COMPUTER CONTROLLED DYNAMIC CINERADIOGRAPHY

O. Fujimura, H. Ishida, and S. Kiritani

The high speed cineradiography can provide very effective means for the study of articulatory movements. There is a difficulty in obtaining useful data because it is hazardous to expose the subject to the x-rays, the dose of which tends to be high for any systematic data collection. The best possible way in principle for minimizing the dose problem is to use the x-ray exposure only when and where it is necessary for deriving immediately useful data. For this purpose, a new radiographic technique of "Computer Controlled Dynamic Cineradiography" has been proposed and preliminary experiments are now under way. The proposed system not only reduces the x-ray dose by a substantial factor but also provides a feasible and effective way for data processing in the study of articulatory movements.[1)2)]

The method employs an on-line digital computer for controlling an x-ray microbeam which is produced by a special x-ray generator. Up to this time, the computer system, an x-ray microbeam generator and an x-ray detector system have been set up and their performances have been tested. Some minor modifications in the x-ray system are also being added in accordance with the results of the tests. Integration of these subsystems into the proposed automatic tracking system is now in process.

Overall Experimental Scheme

Fig. 1 shows a block diagram of the experimental setup employed in the present study. An electron beam emitted from an electron gun is focused by an electromagnetic lens on a tungsten target. A small portion of the radiated x-ray runs out through a pin-hole and forms a fine x-ray beam.[3)] Electrostatic deflection plates are placed between the focusing lens and the target. The deflection voltages that are applied to the deflection plates determine the position of the electron beam on the target and thus control the direction of the x-ray beam. The intensity of the x-ray beam is measured by a detector consisting of a large piece

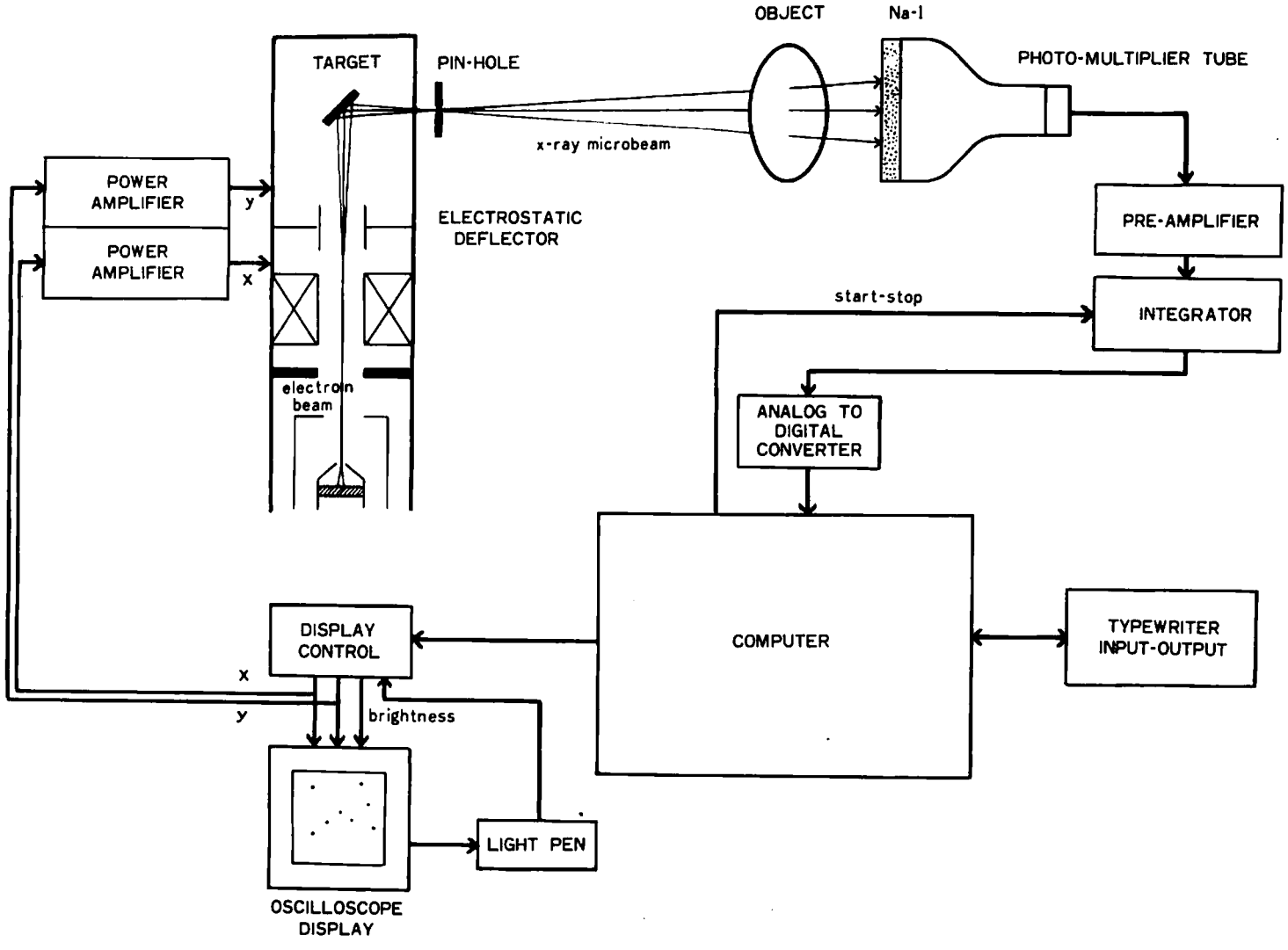

Fig. 1 - Overall experimental scheme.

of Na-I scintillation crystal and a photo-multiplier tube.

The point on the subject to be hit by the x-ray beam is determined by the computer for each moment and the deflection voltages are generated through a D-A converter. At the same time, the output signal of the photo-multiplier tube is integrated for the time interval specified by the computer. This time specification is given by means of start/stop trigger pulses. The digitized value-is then fed into the computer as an intensity value of the x-ray beam that has passed through the specific point of the object. In the present stage of the experiment, tracking of movements of metal pellets which are placed on about ten points on the surface of the subject's tongue, etc. is claimed as the goal. Before trying this scheme on human subjects, several preliminary test procedures are in schedule.

One of the most significant features of the system described above is the flexibility in the control provided by the on-line computer. All sorts of information can be exploited in saving the dose typically by slightly sophiscating the computer programming. This may be substantiated as follows:

(1) The position of a pellet can be predicted to a considerable extent by considering its past movement. Therefore, it is possible to restrict the scanning area of the x-ray beam to a small field around the predicted position. (cf. infra).

(2) In the case of simultaneous tracking of several pellets, there will be correlation between the positions of different pellets, because the possible shape of the tongue, for example, is highly restricted. Therefore, knowledge about the position of one pellet can be used to facilitate detecting others.

(3) The time interval of sampling and also the duration of exposure for one time-space sample can be varied according to the speed of the movement of the pellet, and also depending on observed consistency of the pellet location.

(4) When preliminary knowledge concerning articulatory movements under investigation is available, it can be taken into consideration in computer programming for guiding the pellet-search strategy.

The data of the present observation and the results of analysis can be monitored on the spot by the oscilloscope display. This makes it possible for us to check if the present experiment is worth running from our point of interest. If

not, the exposure is stopped and the source of malfunction is examined or the experiment is replanned.

The data thus obtained can be stored in digital forms and be drawn for further processings whenever necessary. At present, we are not equipped with a magnetic-tape unit, and the data must be kept in paper tape.

Pellet Tracking Program

Tentative computer programs are being written for the automatic tracking of the pellet.

A basic strategy for the pellet tracking is shown in Fig. 2. To find the present position of the pellet, a complete scanning of 5 x 5 consecutive points is tried around the previously detected position. Digitized values of the x-ray intensity signal for all twenty-five points are stored into the core memory. The point of minimum intensity is determined and the coordinates are recorded as the current position of the pellet. At the same time, the detected position together with other data is displayed on the oscilloscope. At the next sampling time for the same pellet, scanning is made around the new pellet position. This process is repeated for an appropriate time interval, and the track of the pellet is displayed. It is found that minimum time that is practically required for determining the position of one pellet is approximately 800 μsec. Consequently, a frame rate of 100 per second for a real-time movie-like display is feasible by tracking ten pellets in a time sharing fashion.

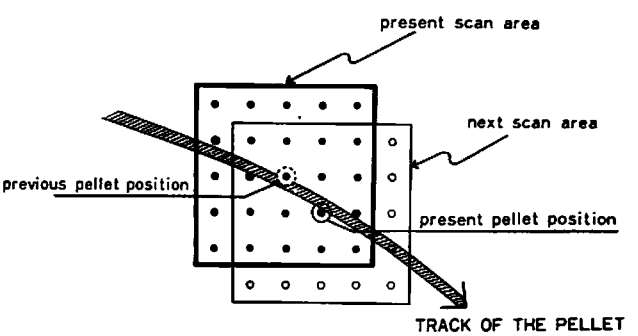

Fig. 2- A strategy for pellet tracking.

Characteristics of the X-ray Generator

In order to carry out the proposed scheme, it is essential to produce an x-ray microbeam with sufficient intensity, so that the outcoming quanta can be measured within the time interval allotted for each scanning point. For the present system, the Micro Focus X-ray Unit manufactured by the Japan Electron Optics Laboratory Co., Ltd. was modified incorporating the electrostatic electron deflecting

system.

An electron beam is produced by a telefocus electron gun and is focused by an electromagnetic lens onto a water-cooled tungsten target. The accelerating voltage of the electron beam is 50-kv. An x-ray outlet pin-hole, 30-micron in diameter, is located at a distance of 35-mm from the target. The position of the object plane of the subject is set at 35-cm from the pin-hole. The swept area on the subject will be 5×10 cm^2 in the first trial stage. The diameter of the x-ray beam will be less than 1-mm at the object plane and the maximum target current of 250-μA will be used for this condition. The present x-ray generator is useful in the pilot study for developing this new experimental technique and collecting data of selected articulatory organs. For fully exploiting the advantage of the computer-combined system in tracking fast articulatory movements in general, it may be concluded that a similar but larger x-ray generator with an acceleration voltage of 150-kv is the most suitable.

This work is supported by PHS Research Grant No. 07233-01 and 07233-02 from the National Institute of Neurological Diseases and Blindness, U.S.A.

References

1) Fujimura, O.: "On the Research Institute of Logopedics and Phoniatrics, University of Tokyo," Japanese J. Medical Electronics and Biological Engineering 5, 53-56 (1967).

2) Fujimura, O.: "Medical Implications of On-line Computer Experiments in Speech Research," The Tokyo J. of Medical Sciences 75, 235-239 (1967).

3) Moon, R. J.: "Amplifying and Intensifying of Fluoroscopic Image by Means of Scanning X-ray Tube," Science 112, 389-395 (1950).