 Follow instruction on the screen. Look at the anomalies and confirm that the print-out from step #3.2 of this procedure is completed. If not, call for a print as per screen instructions.

#3.4 Obtain print-out of total events by day if print-out from step #3.2 is not satisfactory.

#3.5 Use daily events menu as needed to supplement information that should already be on the "Daily Report" obtained from the running system.

#3.6 Be sure at the end of your review to return to REVIEW MODE menu and "Exit Review Mode".

Note: Failure to do so will prevent the memory you are reviewing from being further used in a "Run" situation, until a formal EXIT REVIEW MODE is performed. When you "Exit" step 899 appears on the screen.

#3.7 Press END key to finally finish review mode.

#3.8 On the screen appears "End of Review Mode". The system is in "Run" mode.

Note: The data obtained during the previous "Run" are still in the memory. The new data will be added and the old data successively erased.

#4 REVIEW OF PN/M DATA USING VIDEO TAPES

Video recordings are used to confirm sensor triggering from events occurring in the reactor room or the containment annulus such as

- presence and movement of people
- any other unspecified occurrences

#4.1 Insert video tape into Reviewing Station recorder.

#4.2 Put the MODE switch on the bottom module in position "MEMORY" and select the desired TVl camera with switch on upper module as follows:

Area	Recorder	Camera	Switch pos.
Inner (Reactor Room)	R1IA,R1IB	C1I C2I	CH1 CH2
Inner (Reactor Room)	R2IA,R2IB	C3I C4I	CH1 CH2
Outer (Containment Annulus)	R1OA,R1OB	C10 C20 C30 C40	CH1 CH2 CH3 CH4
Outer (Containment Annulus)	R2OA,R2OB	C50 C60 C70 C80	CH1 CH2 CH3 CH4

#4.3 Play tape and compare recorded scenes against results obtained from review of corresponding data diskette.

#4.4 Confirm indicated events.

#4.5 Complete working papers.

In case of any troubles carry out the activities of the Follow-up (see Follow-up Procedures).

7. History of FCA C/S System development

The history of the development of the integrated C/S System for the FCA is briefly described.

1.	April, 1979	Commencement of Project
2.	January, 1980	Original Portal Monitor(P/M) completed.
3.	November, 1980	Phase I test (two weeks) Task Officer: C. Sonnier(IAEA, SGDE) Letter K. Kawasaki(NSB) to von Backmann(IAEA)
4.	April, 1981	Modified to Mark I of P/M
5.	April to September,1982	Phase II test by P. Vodrazka(IAEA, SGDE), A. Matolcsy(IAEA, SGOA)
6.	January, 1983	Modified to Mark II of P/M
7.	May-July, 1983	Phase II' test by A. Matolcsy(IAEA, SGOA)
8.	January, 1984	Prototype Penetration Monitor(PN/M) built.
9.	March, 1984	Joint technical review by D. Rundquist, K. Taylor(IAEA, SGDE)
10.	February, 1984	Letter S.Matsuzawa(NSB) to P.Tempus(IAEA,DDG-SG)
	May, 1984	Letter V. Schuricht(IAEA, A/DDG-SG) to S. Matsuzawa(NSB)
11.	November, 1984	Modified to Mark III of P/M

12.	June, 1985	Draft of STR-175 by K. Taylor(IAEA, SGDE)
13.	March, 1985	Joint test of P/M and PN/M by P.Vodrazka(IAEA,SGDE),A.Matolcsy(SGOA)
14.	November, 1985	Mark IV of P/M, Scale-up of PN/M
15.	January, 1986	Joint test by IAEA: P. Vodrazka(SGDE), A. Matolcsy(SGOA) and NSB: T. Kojima
16.	July, 1986	Discussion on the field trial test IAEA: W. Frenzel(SGOA), L. Watkins(SGDE) NSB: H. Dosho, T. Kojima
17.	September, 1986 to May, 1987	Field Trial Phase I by L. Watkins(IAEA, SGDE)
18.	July, 1987 to June, 1988	Field Trail Phase II by L. Watkins(IAEA, SGDE)
19.	March, 1988	VTRs of P/M, PN/M changed from Beta to 8mm VTR. PN/M modified.
20.	June, 1988	Metal Detector of P/M failed
21.	July, 1988	Authentication proposal letter from H.Kurihara(IAEA,SGDE) to H. Tani(NSB)
22.	September, 1988	Letter for extension of Field Trial and extension of retirement of L.Watkins, J.Jennekens (IAEA,DDG- SG) to K.Takagi(NSB). Letter for JASPAS/POTAS collaboration on authentication development for FCA C/S System J.Jennekens(IAEA,DDG-SG) to K.Takagi(NSB).

23.	October, 1988	Specification of authentication equipment L. Wakins(IAEA, SGDE)
24.	December, 1988	Metal Detector rebuilt.
25.	December, 1988 to June, 1989	Field trial Phase III L. Walkins(SGDE)
26.	May, 1989	Letter on authentication K. Naito (IAEA, SGDE) to K. Takagi (NSB)
	August, 1989	K. Takagi (NSB) to K.Naito (IAEA, SGDE)
27.	February, 1990	Final report on Field trial L. Watkins, E. Yellin (SGDE)
		Letter for approval of the system under condition on the provision of the authentication equipment. J.Jennekens(IAEA,DDG-SG) to J.Shibata(NSB)
28.	April, 1990	Modified on P/M and PN/M on request by final Report.
29.	May, 1990	Authentication design review meeting at SNL IAEA:E, Yellin (SGDE), J. Janov, S. Beach (SGOA) SNL: D. Mangan, C. Sonnier, K. Ystesund etc. JAERI: T. Mukaiyama
30.	June, 1991	Modified of P/M and PN/M for authentication.
31.	November, 1991	Authentication equipment installed.
32.	November, 1991 to March, 1992	Test of authentication equipment R. Ekarv, S. Beach, J. Janov (IAEA, SGOA)
33.	December,1992 to April,1993	Field test of both authentication equipment and automatic data comparator

34.	November,1993	Interim report of FCA authentication equipment and automatic data comparator M.Goldfarb(SGDE), R.Ekarv(SGOA),K.Rzymkowski(SGOA)
35.	February,1994 May,1994	The second phase field test of FCA authentication equipment and automatic data comparator
36.	May,1995	The final field test report of FCA authentication equipment and automatic data comparator M.Goldfarb(SGDE), K.Rzymkowski(SGOA),R.Ekarv(SGOA)
37.	September,1996	This task was completed. The system will be used for a routine inspection.

Acknowledgments

The development of the portal and penetration monitors for FCA was initiated by the suggestion of Hideo Kuroi of JAERI, who is presently at Japan Nuclear Fuel Ltd. The authors gratefully acknowledge his valuable discussion and encouragement. Thanks are gratefully extended to D.Rundquist, C.Sonnier, P.Vodrazka, A.Matolcsy, L.Watkins of IAEA, who were the IAEA task officers for this project. The authors also thank to K.Ikawa of JAERI, now at IAEA, for his support and encouragement.

The authors thank the FCA staff for their help and support for the development and for the field test, especially, Kazuo Kurosawa and Hirosi Sodeyama for all their endeavors during the field tests. Thanks are also to members of Safeguards Technology Laboratory of JAERI for their valuable discussions and support.

This work has been performed under the framework of the Japan Support Programme for Agency Safeguards (JASPAS).

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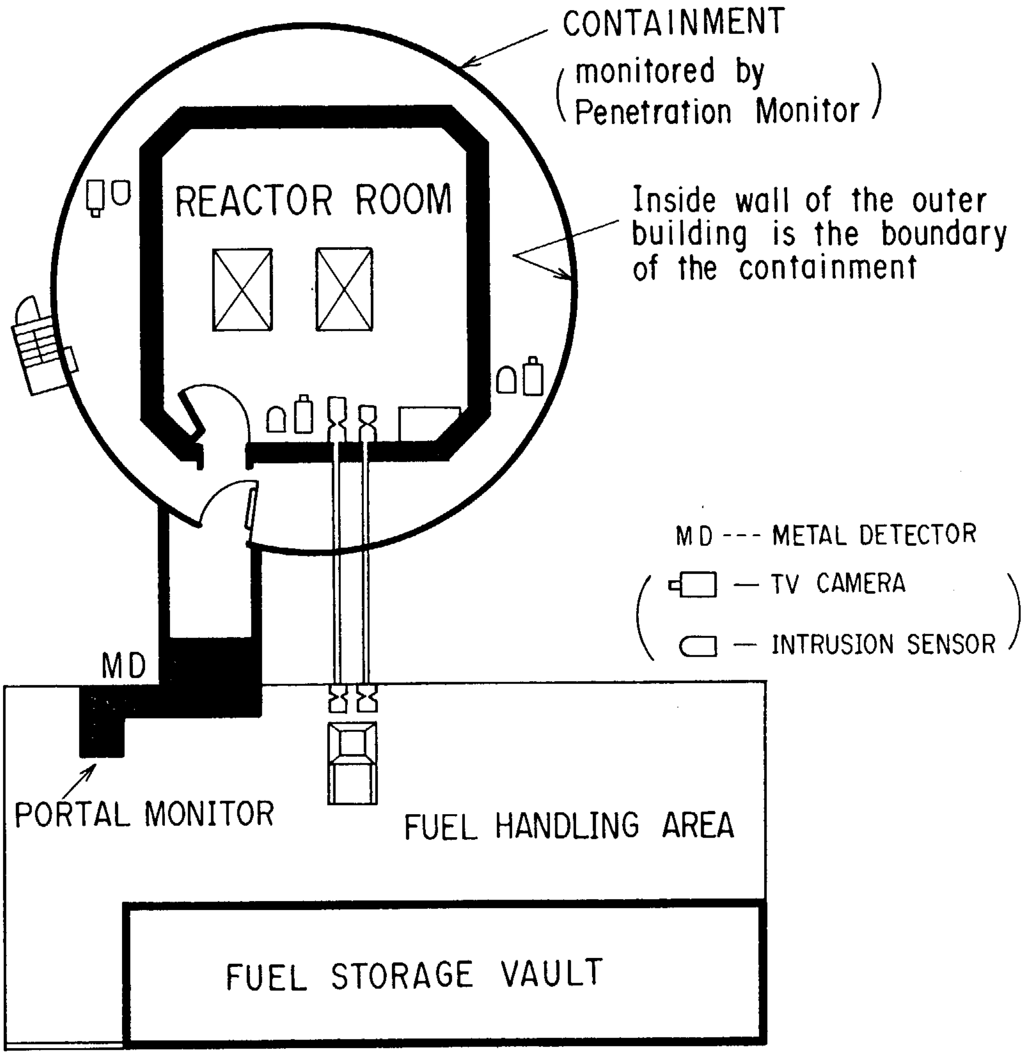


Fig. 1 The Overall Concept of the C/S System at FCA

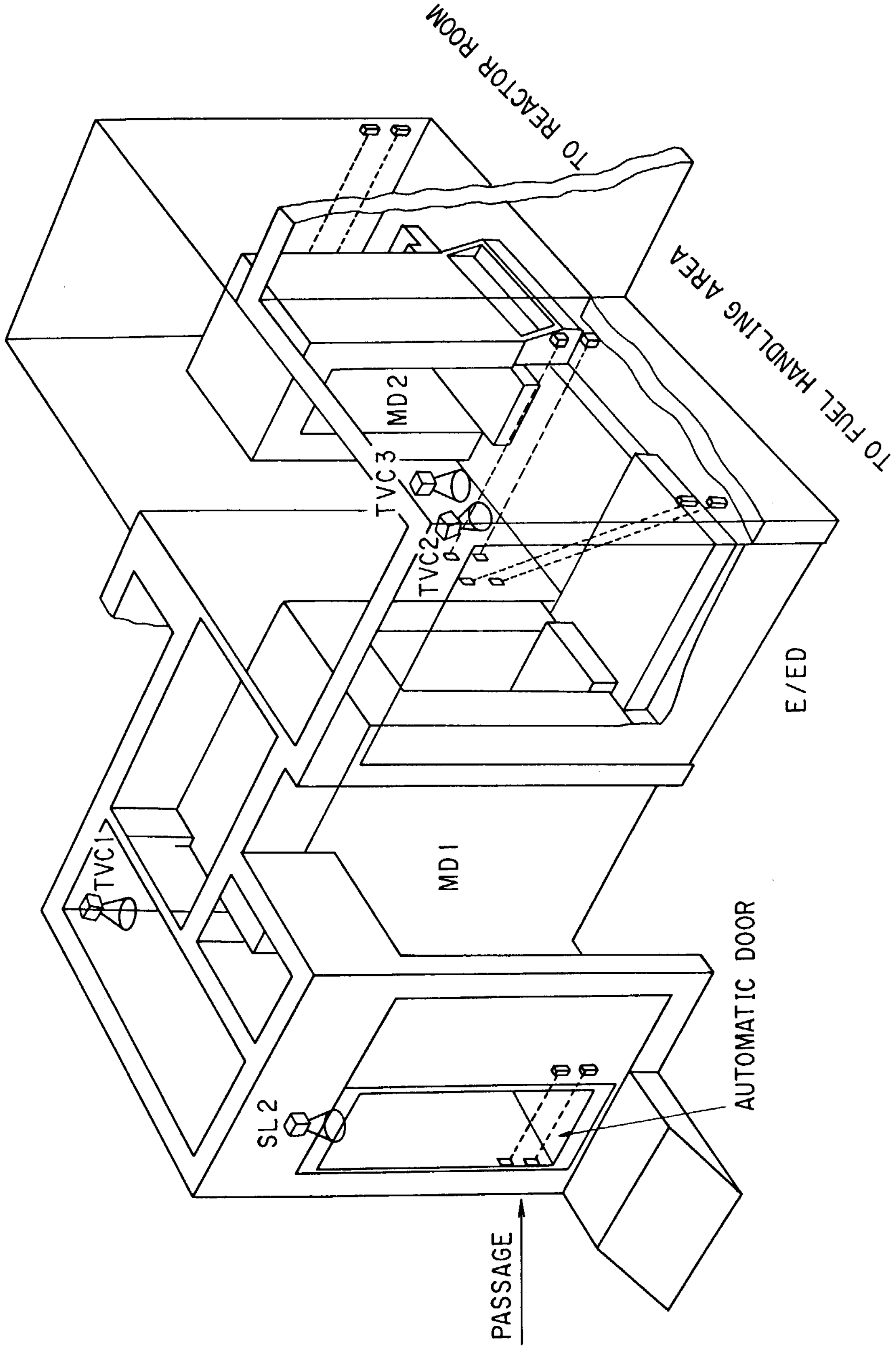


Fig. 2 The Structure of the Portal Monitor (P/M)

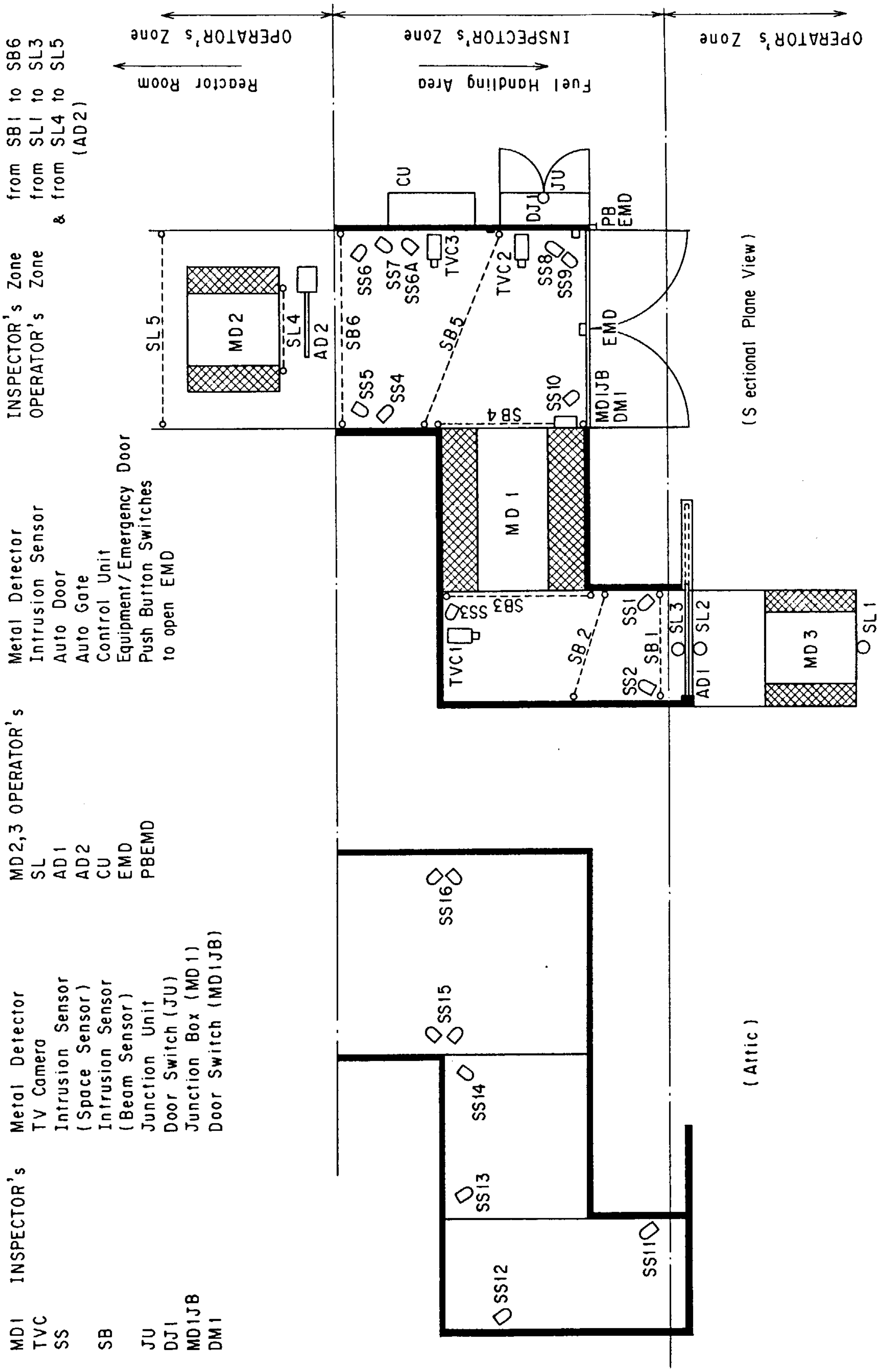


Fig. 3　Devices Arrangement of the Portal Monitor

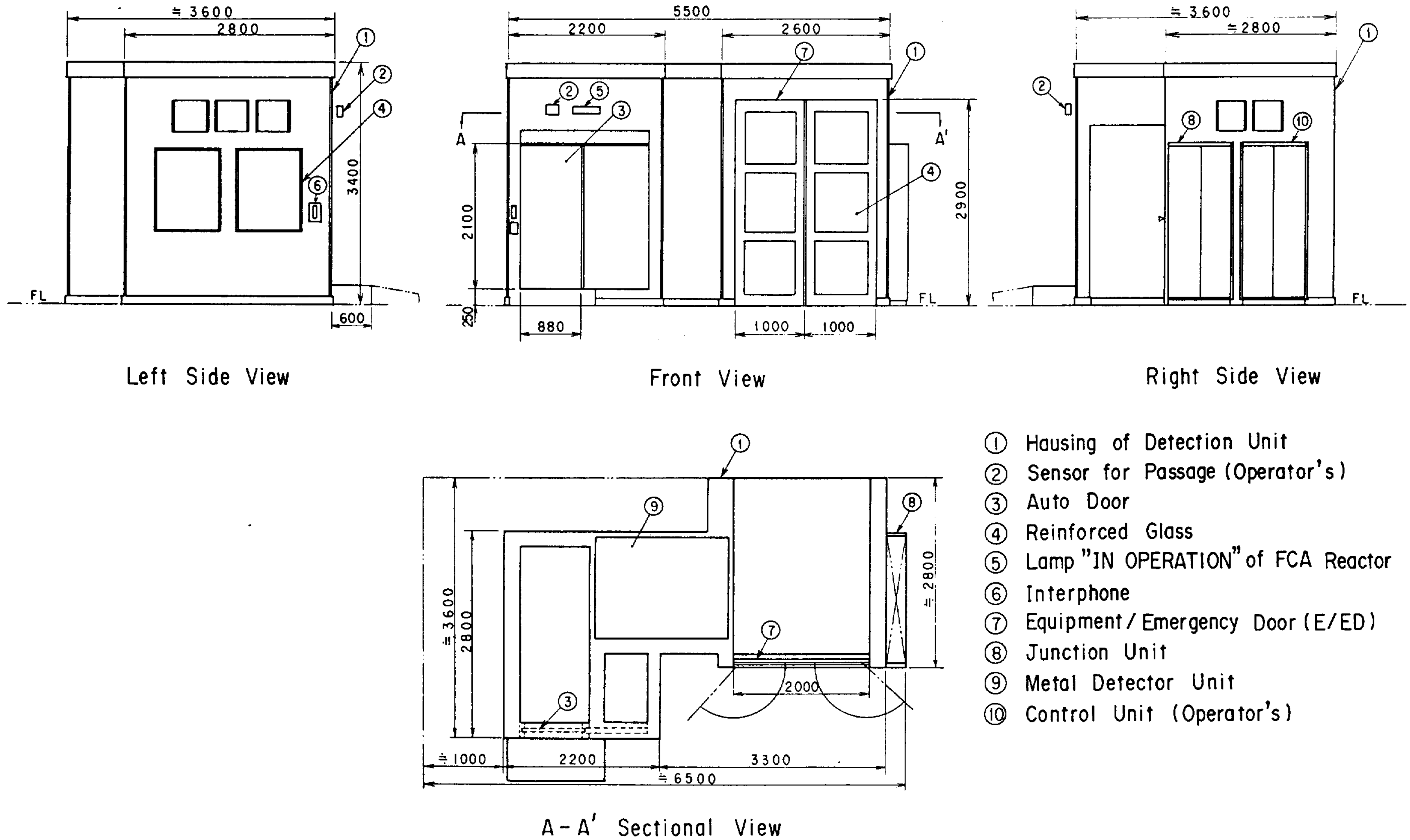


Fig. 4 The Housing of the Portal Monitor

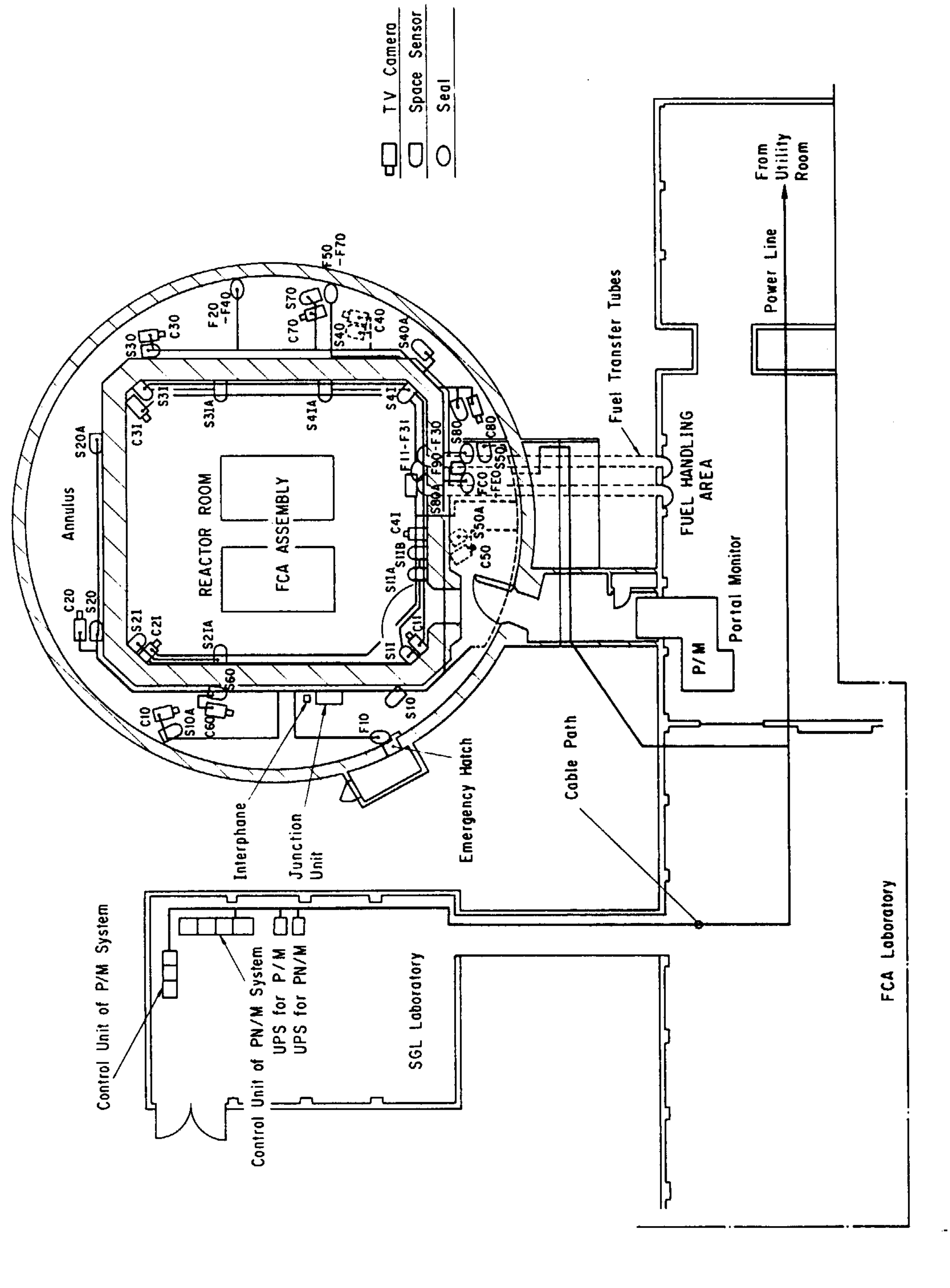


Fig. 5 The Layout of the Portal Monitor

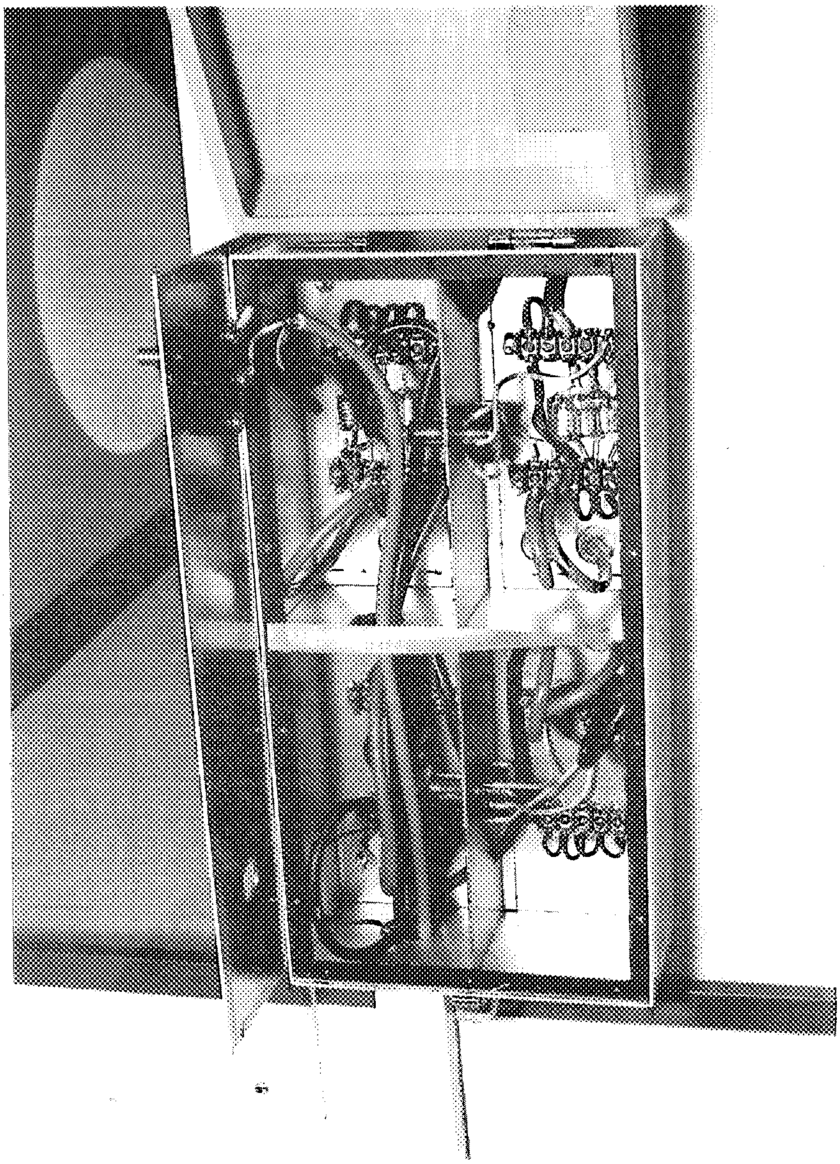
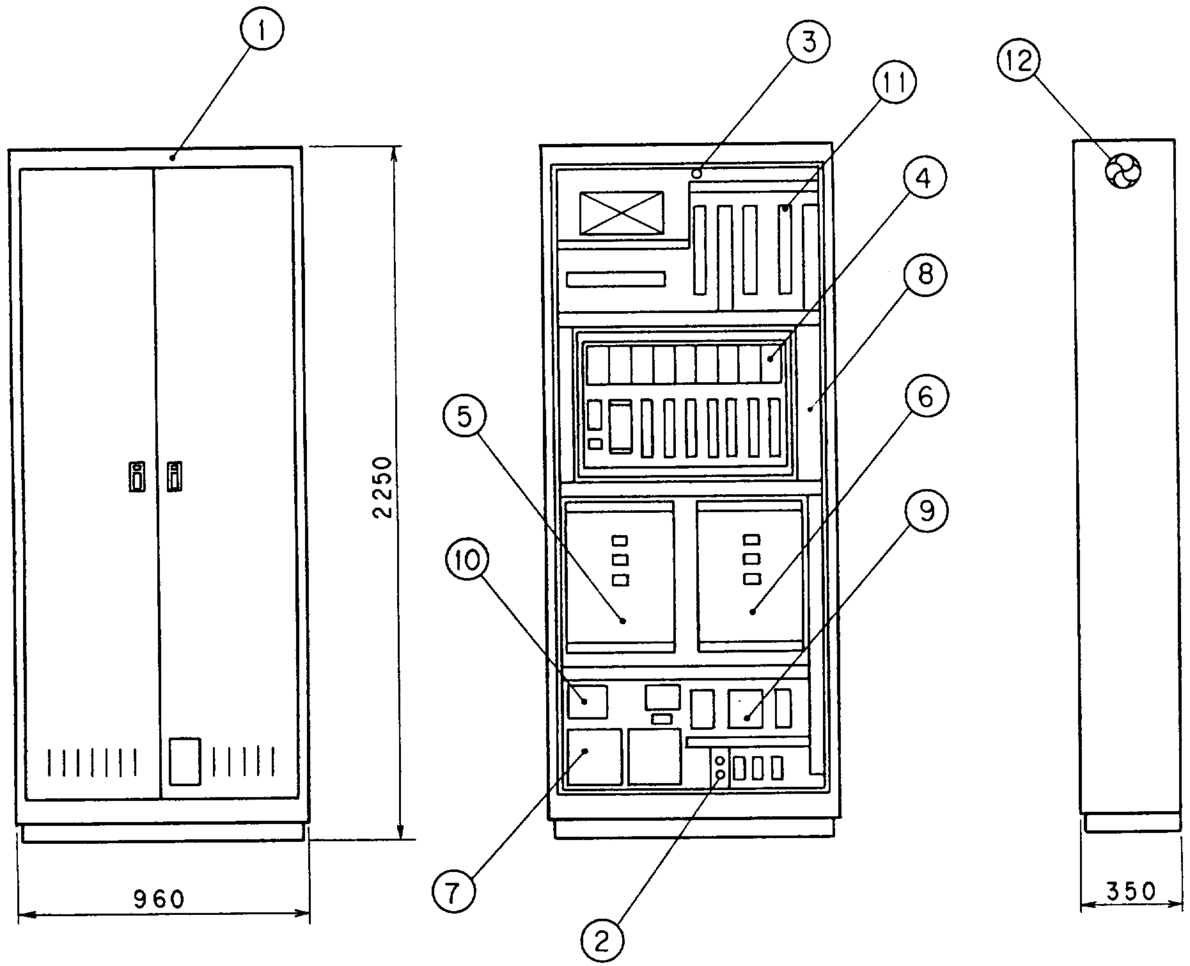


Fig. 6　The Interior of the Junction Box (JB) with the Cover removed



No.	Name
①	Junction Unit
②	Seal Post
③	Door Switch
④	Multiplex Transmitter
⑤	Metal Detector Controller (MD1 A) of XY Axis
⑥	Metal Detector Controller (MD1 B) of Z Axis
⑦	Insufficient Voltage Sensor
⑧	Cable Duct
⑨	DC Power Regulator
⑩	Transformer
⑪	Terminal Stand
⑫	Fan

Fig. 7　The Junction Unit (JU) of the Portal Monitor

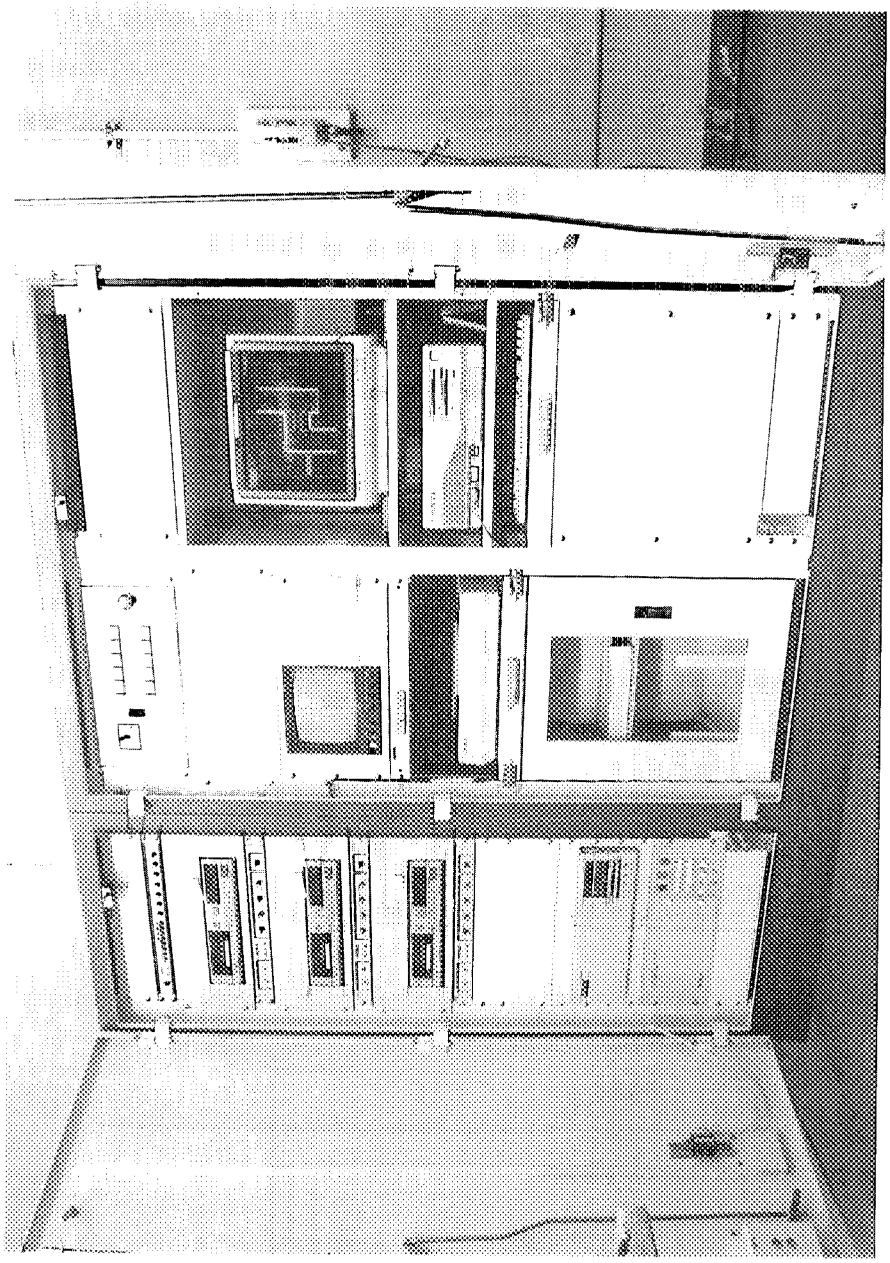


Fig. 8 The Control and Recording Unit (CU) of the Portal Monitor (P/M)

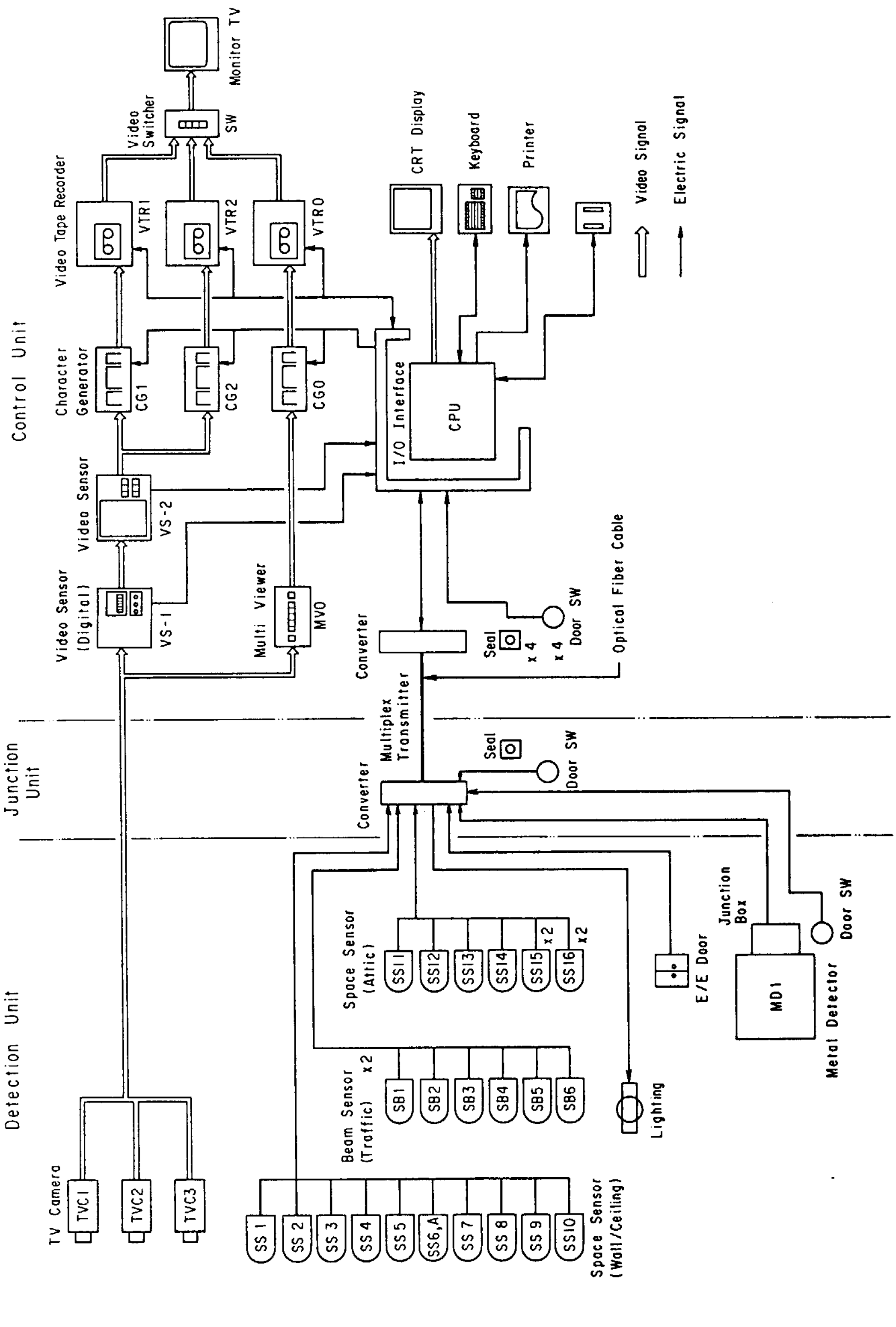


Fig. 9 The Basic Functioning Diagram of the Portal Monitor

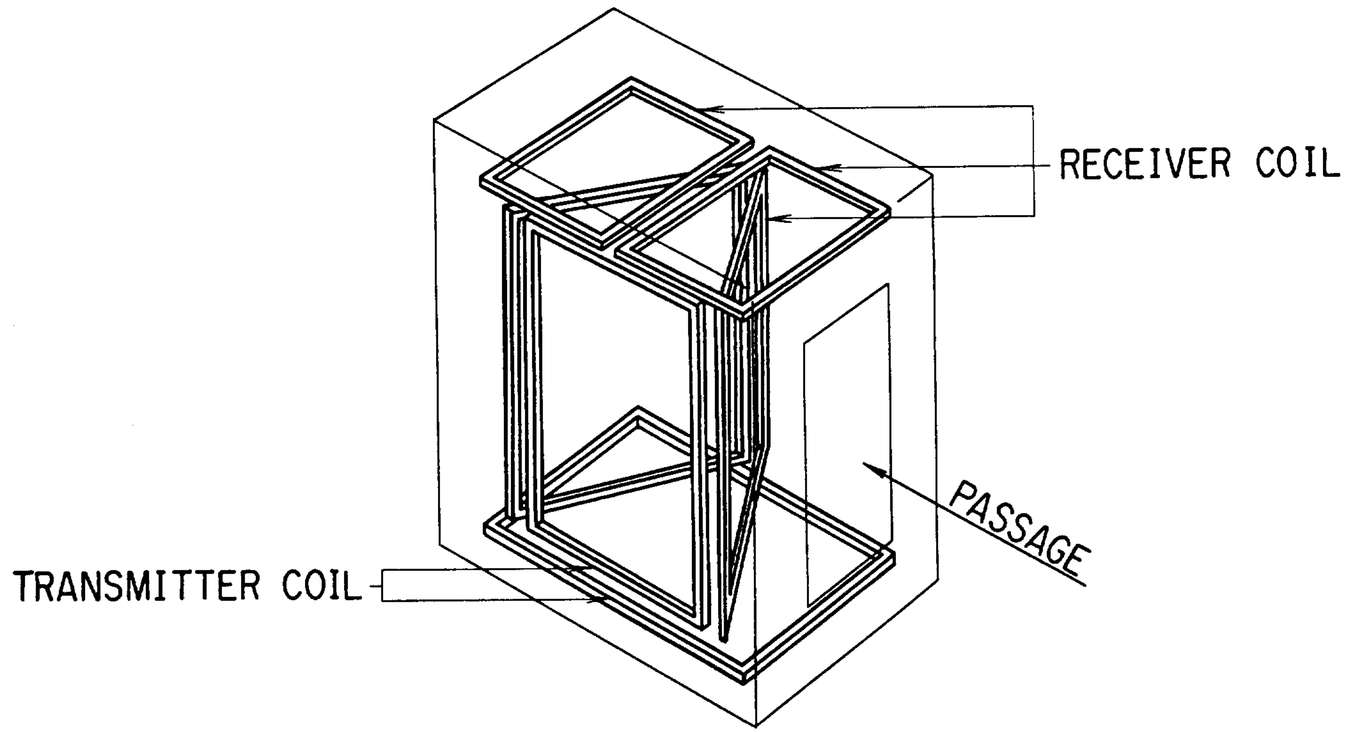


Fig.10 The Coil Arrangement of the Metal Detector (MD)

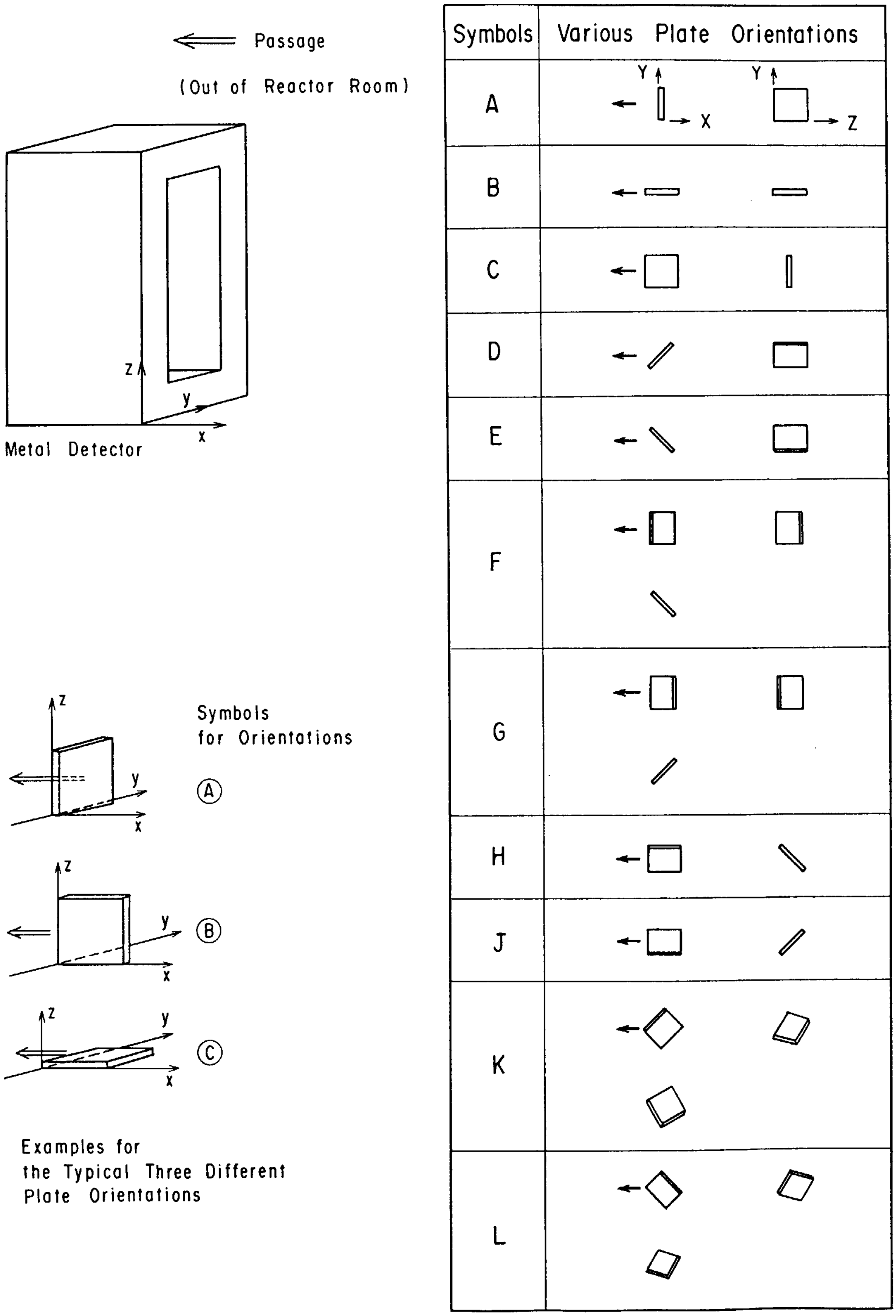


Fig.11 The Various Plate Orientations in the Metal Detector

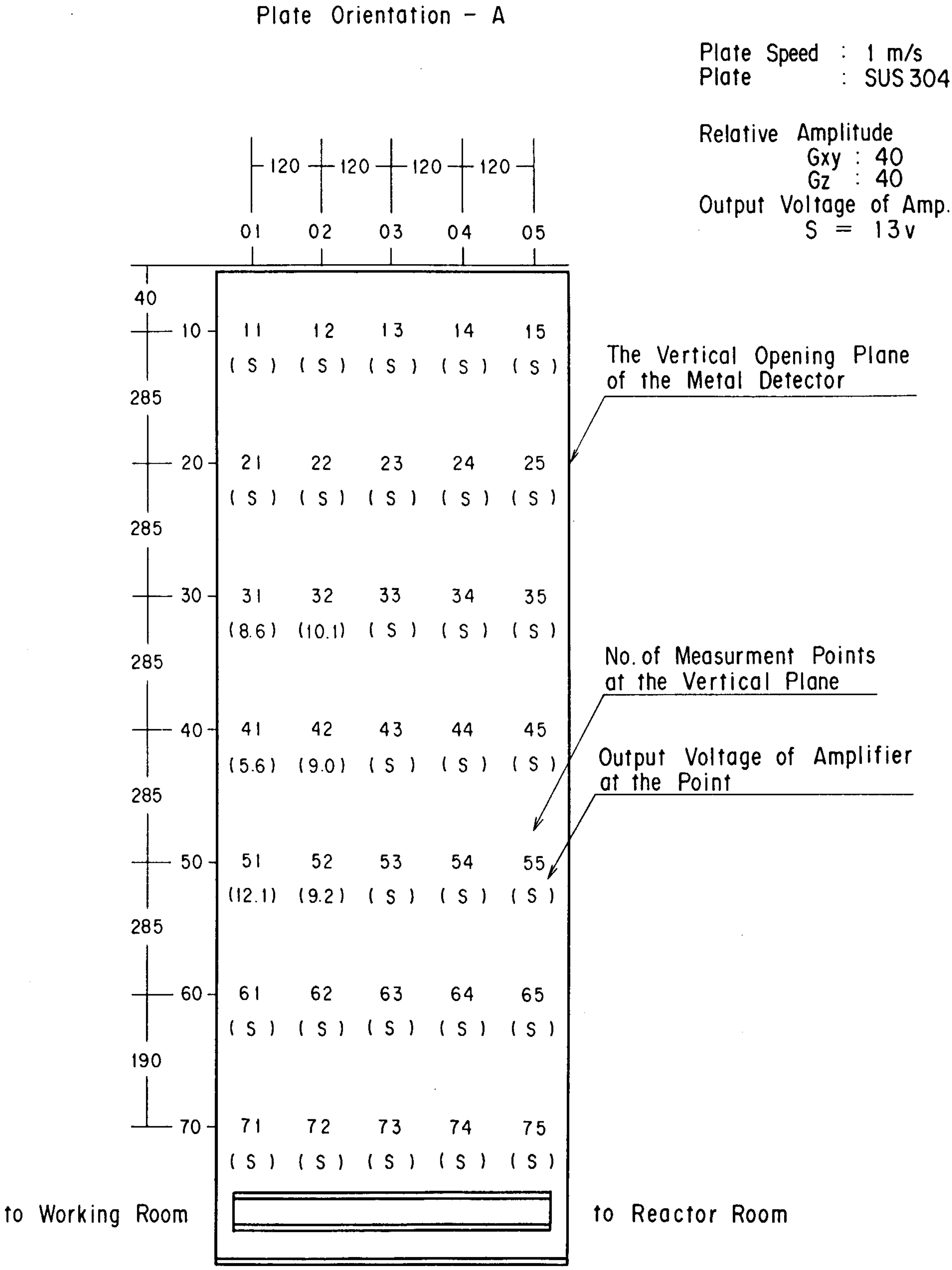


Fig.12 The Sensitivity Map for a Stainless Steel Plate (1st of 3)

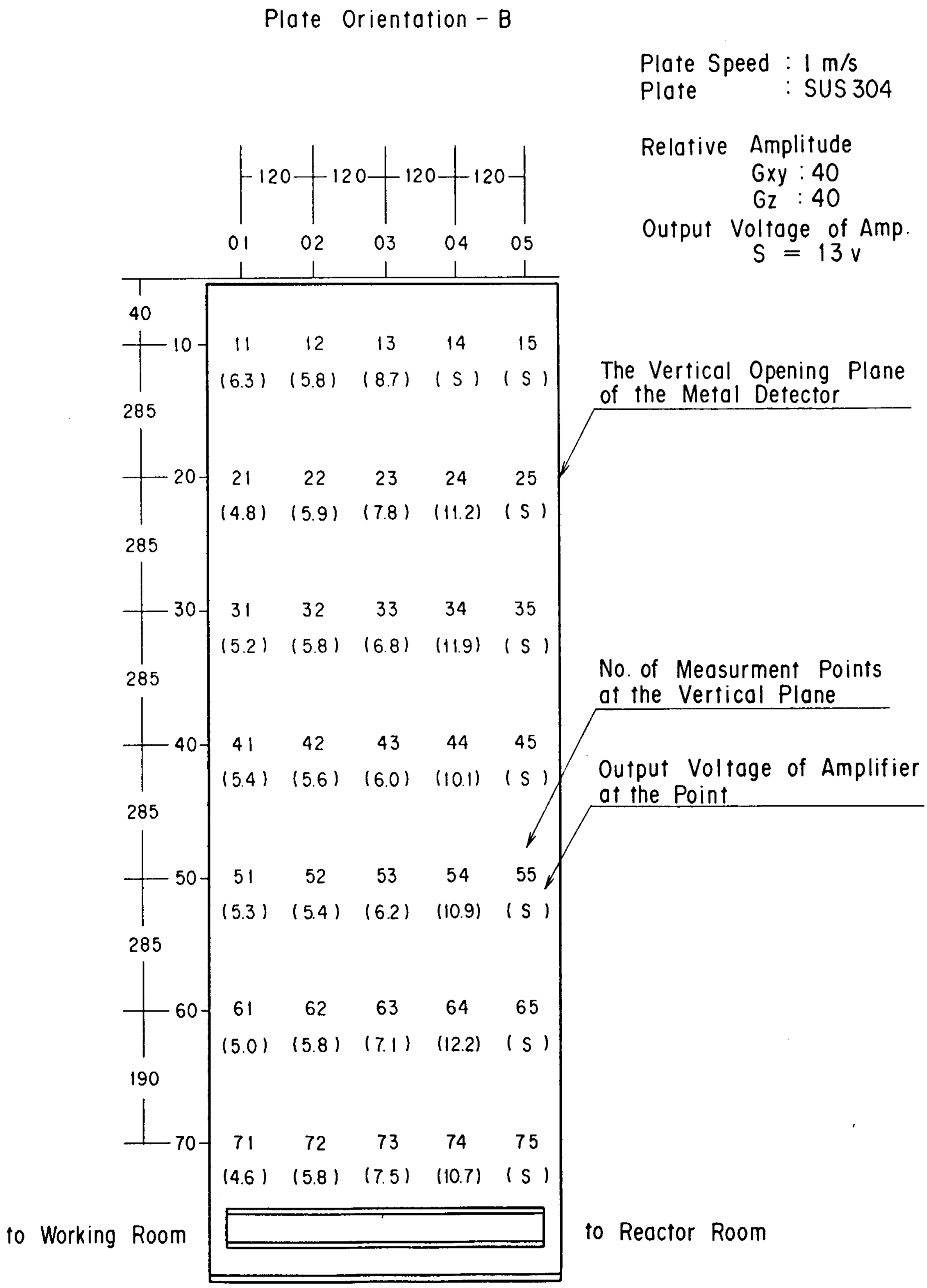


Fig.12 The Sensitivity Map for a Stainless Steel Plate (2nd of 3)

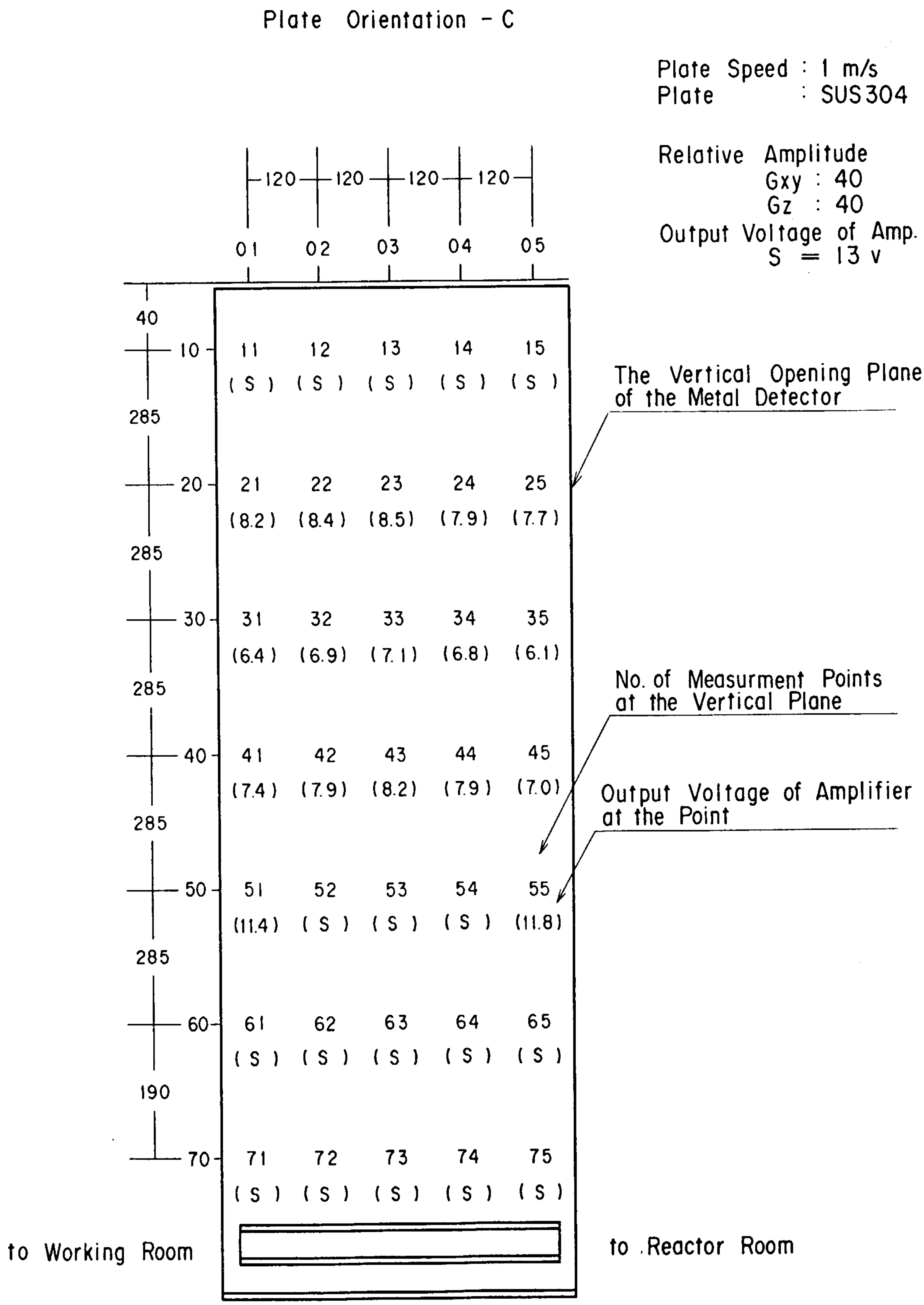


Fig.12 The Sensitivity Map for a Stainless Steel Plate (3rd of 3)

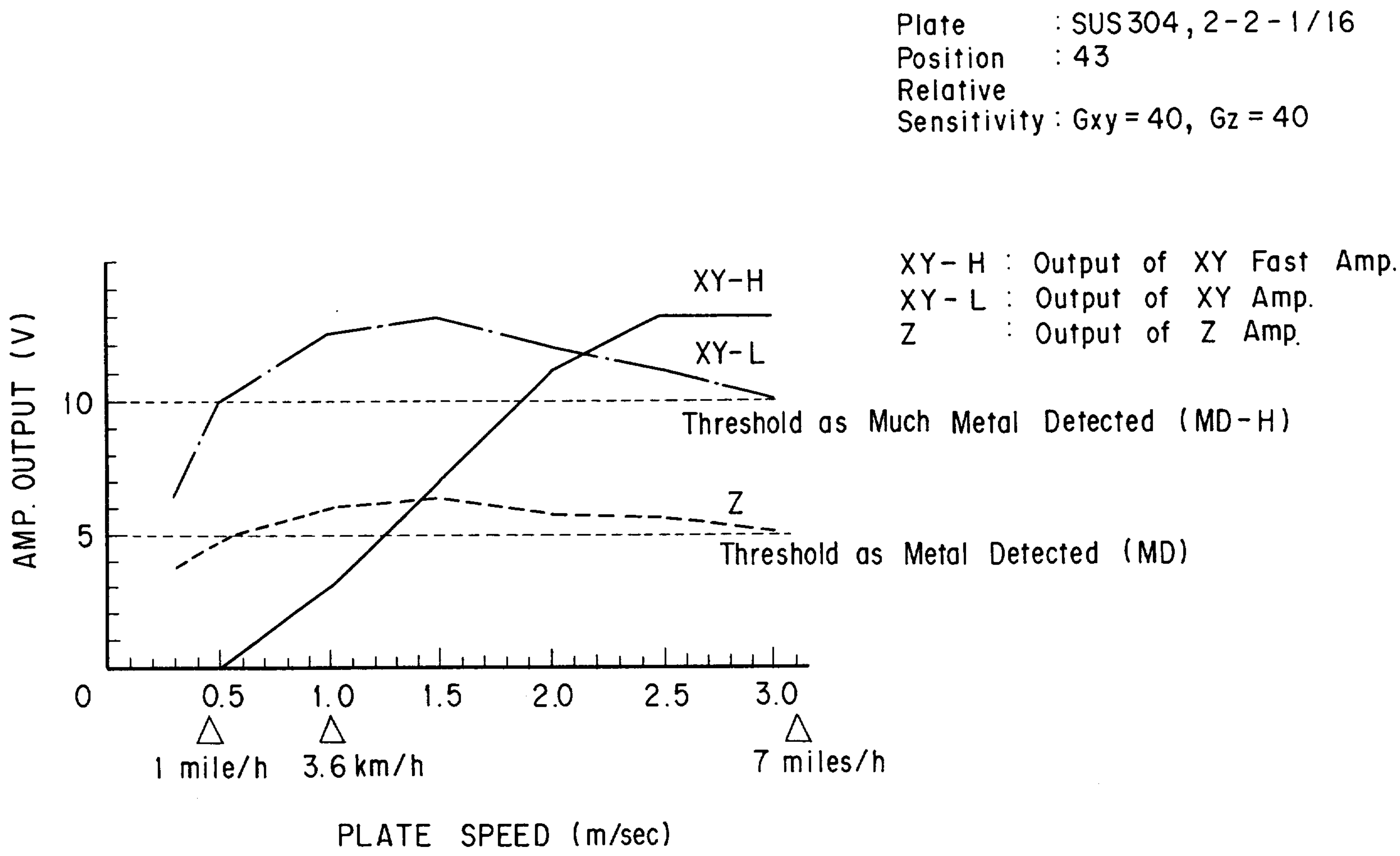
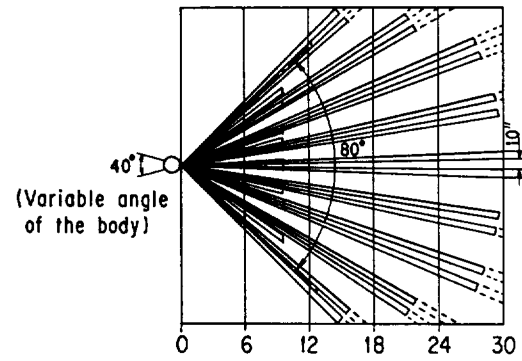


Fig.13 The Metal Detector's Sensitivity depending upon the Speed of the Plate

Wide angle sensor

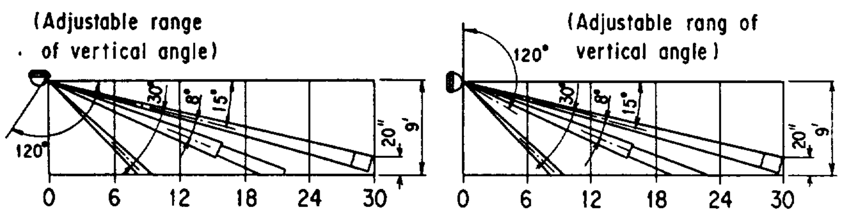
One unit protects an area of 30ft x 30ft (10m x 10m), maximum length 30ft (10m), three-dimensionally, with 28 sensitive zones.

Horizontal range (Top view)



Vertical range (Side view)

[When installed on the ceiling] [When installed on a wall]

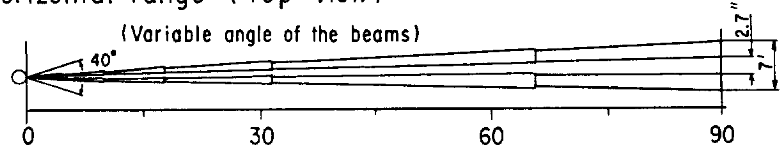


This system has 28 sensitive zones, consisting of 18 upper sensitive zones and 10 lower sensitive zones

Vertical plane sensor

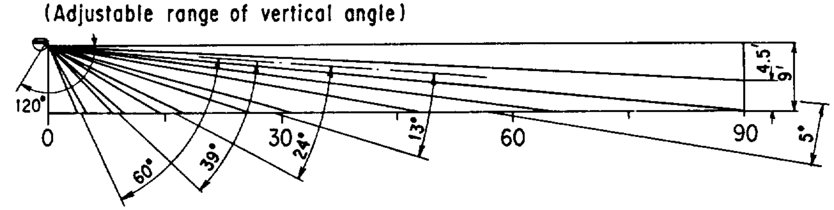
One unit protects an area of 90ft(30m), maximum length using a vertical-field with 12 sensitive zones.

Horizontal range (Top view)



Vertical range (Side view)

[When installed on the ceiling]



[When installed on a wall]

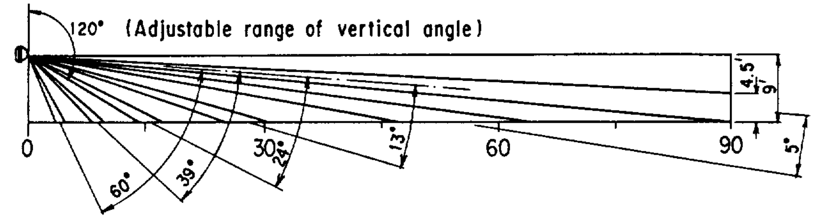


Fig.14 The Typical Capable Coverage of the Space Sensors

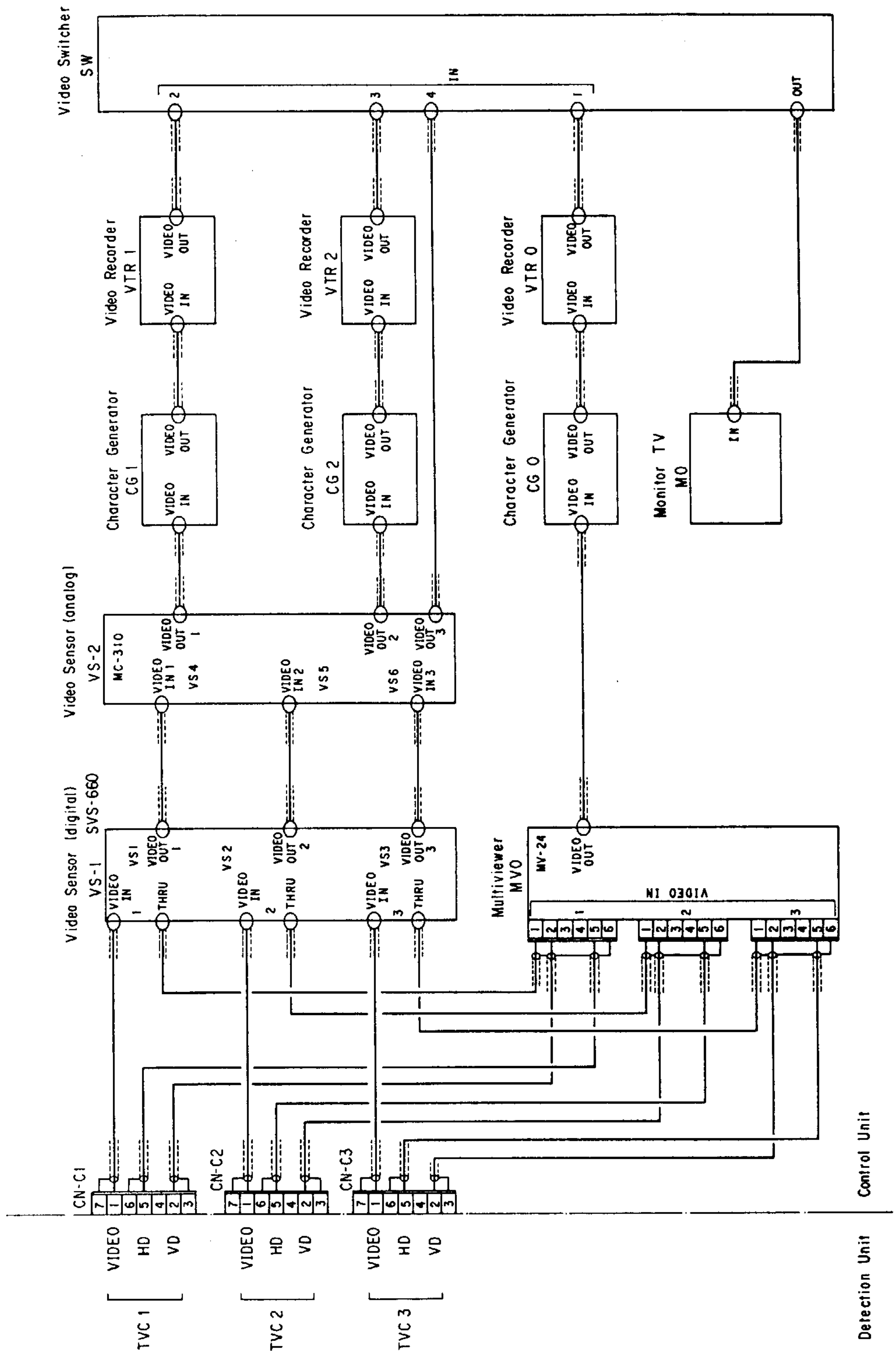


Fig.15 The Functioning Diagram of the Video System

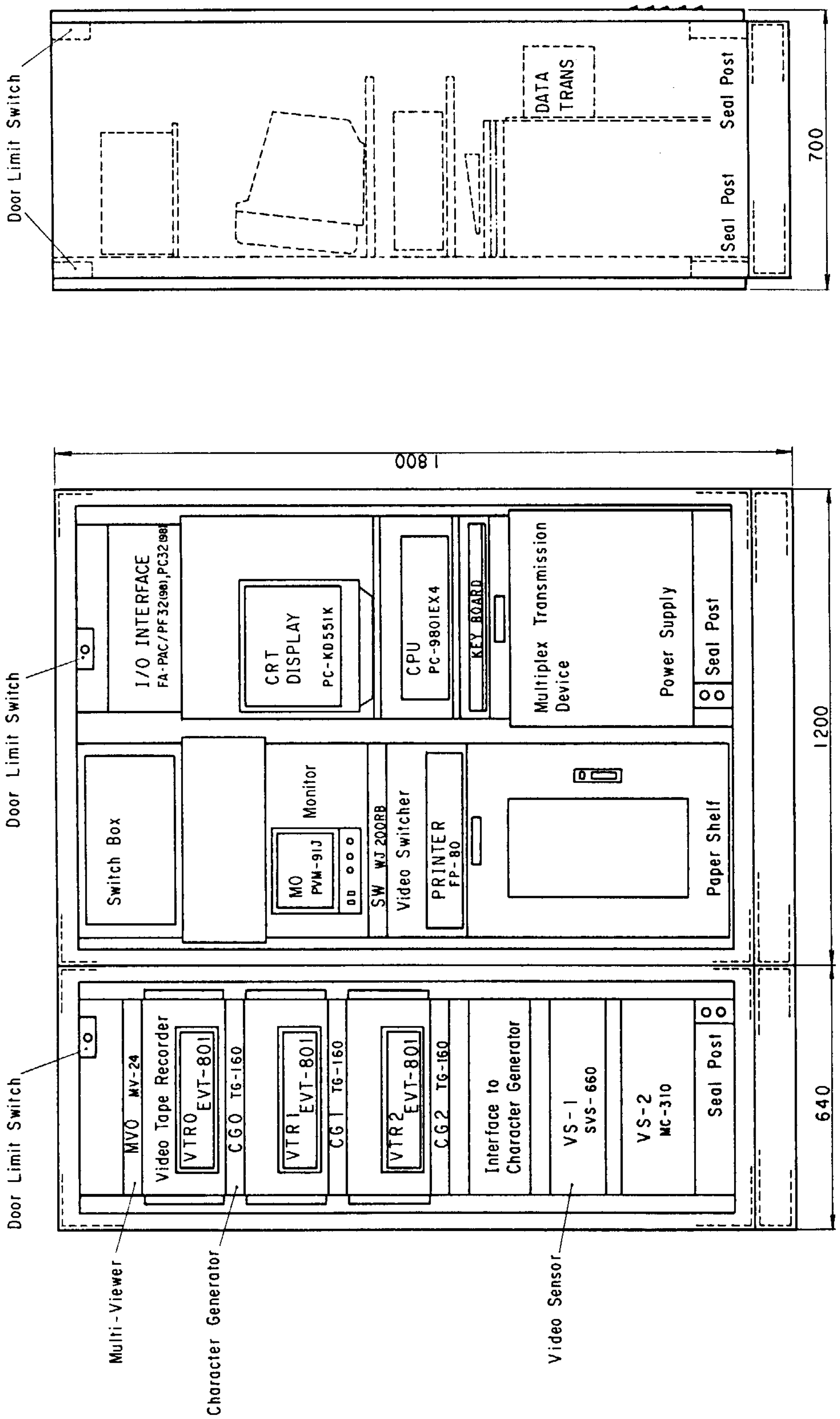


Fig.16 The Control and Recording Unit (CU) of the Portal Monitor

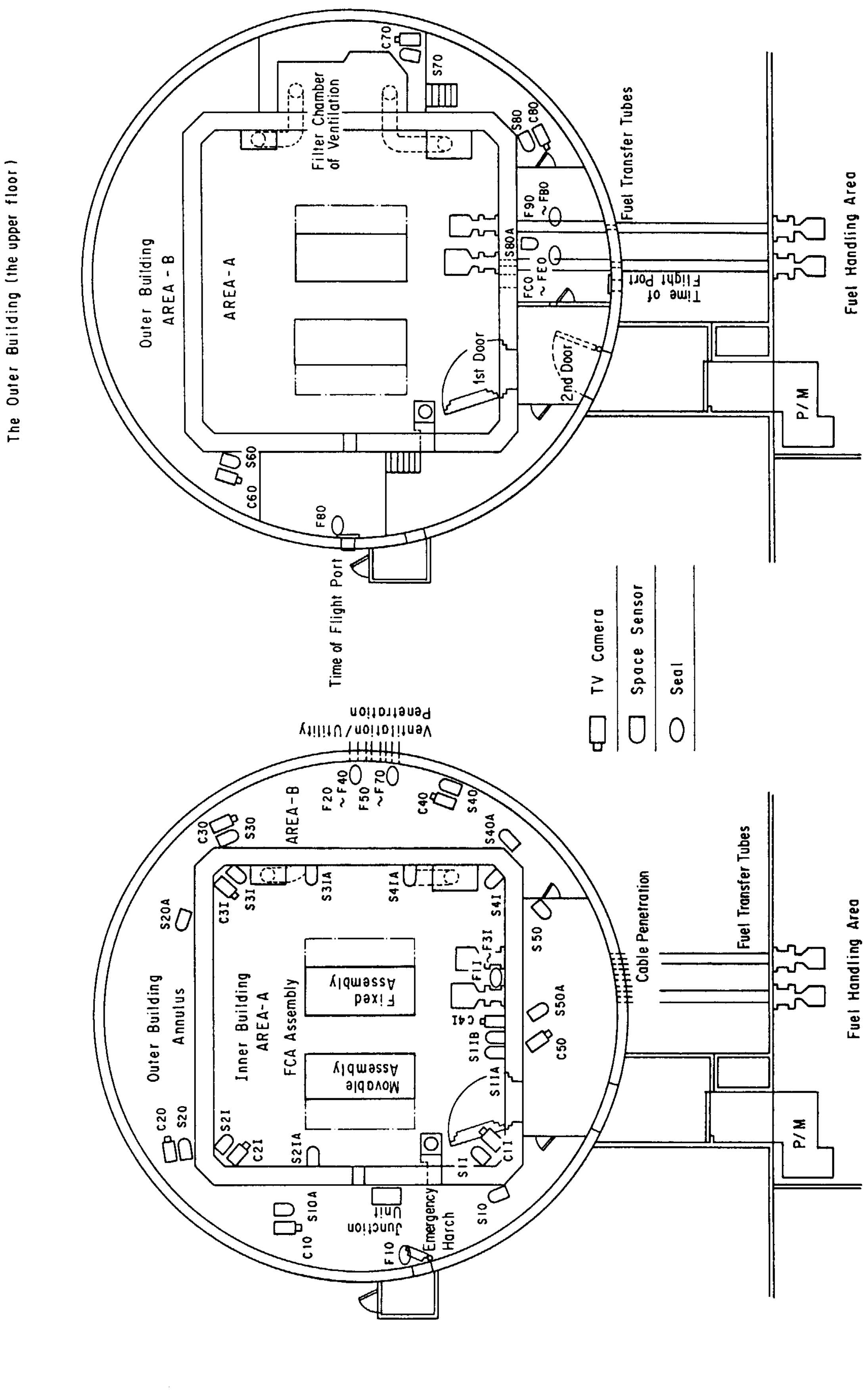


Fig.17 The Layout of the Penetration Monitor (PN/M)

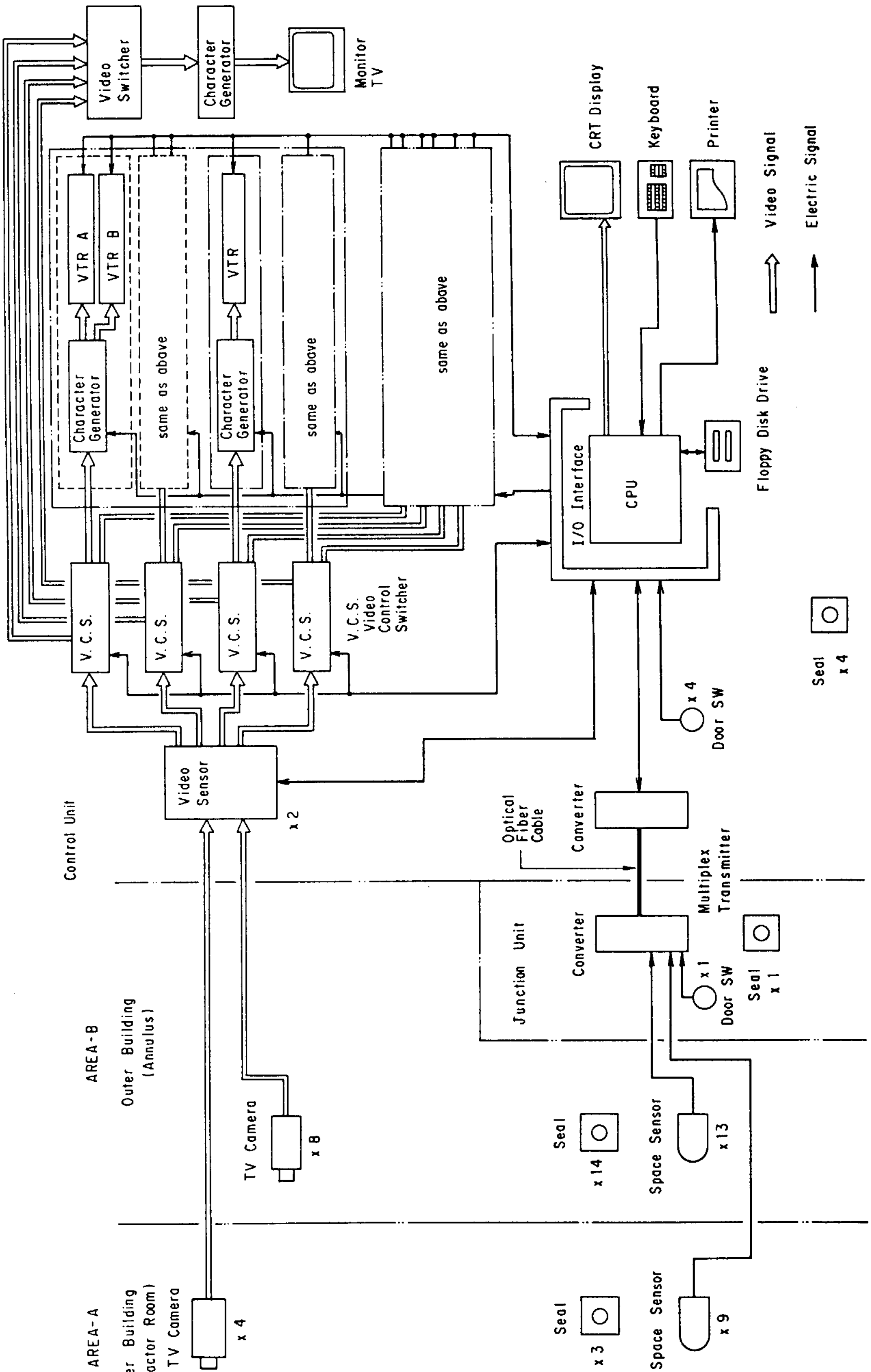


Fig.18 The Basic Functioning Diagram of the Penetration Monitor

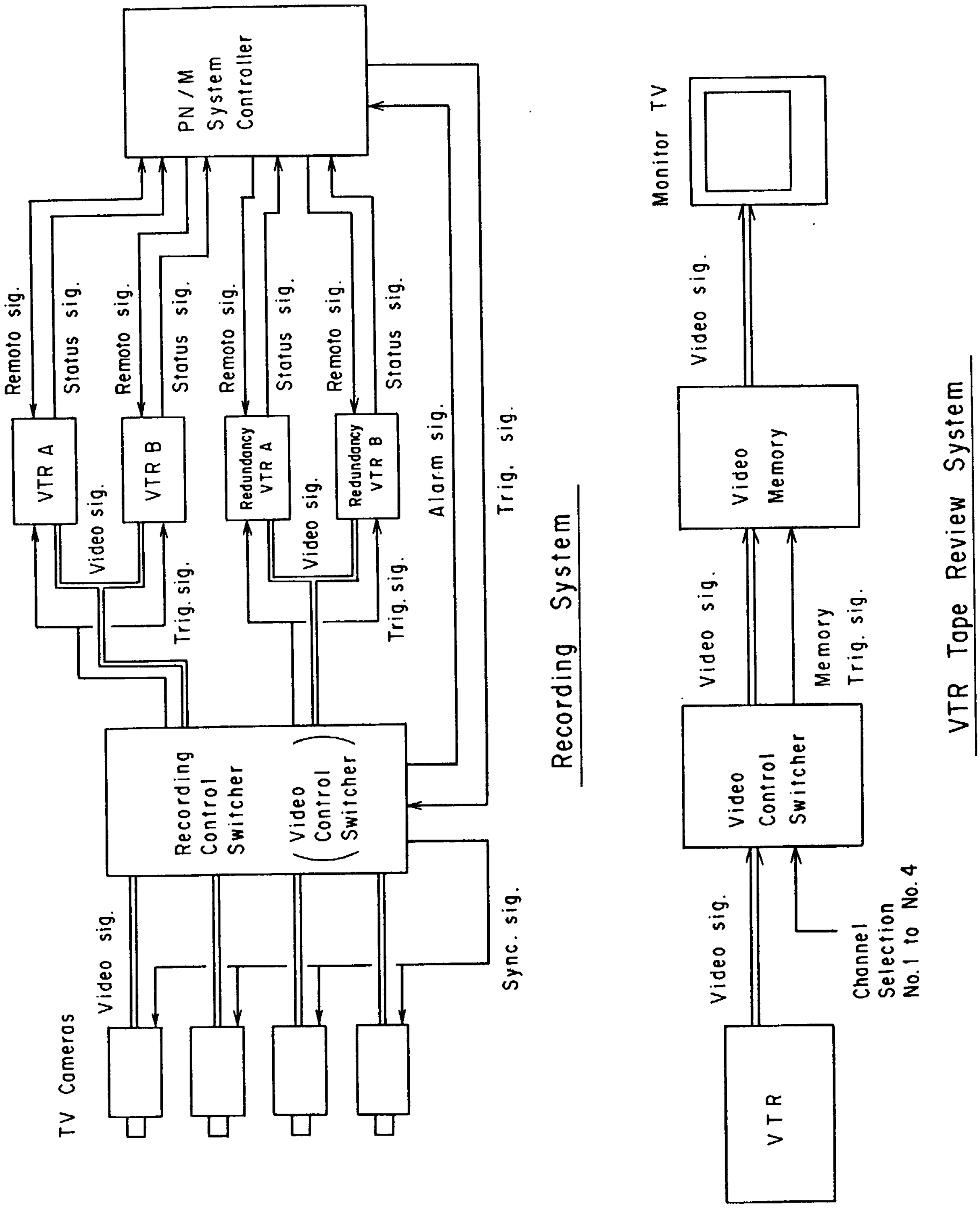


Fig.19 The Schematic Arrangement of CCTV System

Fig.20　The Control and Recording Unit (CU) of the Penetration Monitor (PN/M)

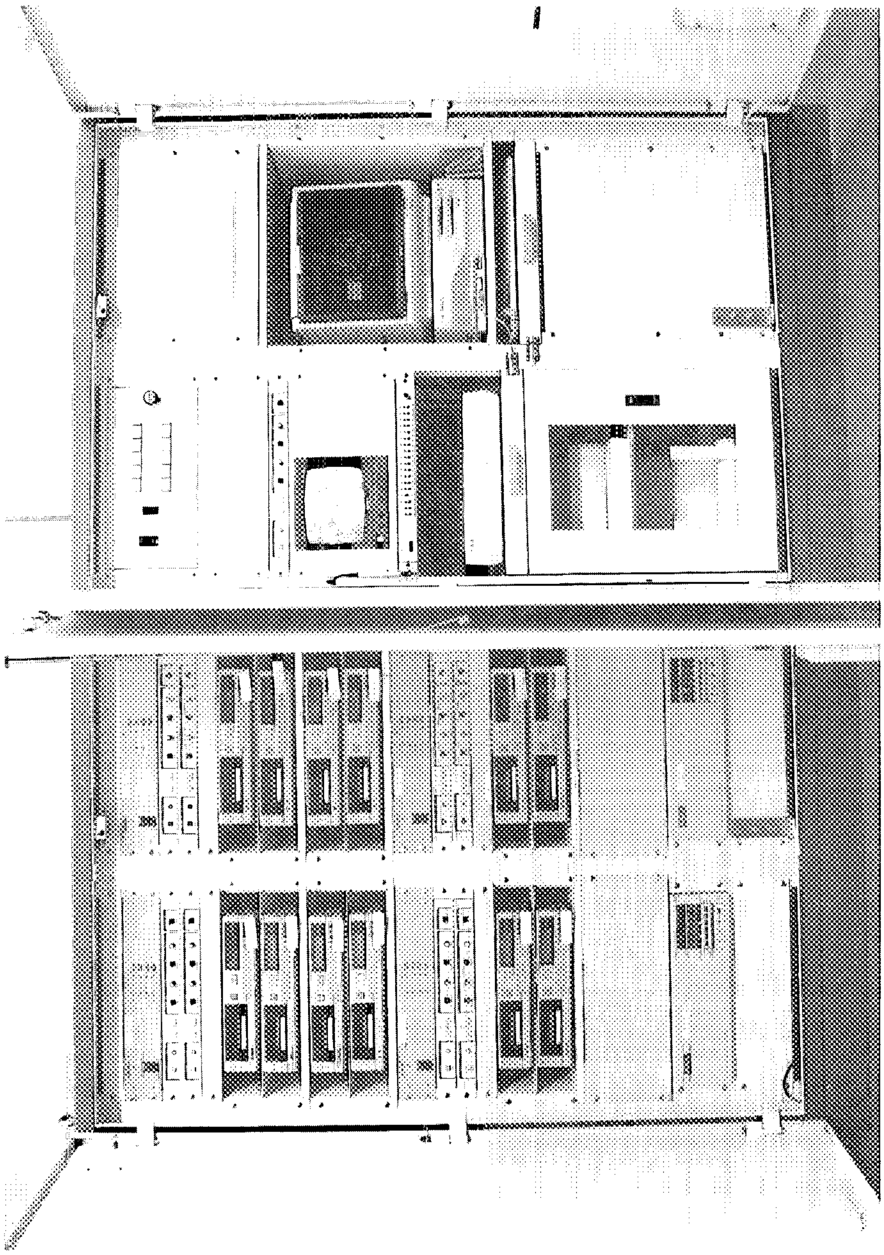
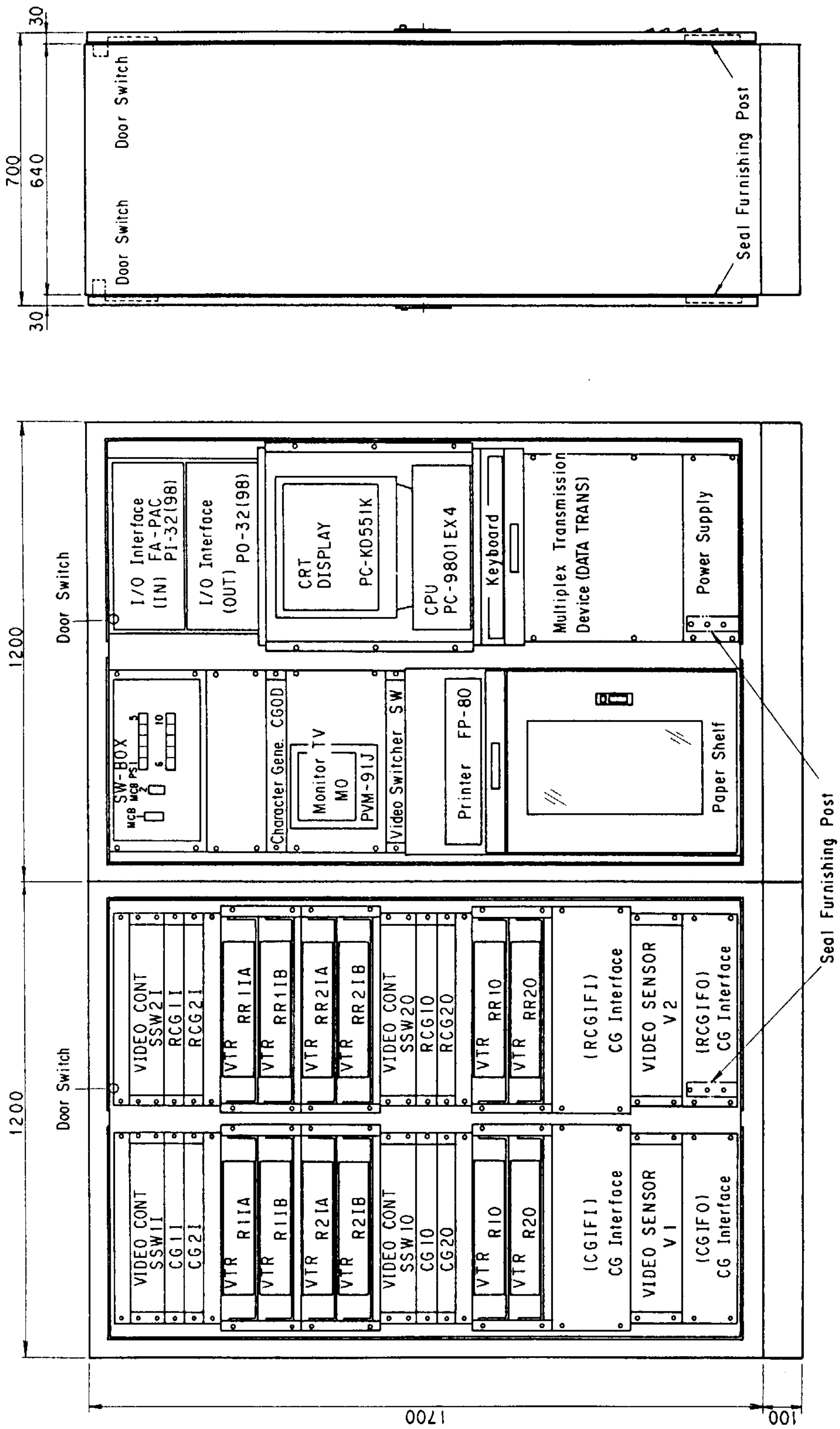


Fig.21 The Control and Recording Unit (CU) of the Penetration Monitor (PN/M)

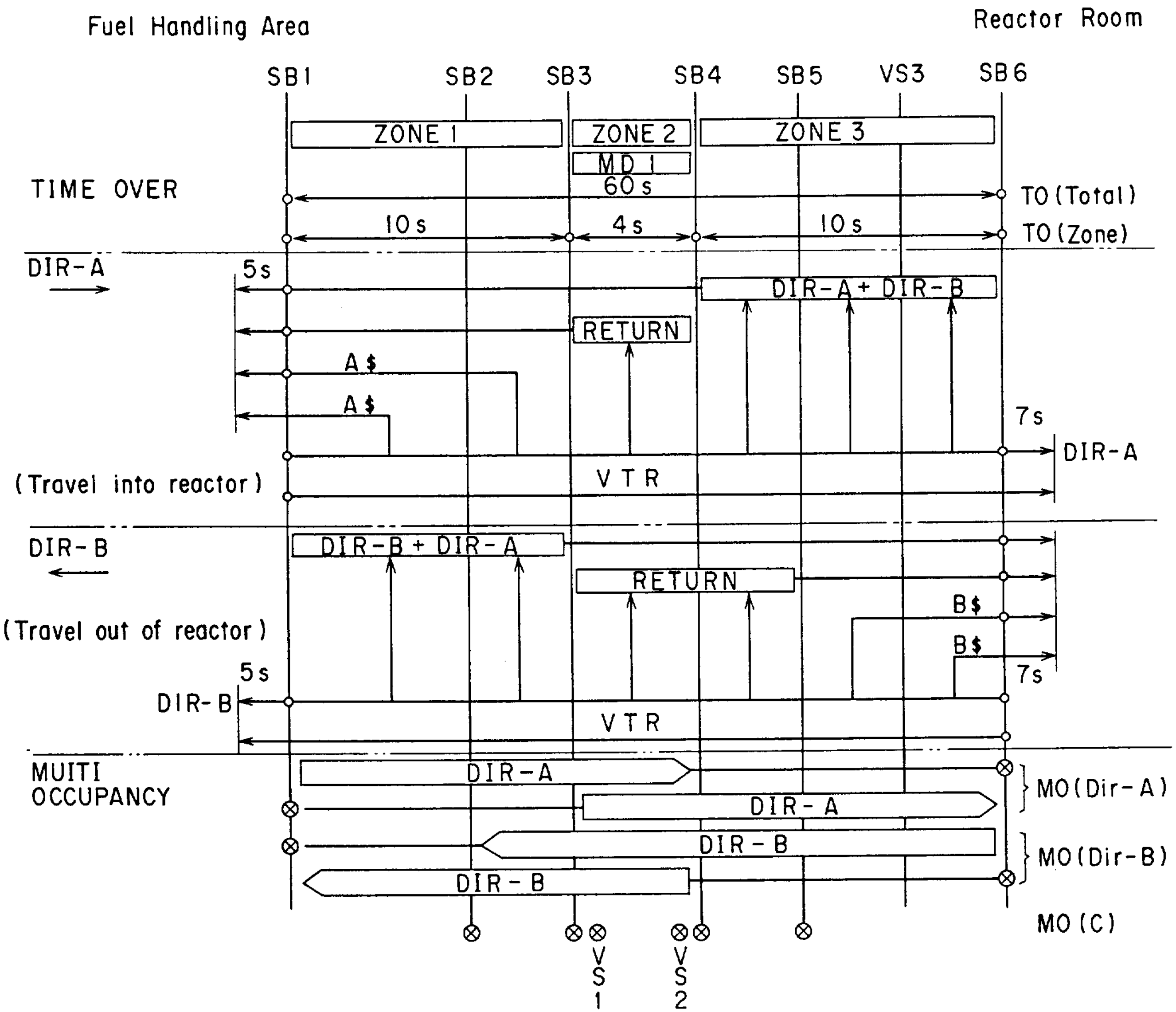


VIDEO CONT : Video Control Switcher : SSW1I, SSW2I, SSW1O, SSW2O
VTR : Video Tape Recorder : R11A, R11B, R21A, R21B, R1O, R2O
EVT-801/2 : RR11A, RR11B, RR21A, RR21B, RR1O, RR2O
Character Generator : CG1I, CG2I, CG1O, CG2O
: RCG1I, RCG2I, RCG1O, RCG2O, CGOD

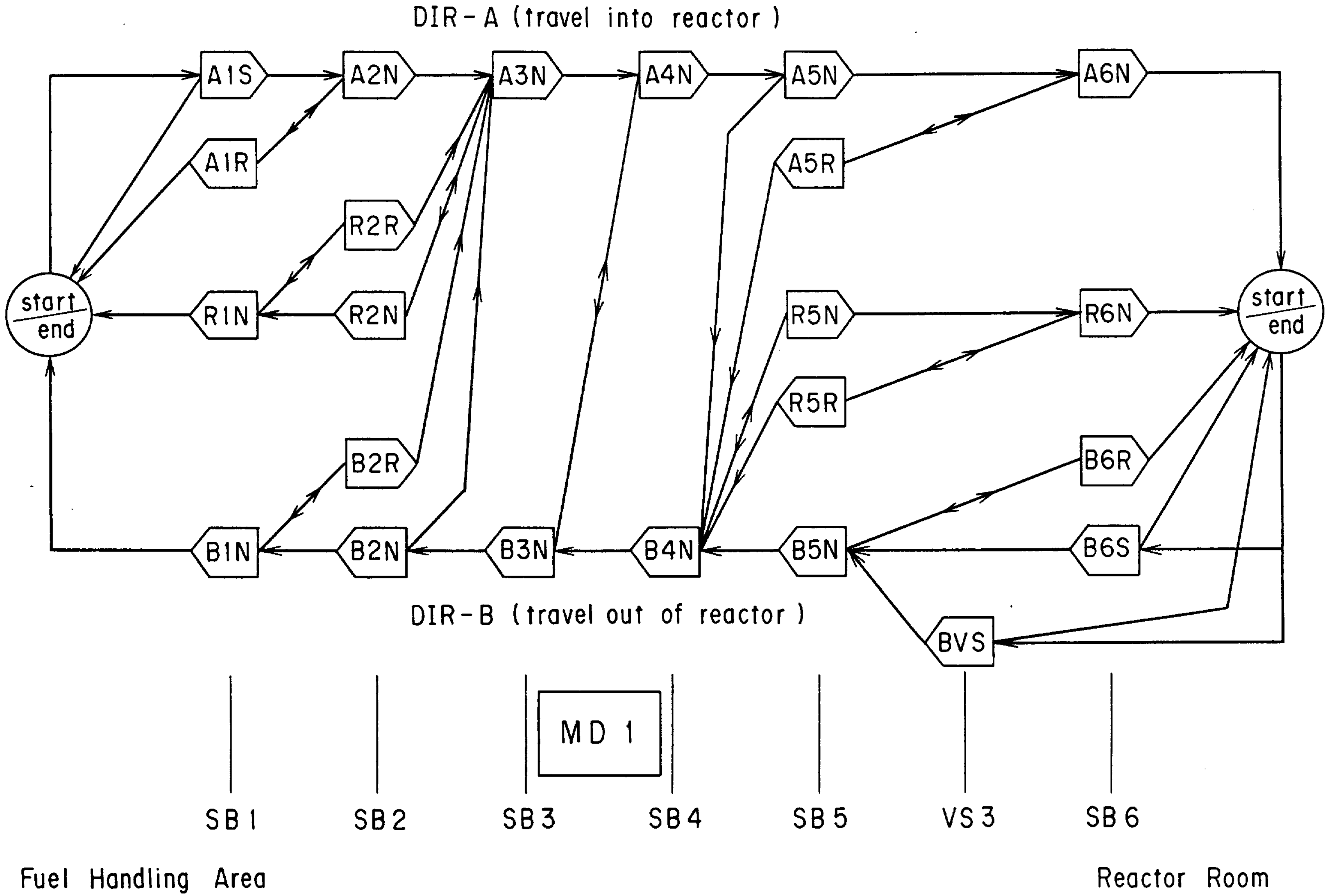
Fig.22 The Schematic Diagram of the Control Unit (PN/M)

Appendixes

(1) The Time Chart for the Passage Scheme of the Portal Monitor.
(2) The Sequential Logic of the Passage.
(3) A List of All Code Designations on the TV Screen of P/M.
(4) A List of All Code Designations on the TV Screen of PN/M.
(5) Seals' Allocation of P/M,PN/M Systems.
(6) The Copy of the Executive Summary of the Final Report.
(7) The Copy of the Letter from J.Jennekens, DDG-SG of IAEA, to J.Shibata of JNSB concerning the IAEA Judgment for the FCA C/S System.



Appendix : The Time Chart for the Passage Scheme of the Portal Monitor



Appendix : The Seqential Logic of the Passage
(Direction－A, B Travel through the Metal Detector)

Appendix : A List of All Code Designations on the TV Screen of P/M

The Interpretation of Labels appearing on P/M Video Scenes.

General Format

□□ 6 5 27/17:32:23

- Label — □□
- Year = 1986 — 6
- Month = May — 5
- Day = 27th — 27
- 17:32:23 — HH:MM:SS

Description

Events	Labels	Remarks
Identification of Split Screen of Camera TCV1/2	CO	Normal status
Camera − TVC1	C1	Normal status
Direction A (travel into reactor)	A	Normal status
Direction B (travel out of reactor)	B	Normal status
Return (turn back on the way of travel)	R	Normal status
Multiple occupancy	MO	
Time over	TO	
Tamper	TP	Can be seal, Video Camera, Wall/Attic or Seal Tamper
Trouble	TR	Video Sensor, Space Sensor, Beam Sensor, AC Power, VTR, Metal Detector, CPU
Metal Detected	MD	MD1-A, MD1-B or ghost MD1-C
Equipment/Emergency Door opened	ED	
Tape End of VTR	TE	

Appendix : A List of All Code Designations on the TV Screen of PN/M

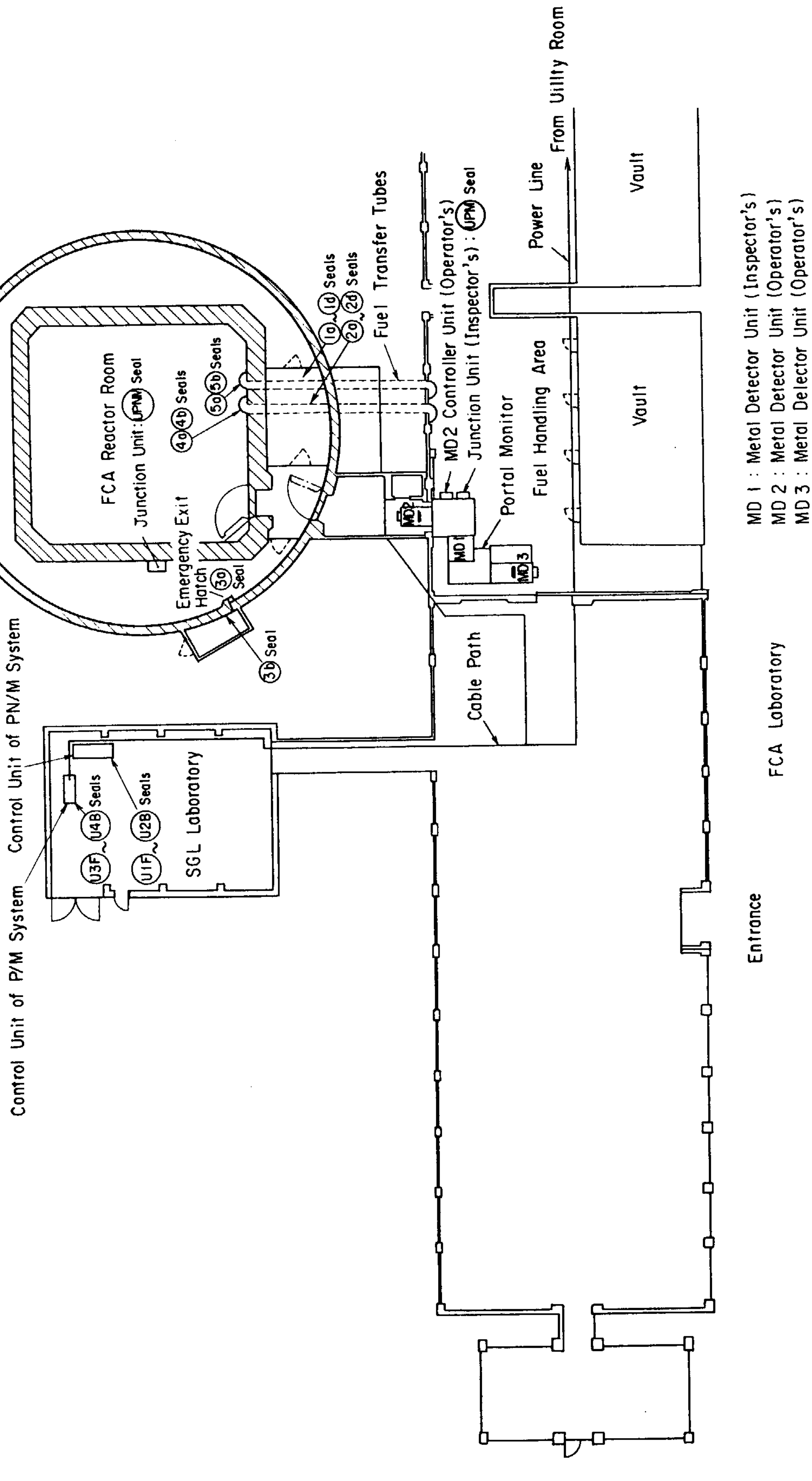
The Interpretation of Labels appearing on PN/M Video Scenes

Label

Label		
□□□ ↑ Cause of triggering of scene	1 7 23/ 10:54:50 Year Month Day Time (HH:MM:SS)	General Format
No indication of label		Normal status (Camera NO.(ex. CI I) is indicated upside of the picture all the time)

Description

Labels	Remarks
S□□ ← Inner / Outer ↑ Space Sensor NO. ex. S1I	Scene triggered by space sensor
V□□ ← Inner / Outer ↑ Same as Camera NO. ex VII	Scene triggered by possible tampering Video Camera (actuated by video sensor)
F□□ ← Inner/Outer/Junction Unit /Control Unit ↑ Seal NO. ex. FIC	Scene triggered by seal
D□□ ← Junction Unit/Control Unit ↑ Door SW NO. ex. DIJ	Scene triggered by door switch
C□□ ← Inner / Outer ↑ Same as Camera NO. ex CII	Scene triggered by attempt to tamper with video line (actuated by video recording switcher)
TR	Trouble (usually means a failure of voltage or equipment e.g. Space Sensor. Video Sensor, Power, VTR, end of Tape etc.
TE	Tape End of VTR (means only for R1IA, R2IA, R1IA, RR2IA)



Appendix : Seals Allocation of P/M, PN/M Systems

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Appendix : The Copy of the Executive Summary of the Final Report

FINAL REPORT

Field Trial - Fast Critical Assembly (FCA) Containment and Surveillance (C/S) System

0. Executive Summary

0.1 Scope

This report assesses the overall performance of the Fast Critical Assembly (FCA) C/S system during its recently completed field trial. It also details the results from the third and last phase of the field trial (Dec.'88 to June 89) the first two phases having been detailed in previous reports [7, 8]*.

0.2 History

The development background of this 11 years old project is briefly summarized in section 3.

A few key points concerning this development history justify emphasis:

1. The C/S system development was initiated by JAERI because it promised to be not only less operator intrusive, but also resource saving for all parties concerned in comparison with the bimonthly RH NDA regime then in effect. The FCA facility attachment (written in 1978) also foresaw such development when it stated that core verification for timeliness by NDA be carried out "until such time as mutually satisfactory containment and surveillance techniques are available".

* Reference numbers cited in this Executive Summary refer to the list of references in the main body of the report.

2. Agency development and operations personnel were involved in system definition and evaluation at each step of the development.

3. An Agency report, STR-175(1) assessing the system was prepared. The report confirmed that the system appeared to save resources for all parties. It further concluded that subject to certain conditions the system "provides a timely means of detecting with high probability the abrupt or protracted diversion of 1 SQ of nuclear material in the form of fuel elements from the reactor room (KMP-B)".

4. An IOM(3) sent to Mr. Tempus and cleared by the director of SGDE and the coordinator of SGOA concluded that again subject to certain requirements the approach described in STR-175 was "acceptable in principle to the Agency".

5. A Field Trial Test Plan(5) was produced which set out to answer the requirements and conditions raised in STR-175 and in the IOM to Mr. Tempus.

   The Field Trial Test Plan indicated that the two primary aims of the field trial were:

   a) To assess whether the FCA C/S system should be put into routine use when judged against the two overall criteria of effectiveness and efficiency.

   b) To try out the inspection, training, performance monitoring, testing, and maintenance procedures that will be necessary when the system goes into routine service.

6. Judgement of effectiveness was to be based on assessment of such factors as

   a) Tamper resistance
   b) Reliability
   c) Completeness of coverage
   d) False alarm rate
   e) Adequacy of self-annunciation of failures

7. Efficiency was to be judged by such factors as

   a) Overall IAEA/Japan inspection effort including time spent by facility operators
   b) Reactor operating time savings
   c) Radiation exposure to all parties concerned
   d) Maintenance cost.

8. The field Test Plan also indicated that in the event of a situation where overall resource gain came at the expense of significant additional Agency manpower expenditure a consensus between Agency and Japanese authorities would have to be reached.

9. During the course of the system development the safeguards inspection activities for timeliness changed from the original bimonthly RH (alternately on EU and PU) to monthly RM on both EU and PU. These latter activities require fewer NDA mandays than were required for the original approach under which the C/S system development was justified.

10. During the field trial a new FCA experimental programme was initiated that required 3 or 4 core changes a year as opposed to the original one per year at PIT time.

11. The field trial due to reasons given in section 3 was conducted in 3 phases. The last of these phases during which 6 running-months were accumulated terminated in June 1989.

0.3 Results of Assessment

1. When judged against the criteria in the Field Test Plan the system is judged to be effective. Details are given in section 6. It should be noted that this judgement is conditional on the provision of independent Agency authentication equipment.

2. When judged against the criteria in the Field Test Plan (and assuming no more than 1* major C/S anomaly per year) the following can be said about efficiency:

   (i) The system would have been efficient (considerable resource saving) in comparison to NDA for all parties under the conditions in effect at the time the development was justified.

   (ii) The system is still resource saving for all parties if the original regime of facility operation is re-instituted (e.g. 1 major core change per year).

   (iii) The system is resource saving for all parties concerned under the current regime of facility operation (e.g. 1 major core change and 2 medium core changes and a 2 months annual FCA machine maintenance) assuming no major C/S anomaly occurs per year. It is very likely that as the system will go into routine-use and the inspectorate will gain more experience or as compliance with C/S performance specifications will permit the Agency to rely more on C/S it has the potential of saving resources to all parties under any regime of operation.

More complete details on the assessment of efficiency are given in section 7.

* It is judged that the number of major C/S anomalies per year can be restricted to no more than 1 if the improvements listed in section 8 are implemented. Each additional C/S anomaly is costly as indicated in Tables 1 and 2 of the main report.

0.4 Discussion and Recommendations

It can be seen from section 14 and reference 23, that for equipment to be approved for routine use the emphasis is on meeting technical, safety, training, maintenance, and documentation requirements.

The technical and safety requirements are usually assessed in a field trial.

If the field trial is successful the required documentation and training programme are then put into place.

Considerations of efficiency, at least to date, have not entered into the approval procedure, since efficiency is very much a matter of conditions of use.

Actual employment of particular equipment items on the approved list is an Operations decision based on its efficiency in competition with other equally effective equipment.

With this in mind the process to approve the FCA C/S system for routine use can be initiated because:

1. The system is judged to meet its technical specifications (e.g. it is effective) subject to certain improvements and presence of Agency authentication equipment detailed elsewhere in this report.

2. The system is judged to be safe, subject to the provision of a safety certificate as outlined in section 10.

3. The training maintenance and documentation programmes have been defined and - given a decision to proceed - can be put in place at the appropriate time.

The decision, however, to proceed to final approval will require the expenditure of significant Japanese, US and Agency resources. These include:

1. Agency Development Division manpower in completing documentation, preparing a training module and in managing the development and testing of the authentication equipment.
2. Agency Operations Division manpower in training and participation in authentication equipment development and testing.
3. JAERI and POTAS expenditures on developing the required authentication equipment (estimated to total 455 K US$).
4. JAERI expenditures in implementing the recommended improvements (cost not known but not insignificant).

None of the above resource expenditures were considered in the original Field Test Plan.

The basic issue to be resolved is the justification for these extra resource expenditures. An important factor to be considered in this decision is the increasing importance of C/S in Agency safeguards. The FCA C/S system is a comprehensive and pioneering development thoroughly tested and completed after long and extensive efforts by all parties. In using the FCA C/S system the Agency can accumulate experience which may be required in the future for using an operator-provided comprehensive C/S system.

A further topic should be the practicality of re-scheduling for re-verification NDA after a major C/S anomaly occurs.

These discussions should also include a review of the likely future regime of facility operation because, as has been shown, this has a big impact on manpower resources expended.

Given that the outcome of these discussions is positive, it is recommended that the remaining steps required to authorize the system for routine use be completed.

Appendix : The Copy of the Letter from J.Jennekens, DDG-SG of IAEA, to J.Shibata of JNSB concerning the IAEA Judgment for the FCA C/S System

INTERNATIONAL ATOMIC ENERGY AGENCY
AGENCE INTERNATIONALE DE L'ENERGIE ATOMIQUE
МЕЖДУНАРОДНОЕ АГЕНТСТВО ПО АТОМНОЙ ЭНЕРГИИ
ORGANISMO INTERNACIONAL DE ENERGIA ATOMICA

WAGRAMERSTRASSE 5, P.O. BOX 100, A-1400 VIENNA, AUSTRIA
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PRIERE DE RAPPELER LA REFERENCE:

DIAL DIRECTLY TO EXTENSION:
COMPOSER DIRECTEMENT LE NUMERO DE POSTE:

412.M2.05-JNT 00374 1990-02-09

Dear Mr. Shibata,

It gives me pleasure to submit to you the Final Report on the Field Trial - Fast Critical Assembly (FCA) Containment and Surveillance (C/S) System which was concluded on June, 1989 for your consideration and approval.

I wish to use this opportunity to express our appreciation to your authorities and to the Japan Atomic Energy Research Institute for the great efforts and expenditure in the development and testing of this unique, pioneering and sophisticated C/S system.

I am glad to add that the major conclusion of the field trial, when judged against the criteria in the Field Test Plan, is that the system is effective, reliable and efficient. These conclusions however are conditional on the provision of independent IAEA authentication equipment and on some improvements as specified in the Final Report attached herewith.

This successful conclusion of the field trial allows me to state that the system is acceptable to the IAEA for meeting part of its safeguards goals at FCA, and will be implemented as such as soon as the authentication equipment has been installed and successfully tested, and the necessary improvement carried out as specified.

./2

Mr. J. Shibata
Director
Safeguards Division
Science and Technology Agency (STA)
2-1-1 Kasumigaseki
Chiyoda-ku
Tokyo 100
Japan

Enclosure

I am looking forward to have this pioneering system used on a routine basis at FCA as a forerunner in a trend of safeguards implementation in modern automated facilities.

I remain sincerely yours

Jon Jennekens
Deputy Director General
DEPARTMENT OF SAFEGUARDS

国際単位系 (SI) と換算表

表1　SI基本単位および補助単位

量	名　称	記　号
長　さ	メートル	m
質　量	キログラム	kg
時　間	秒	s
電　流	アンペア	A
熱力学温度	ケルビン	K
物質量	モル	mol
光　度	カンデラ	cd
平面角	ラジアン	rad
立体角	ステラジアン	sr

表2　SIと併用される単位

名　称	記　号
分，時，日	min, h, d
度，分，秒	°, ′, ″
リットル	l, L
トン	t
電子ボルト	eV
原子質量単位	u

$1\ eV = 1.60218 \times 10^{-19} J$

$1\ u = 1.66054 \times 10^{-27} kg$

表5　SI接頭語

倍数	接頭語	記　号
10^{18}	エクサ	E
10^{15}	ペタ	P
10^{12}	テラ	T
10^{9}	ギガ	G
10^{6}	メガ	M
10^{3}	キロ	k
10^{2}	ヘクト	h
10^{1}	デカ	da
10^{-1}	デシ	d
10^{-2}	センチ	c
10^{-3}	ミリ	m
10^{-6}	マイクロ	μ
10^{-9}	ナノ	n
10^{-12}	ピコ	p
10^{-15}	フェムト	f
10^{-18}	アト	a

表3　固有の名称をもつSI組立単位

量	名　称	記号	他のSI単位による表現
周波数	ヘルツ	Hz	s^{-1}
力	ニュートン	N	$m \cdot kg/s^2$
圧力，応力	パスカル	Pa	N/m^2
エネルギー，仕事，熱量	ジュール	J	N·m
工率，放射束	ワット	W	J/s
電気量，電荷	クーロン	C	A·s
電位，電圧，起電力	ボルト	V	W/A
静電容量	ファラド	F	C/V
電気抵抗	オーム	Ω	V/A
コンダクタンス	ジーメンス	S	A/V
磁束	ウェーバ	Wb	V·s
磁束密度	テスラ	T	Wb/m^2
インダクタンス	ヘンリー	H	Wb/A
セルシウス温度	セルシウス度	℃	
光束	ルーメン	lm	cd·sr
照度	ルクス	lx	lm/m^2
放射能	ベクレル	Bq	s^{-1}
吸収線量	グレイ	Gy	J/kg
線量当量	シーベルト	Sv	J/kg

表4　SIと共に暫定的に維持される単位

名　称	記　号
オングストローム	Å
バーン	b
バール	bar
ガル	Gal
キュリー	Ci
レントゲン	R
ラド	rad
レム	rem

$1\ Å = 0.1\ nm = 10^{-10} m$

$1\ b = 100\ fm^2 = 10^{-28} m^2$

$1\ bar = 0.1\ MPa = 10^5 Pa$

$1\ Gal = 1\ cm/s^2 = 10^{-2} m/s^2$

$1\ Ci = 3.7 \times 10^{10} Bq$

$1\ R = 2.58 \times 10^{-4} C/kg$

$1\ rad = 1\ cGy = 10^{-2} Gy$

$1\ rem = 1\ cSv = 10^{-2} Sv$

(注)

1. 表1－5は「国際単位系」第5版，国際度量衡局 1985年刊行による。ただし，1 eVおよび1 uの値はCODATAの1986年推奨値によった。
2. 表4には海里，ノット，アール，ヘクタールも含まれているが日常の単位なのでここでは省略した。
3. barは，JISでは流体の圧力を表わす場合に限り表2のカテゴリーに分類されている。
4. EC閣僚理事会指令ではbar，barnおよび「血圧の単位」mmHgを表2のカテゴリーに入れている。

換　算　表

力	$N (=10^5 dyn)$	kgf	lbf
	1	0.101972	0.224809
	9.80665	1	2.20462
	4.44822	0.453592	1

粘　度　$1\ Pa \cdot s (N \cdot s/m^2) = 10\ P$(ポアズ)$(g/(cm \cdot s))$

動粘度　$1\ m^2/s = 10^4 St$(ストークス)(cm^2/s)

圧力	MPa(=10 bar)	kgf/cm^2	atm	mmHg(Torr)	lbf/in^2(psi)
	1	10.1972	9.86923	7.50062×10^3	145.038
	0.0980665	1	0.967841	735.559	14.2233
	0.101325	1.03323	1	760	14.6959
	1.33322×10^{-4}	1.35951×10^{-3}	1.31579×10^{-3}	1	1.93368×10^{-2}
	6.89476×10^{-3}	7.03070×10^{-2}	6.80460×10^{-2}	51.7149	1

エネルギー・仕事・熱量	$J (=10^7 erg)$	kgf·m	kW·h	cal(計量法)	Btu	ft·lbf	eV
	1	0.101972	2.77778×10^{-7}	0.238889	9.47813×10^{-4}	0.737562	6.24150×10^{18}
	9.80665	1	2.72407×10^{-6}	2.34270	9.29487×10^{-3}	7.23301	6.12082×10^{19}
	3.6×10^6	3.67098×10^5	1	8.59999×10^5	3412.13	2.65522×10^6	2.24694×10^{25}
	4.18605	0.426858	1.16279×10^{-6}	1	3.96759×10^{-3}	3.08747	2.61272×10^{19}
	1055.06	107.586	2.93072×10^{-4}	252.042	1	778.172	6.58515×10^{21}
	1.35582	0.138255	3.76616×10^{-7}	0.323890	1.28506×10^{-3}	1	8.46233×10^{18}
	1.60218×10^{-19}	1.63377×10^{-20}	4.45050×10^{-26}	3.82743×10^{-20}	1.51857×10^{-22}	1.18171×10^{-19}	1

1 cal = 4.18605 J (計量法)
　= 4.184 J　(熱化学)
　= 4.1855 J　(15 °C)
　= 4.1868 J (国際蒸気表)

仕事率　1 PS (仏馬力)
　= 75 kgf·m/s
　= 735.499 W

放射能	Bq	Ci
	1	2.70270×10^{-11}
	3.7×10^{10}	1

吸収線量	Gy	rad
	1	100
	0.01	1

照射線量	C/kg	R
	1	3876
	2.58×10^{-4}	1

線量当量	Sv	rem
	1	100
	0.01	1

(86年12月26日現在)

DEVELOPMENT OF INTEGRATED CONTAINMENT AND SURVEILLANCE SYSTEM FOR FAST CRITICAL FACILITY FCA –PORTAL AND PENETRATION MONITORS–