THERAPY CONTROLLER DESIGNED FOR PATIENT IRRADIATION AT THE SIN π^--APPLICATOR

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Abstract

The ability to irradiate deep-seated cancers in human patients by using a powerful multientrant pion source is promising. The treatment time to deposit the necessary dose, measured in minutes, seems ideal for the clinical application. But there may be problems ahead if such fast-working, high-intensity equipment is not supervised by safety oriented control electronics. Therefore, human therapy is considered as a two step procedure. The first step, treatment planning, is done by a powerful computer. This computer generates commands and stores them on magnetic tape. In the second step the therapy controller reads, accepts, executes, and tests these commands automatically by using specially made control electronics. Continuous supervision of the pion irradiation is provided by a number of μP. If any malfunction is detected within the therapy control system, the automated treatment will be interrupted.

1. Introduction

Since the commissioning of the 600 MeV proton beam in 1974, radiobiological experiments and dosimetric studies have been carried out at SIN. The double stage cyclotron delivers at present about 40-60 μA of 590 MeV protons to the target stations. However, the available dose rates for these experiments were limited to approximately a few rads per minute.

In 1975, the decision was made to build a new irradiation facility, using a superconducting double wheel spectrometer of the Stanford SMPG-type. This facility represents a powerful experimental tool to study negative pi-mesons for their potential in the treatment of deep-seated cancers. It is planned to perform both radiobiological studies and real clinical patient treatments as well.[1]

The so called Applicator is designed to collect pions, by means of the first superconducting ring, the pions being internally generated in production target by 20 μA protons.[2] The ring is made up of 60 superconducting pancake shaped coils. An additional second magnetic ring directs the 60 individual beams again toward the axis, radially, where the patient is located. Within the Applicator 60 individually operated slits enable the absorbed dose distribution to be matched to the desired shape. The patient will be moved through the pion beam by means of a mechanical couch, which can be very accurately positioned. The maximum available dose rate is calculated to be as high as 50 Rad/min in a cylindrical volume as large as 1 litre. Therapy will typically last a few minutes with this powerful pion facility.

2. Therapy Control System

Since our new facility is designed for patient treatment, the therapy control system has to conform to the basic safety principles of normal radiotherapy practice.

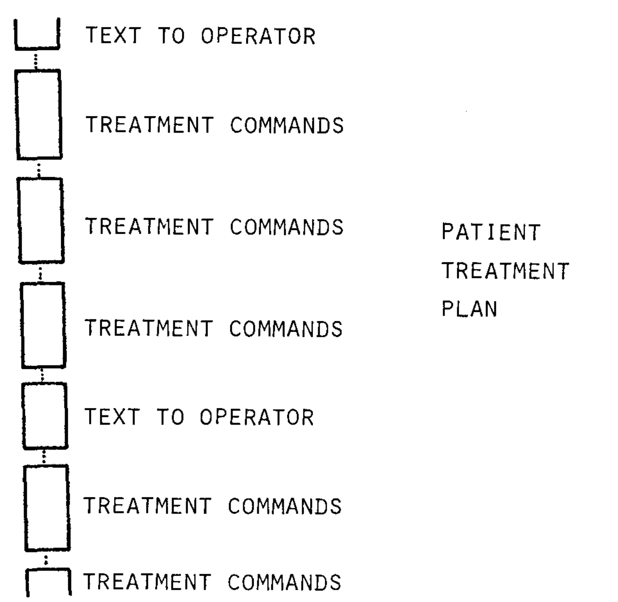
The therapy controller is shown in Fig. 1 with the major functional modules. The system consists of a number of control devices which are interconnected via a high speed data bus (ROAD-system).[3]

It is the function of every control device to receive and execute treatment commands. Since the number of variables is high and the dynamic execution of the command very fast, step by step visual control through the operator becomes impossible. Therefore, the responsibility for correct execution of the human treatment has been automated by the control electronics and its interlock system.

Due to the high intensity multiple beam therapy, the patient treatment program represents a continuous flow of sequential commands. To allow control of the therapy for safety reasons, these commands are not generated in real-time, but rather prepared in advance by the planning computer and stored on magnetic tape. This provides us with additional safety aspects such as off-line computer simulation and checking beforehand of the treatment which is programmed to be delivered to each individual patient.

Therefore the therapy input tape is the common communication base between the medical doctor responsible for the diagnostic and planning work and the medical technician applying the treatment to the patient.

The information string on the tape includes both parameters which might be altered during the treatment and also visual information and text, which has to be displayed to the operator.



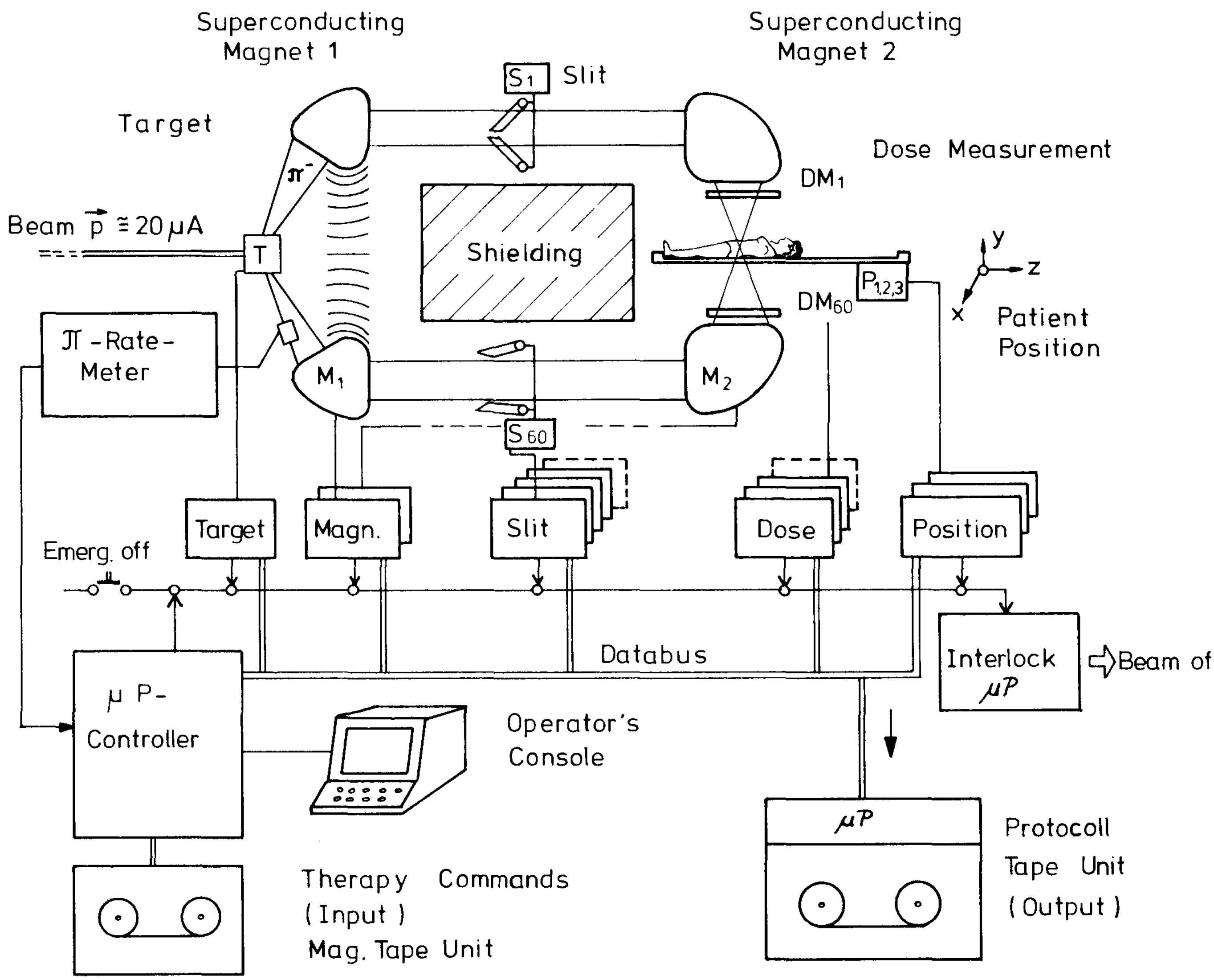


Fig. 1 Therapy Controller For Patient Treatment

The treatment is finally reduced at least in the operator's view, to very few manipulations such as:

- assemble the patient treatment tape into the tape unit.
- control the intial position of the patient.
- start up the automatic therapy program and supervise the messages on the screen.
- the therapy program will either proceed to the end or will stop automatically when a malfunction is detected.
- remove tape if patient treatment is finished. End of therapy.

The safety concept of the therapy is based on the continuous supervision of every datatransfer and every control action during the therapy (Fig. 2). The following techniques are employed to detect malfunctions. The patient file on the tape is made in a predefined format. The therapy controller with the built-in F-8 microprocessor and operating firmware reads and stores the commands by testing the information for correct sequence, parity, wordcount and format. The time base of the treatment is modulated with respect to the pion production rate such that the patient dose remains constant even with slight fluctuations of the pion production rate.

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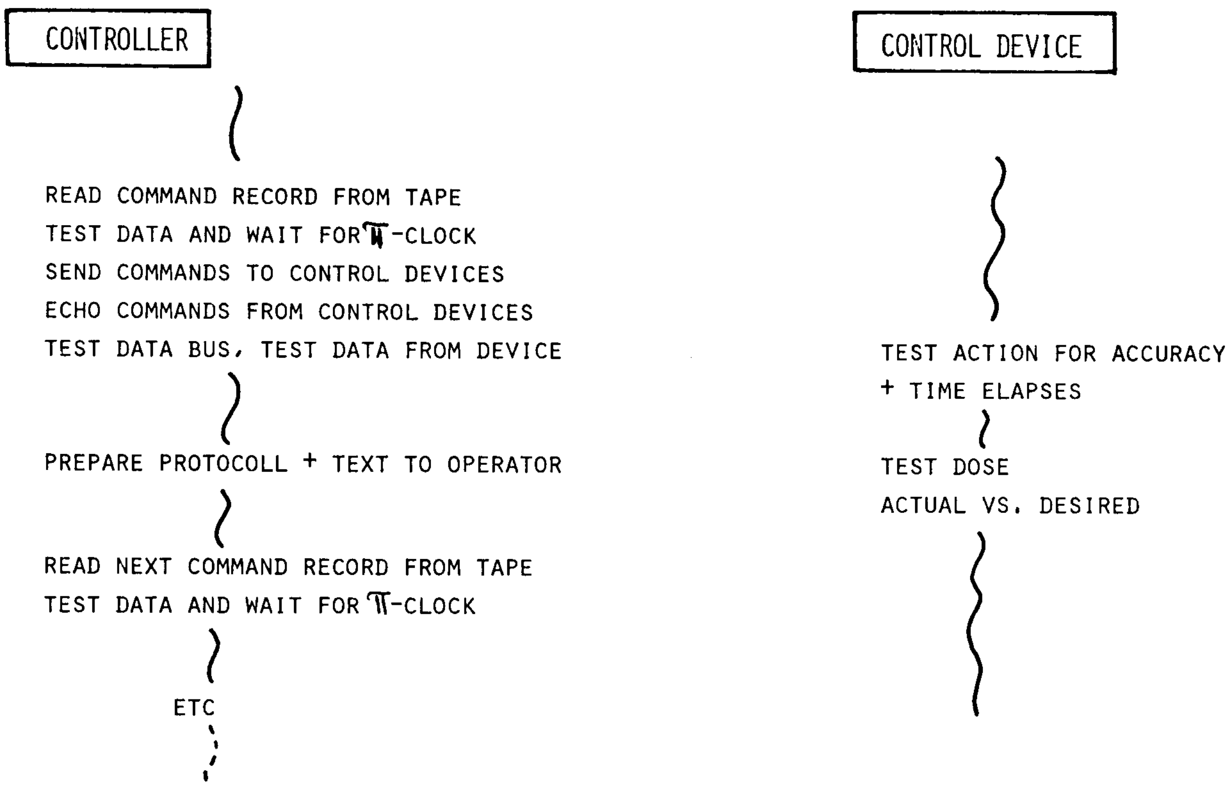

FIG. 2 TYPICAL COMMAND STRING FOR THERAPY

If any of the parameters has to be changed the appropriate command will be transferred from the controller to the control device for execution. The internal structure and speed of the data bus (ROAD) allows practically in the same time the recollection of the commands for echo-checking. Any type of transmission error might be detected and indicated within milliseconds.

The control devices for the therapy are hybrid in nature, utilizing control loops to operate the attached devices as well as supervisory loops for detection of different types of malfunctions. The simplest form of supervision is to compare the desired command against the actual value after the command execution. In addition to that also the response time to the command is tested. (For example any new slit position has to be executed, after the command was received, within 300 msec) Fig. 3.

If any of those conditions monitored by the safety system fails, an interlock alarm will result. The interlock system is capable of switching the beam off and moving the patient to the park position. Following this emergency procedure the alarm message is printed and visual information delivered to the operator.

Unfortunately, pion production will stop at any time that the proton beam stops. In that case, the therapy program will stop instantly and hold its position until the pion production recovers. The operator can also use the "halt" button to interrupt the automatic therapy program when necessary. In this case, the "continue" button will then cause the system to continue the treatment from where it was halted.[3]

The control desk delivers information relevant to the treatment such as patient identification, elapsed time, treatment sequence, accumulated dose, patient position, target identification, proton and pion intensity, interlock conditions, etc.

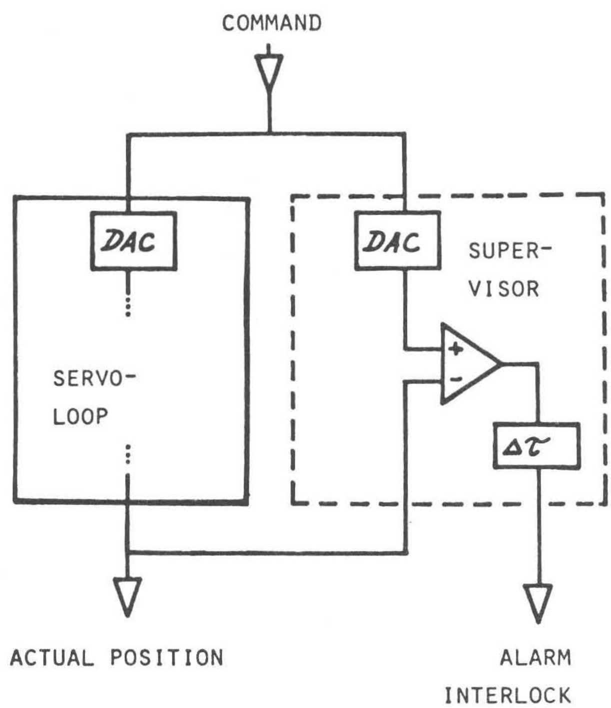

FIG 3

OVERSIMPLIFIED BLOCKDIAGRAM OF CONTROL DEVICE

3. Status of the Project

In the biomedical project, simulated patient therapy with the actual pion beam, as a final test for the control system, is scheduled for approximately Autmn 1979. The basic components such as the controller, data bus, etc. have already been tested with the attached applicator hardware. Extensive testing of the slit system (fig. 4) has been carried out: the slits are adjustable, while operated at very high speeds, within 0.25 secs. One of the slits with heavy copper blades (∿ 30 kg) was lifetime tested and was still operating well after 2 million operations. The interlock-system and the human engineering of the operator's console are not yet finished but well underway.

4. References

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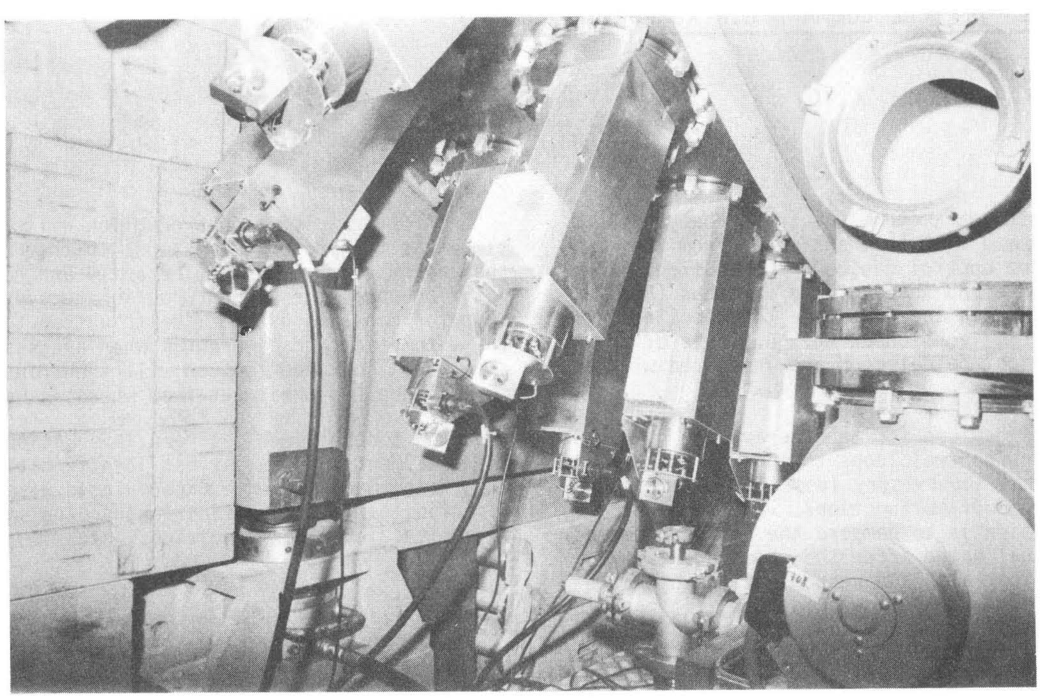

FIG. 4

PARTIAL VIEW OF THE MOTOR DRIVEN SLIT DEVICES

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