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Health and Safety

AEC Research and Development Report

AUTOMATIC PROCESSING SYSTEM FOR FILM BADGES

by

J. W. Adams

Engineering Assistance Section
Works Technical Department
Savannah River Plant

September 1962

Issued by

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HEALTH AND SAFETY
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AUTOMATIC PROCESSING SYSTEM FOR FILM BADGES

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Approved by
T. C. Evans, Superintendent
Engineering Assistance Section
Works Technical Department
Savannah River Plant

ABSTRACT

A semiautomatic film badge system was developed to process dosimeter film faster and more reliably than the previously used manual method. The films are automatically loaded and unloaded from the badges and marked with identifying numbers, manually developed, and automatically read. The resultant information is punched into IBM cards.

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AUTOMATIC PROCESSING SYSTEM FOR FILM BADGES

INTRODUCTION

At the Savannah River Plant up to 3500 film badges are used each week for measuring employee exposure to beta and gamma radiation. Rapid, accurate film and data processing is required for effective employee exposure control at minimum cost. A study was made of some aspects of the existing film badge system with the objectives of increasing efficiency of operation, increasing data reporting accuracy, and reducing labor cost.

SUMMARY

A film badge handling system was developed to read and record data automatically from personnel dosimeter films. Loading and identification of the films is also handled automatically. To make this automatic processing practical, a new film badge was designed. Film data are punched on IBM cards for calculation and record purposes. Figure 1 shows the principal operations of the new and old systems.

The automatic handling system will process about 200 films per hour, including time for calibration checks and changing of film racks. Its principal advantage over the previous system is the elimination of data transcription errors. Some reduction in operating personnel requirements was also achieved. The system has been in full-scale operation since November 1959.

DISCUSSION

BACKGROUND

The old film badge system was entirely a manual operation. The badge change crews worked two shifts in the field, manually marking and changing the films in the film badges. The used films were then transported to the Health Physics building and processed. Film densities were read manually and converted to personnel radiation dosage by reading a standard calibration graph. The information was transcribed manually to tally sheets. The tally sheet information was then manually punched into IBM tabulation cards. The manual reading, recording, and transcribing were time consuming, costly, and subject to frequent human errors.

OPERATION WITH NEW SYSTEM

With the new film badge system all of the film and badge processing operations have been automated as far as practical (Figure 1). With this new system, each person is assigned two badges, one white and one yellow. While one badge is being worn, the other is being processed. Freshly prepared badges are carried in special racks to the area where they are to be used. The racks of used badges are removed and replaced by racks of fresh badges. At the present time, the badges are changed every two weeks.

Racks of used badges, as they are returned to the Health Physics building from the various locations, are placed in a loader-marker machine for automatic processing. Each badge is automatically moved from the rack to the loading position, the old film removed, new film inserted, a binary-coded number exposed on the film and the badge returned to the rack. The same steps are repeated for each badge. The racks of processed badges are then stored in a cool room until they are needed for the next badge cycle.

In the darkroom, used films are manually stripped of their covering, but loaded into the developing trays automatically. The loaded trays are then processed manually.

After darkroom processing, each tray of films is inserted into the film reader and the reading cycle is begun. Each film is in turn pushed into the reading position where the badge number and accumulated dose are read. Then the film is returned to the tray.

A stepping switch scans the number reading and dose reading systems sequentially and actuates the proper circuits in an IBM card punch to record the information.

FILM BADGE

An important requirement for a practical automatic system was the designing of a new film badge. The old badge was complex and did not lend itself to automatic film changing. The new badge (Figure 2), made of "Zytel 31", holds a standard dosimeter film packet and may be loaded either automatically or manually. The film packet is retained in the badge by small projections located where the corners of the packet are positioned. A one-millimeter-thick silver filter and a two-millimeter-thick aluminum filter are located in the lower portion of the badge. In addition, there is a space for the possible inclusion of another filter, should it be desired. There is also an open window area which allows direct irradiation of the film packet.

A cavity in the front of the badge holds an insert which contains a lead and an indium foil in addition to the plastic laminates (see Figure 2). The wearer's badge number and name are printed on the front of the insert. A series of binary-coded holes punched through the lead-indium portion of the insert allows the badge number to be X-rayed onto the film. The indium foil is to be used for determining neutron dosages of personnel who have had neutron exposure.

The binary code for this system was chosen so that no more than two holes would be required on any line. The design of an insert punch was simplified by limiting the number of holes to be punched at one time. Figure 3 shows the code sequence.

INSERT PUNCH

For identification purposes, it is desirable to identify each piece of film before the badges are released to the field. The identification

must be readable either manually or by machine. This binary-coded information is put on the dosimeter film by X-ray in the form of black dots. Holes for X-ray marking are punched in the badge insert. To punch these holes, it was necessary to design and construct a decimal-to-binary converter and punch (Figure 4). Conversion is made by code bars set at the appropriate decimal numbers. The bars contain teeth at appropriate positions which hold down punch pins. The badge insert is pushed against the pins when the vertical lever is pulled. Those pins which are held down by the code bars penetrate the insert. Those pins which are not held down move freely and do not punch the insert. The open window hole is punched at the same time by a fixed punch.

LOADER-MARKER

The function of the loader-marker (Figures 5 and 6) is to automatically change the films in the badge and X-ray each new piece of film for identification purposes. Whole racks of badges are loaded into the machine at one time. After manual initiation, the whole rack is processed automatically. In the first step, a pneumatic piston rod (Figure 7) pushes the first badge up a slide into the operating position. When in position, a microswitch is closed that starts the film loading sequence. A piece of film from the bottom of the film hopper is pushed into the badge by another pneumatic cylinder displacing the used film. When the used film slides down the exit chute after being ejected from the badge it interrupts a light beam. The interruption is sensed by a photocell which emits a pulse to start the X-ray machine (Figure 8). The machine is then turned on for 0.1 second. While the badge is being X-rayed, some of the radiation is scattered through a slot in the shielding where it is detected by a geiger counter tube. The geiger counter circuit actuates the return cycle which puts the badge back in the rack and resets all the cylinders. The rack lifting mechanism then moves the rack to the next badge location and the cycle is repeated. If there is no badge at the location, the lifting mechanism continues to operate until a badge is in position.

Each step in the process is interlocked with the preceding step. This prevents the re-use of a film and also insures that there is a film in the badge. In the case where an incoming badge is empty, there is a button which bypasses the photocell portion of the cycle and allows X-raying of the new film.

DARKROOM FILM LOADER

To assist in manually loading film into the developing tray slots, a machine (Figure 9) was built which moves the tray ahead when the film is seated. As the film is placed in the slot at the top, a switch is tripped which cocks the drive solenoid. When the film is pushed further, the switch is released and the solenoid drives the tray forward. After 50 films have been loaded, a safe light is illuminated indicating that the tray is full and should be replaced.

FILM READER

The function of the film reader (Figure 10) is to scan the developed dosimeter film and punch out the identification and dose on a tabulation card. The film reader consists of the feed mechanism, the dose computer, and number reader. A block diagram of the circuitry is shown in Figure 11.

FEED MECHANISM

Loaded film developing trays are accepted by the feeding mechanism on an inclined chute (Figure 12). At the presentation point, the film is pushed up into the reading head by an arm powered by a pneumatic cylinder. In the reading head both identification and dose readings are made. When the readings have been completed, the film is extracted and replaced in its slot in the developing tray. The tray is then moved forward to the next position by a ratchet mechanism. At the end of the tray, after the last reading has been completed, the machine is turned off. If no film is pushed up into the reading position, or the film sticks before getting to the correct reading position, the machine will not proceed with the cycle. Operation will be resumed only when the operator takes the proper remedial action. A counter attached to the panel indicates the tray location of the film being read.

DOSE COMPUTER

The dose computer converts the light transmission of the exposed areas of the film beneath the open window and silver filter to $\beta + \gamma$ and γ readings. The photocells (Type 934) are connected so that they operate in a self-generated retarding field (i.e., plate negative with respect to cathode). Output current is proportional to the logarithm of the incident light in the range from 0.3 to 0.2 lumen. Since the transmission density equation $T = C^{-eD}$ is exponential, the output of the photocell is linear with density of the film. The outputs of the cells are fed to separate analog computers (Figure 13) through triode impedance matching stages in series with the zero controls. The cathode follower output is fed into one of the input windings on the "Preac" magnetic amplifier.

Control currents from the span controls are also fed into the input windings. The outputs of each of the amplifiers is filtered to produce a DC voltage. A portion of the output voltage from the γ channel is fed back into the input of the $\beta + \gamma$ channel to compensate for the unequal film darkening effects of the β and γ radiation. The output voltage of each channel is read on a meter calibrated in either mrad or mr dose. If the γ reading should exceed the $\beta + \gamma$ reading because of high energy γ effects on the film, a magnetic amplifier on the output will drive a relay coil and allow only the γ reading to be indicated. The $\beta + \gamma$ and γ voltage outputs are scanned sequentially during the reading cycle and are fed to an analog-to-digital converter. The digital output of the converter drives an IBM card punch through mercury-wetted relays. The mercury-wetted relays are used to electrically isolate the reader from the card punch.

BADGE NUMBER READER

The binary-coded dots appearing on the dosimeter film are converted to decimal numbers by means of the badge number reader. Twenty-four photodiodes, four amplifiers, and a diode decoder matrix are the component parts of the number reader (Figure 14). Four photodiodes for each digit are selected by the stepping switch and connected to the amplifiers. Under normal conditions there is no dot between the light source and the photodiode and the "0" line is grounded through transistor Q_5. If there is a dot between the lamp and the photodiode, the resistance of the diode increases. The change in signal is amplified by transistors Q_1 and Q_2 driving Q_3 and Q_4 on and Q_5 off. The "1" line is then grounded and the "0" line is floating. When all of the amplifiers are operating correctly, only one of the ten lines will be ungrounded and allowed to drive the mercury-wetted relay.

CONTROL SYSTEM

Coordination of the operation of the reader and the card punch, indication of alarm, and the generation of pulses are the function of the control system.

Stepping Switch

The stepping switch is the master programmer for the entire system. It selects the digit to be read, the sequence in which the digits are read, and the order in which the control relays are to function.

Alarm System

When certain preset exposure limits have been exceeded, the machine will either punch an ampersand into the card or stop. Below 300 mr the machine spaces through the last position in the punch field in the tabulating card and continues the cycle. Between 300 and 600 mr an ampersand is punched into the card. Above 600 mr the machine stops and waits for the operator to acknowledge the alarm before proceeding. The machine then causes an ampersand to be punched in the card.

Pulse Generator

The stepping switch is driven by a pulse generator consisting of an asymmetrical flip-flop and a silicon controlled rectifier (SCR). The SCR is pulsed by the flip-flop at 0.5-second intervals for a period of 0.05 second. The pulse width, 0.05 second, allows only one character to be punched in the tabulating card. If the pulse width were greater, more than one punch would appear in the card for the same bit of information.

IBM CARD PUNCH

An IBM type 026 card punch (Figure 15) was modified to receive punch actuating signals from the reader and the IBM control circuitry was changed to operate in conjunction with the reader. The drum-card control circuits were also modified. Short interval (0.05 second) closures of the mercury-wetted relays in the reader actuate the card punch magnets. The keyboard may be used for manual punching if required. Both the card punch and the reader must be in the proper operating position before automatic operation can begin. If during operation the machine should get out of synchronism the control circuits will stop both machines.

OPERATING EXPERIENCE

The automatic film badge system was put into operation in November 1959. Since that time, it has been processing 3000 to 3500 film badges each week. No serious operating or maintenance problems have been encountered during this period.

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Engineering Assistance Section
Works Technical Department
Savannah River Plant

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1. Davis, J. E. Automatic Dose Computer for Radiation Film Badge. E. I. du Pont de Nemours & Co., Savannah River Plant, Aiken, S. C. AEC Research and Development Report DP-471, 12 pp. (April 1960).

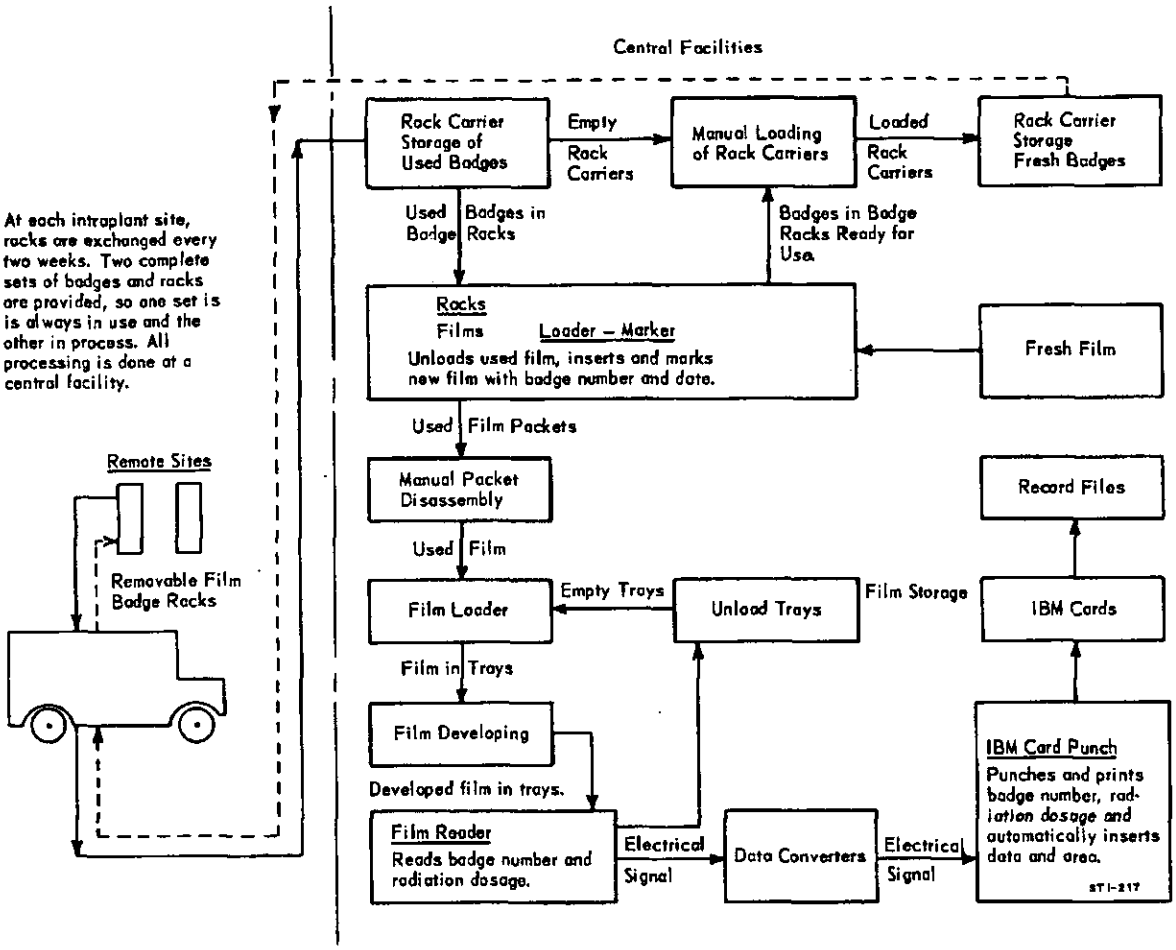

FIG. 1 BLOCK DIAGRAM OF AUTOMATIC FILM BADGE PROCESSING SYSTEM

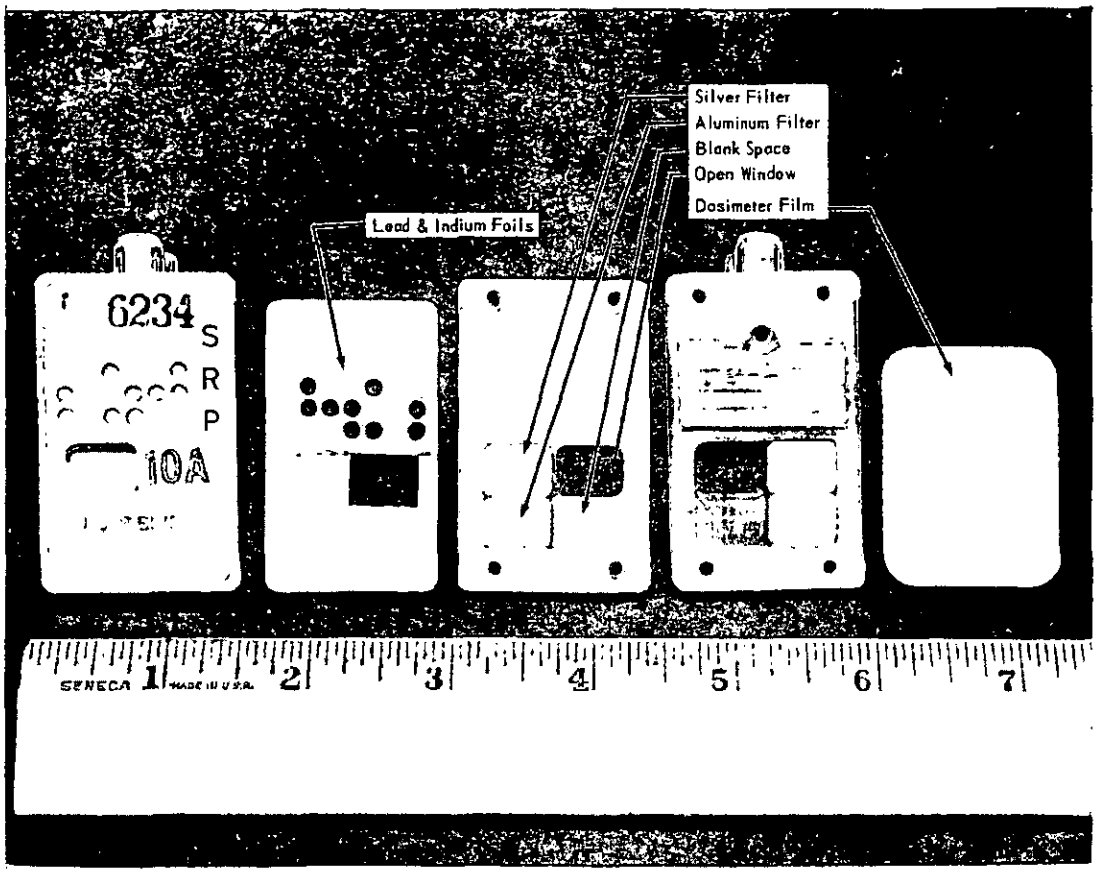

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FIG. 2 NEW FILM BADGE

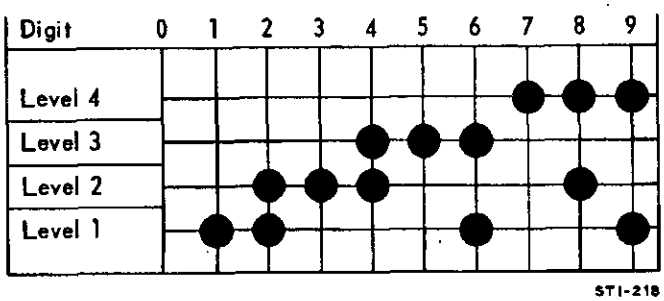

FIG. 3 MODIFIED BINARY CODE

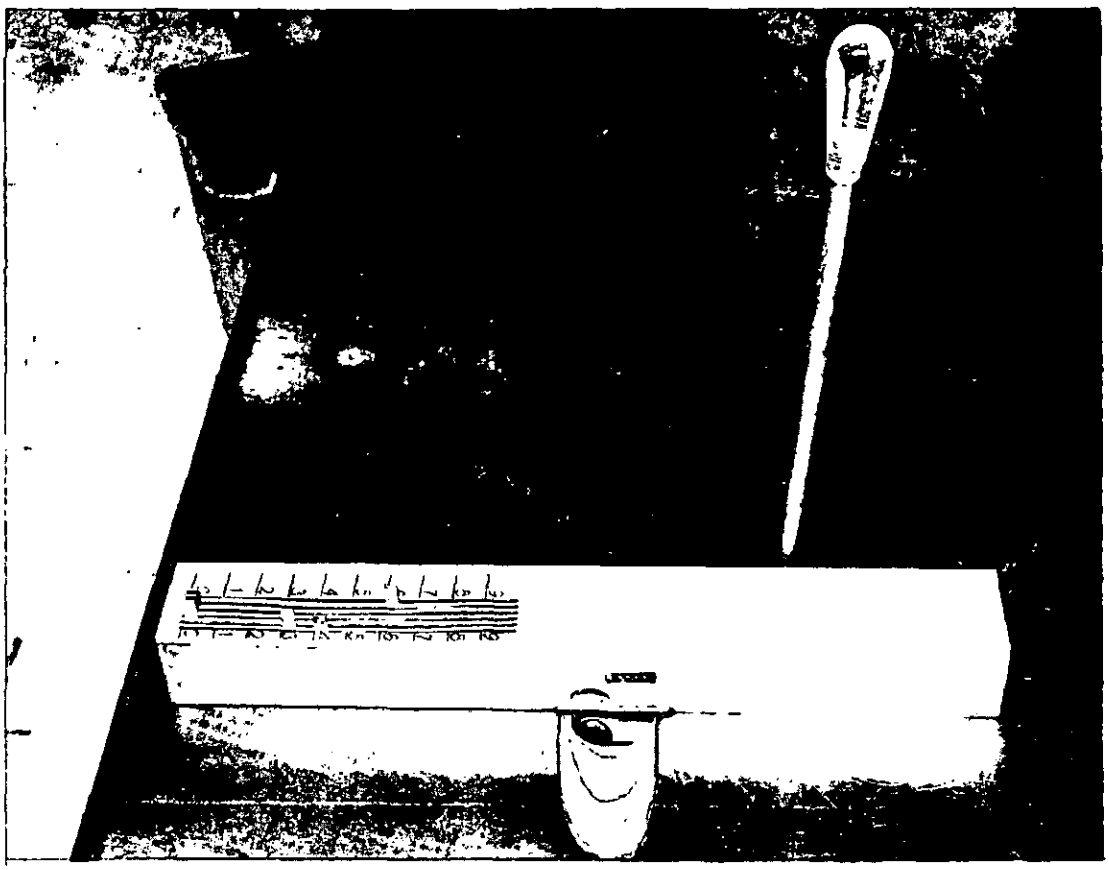

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FIG. 4 INSERT PUNCH

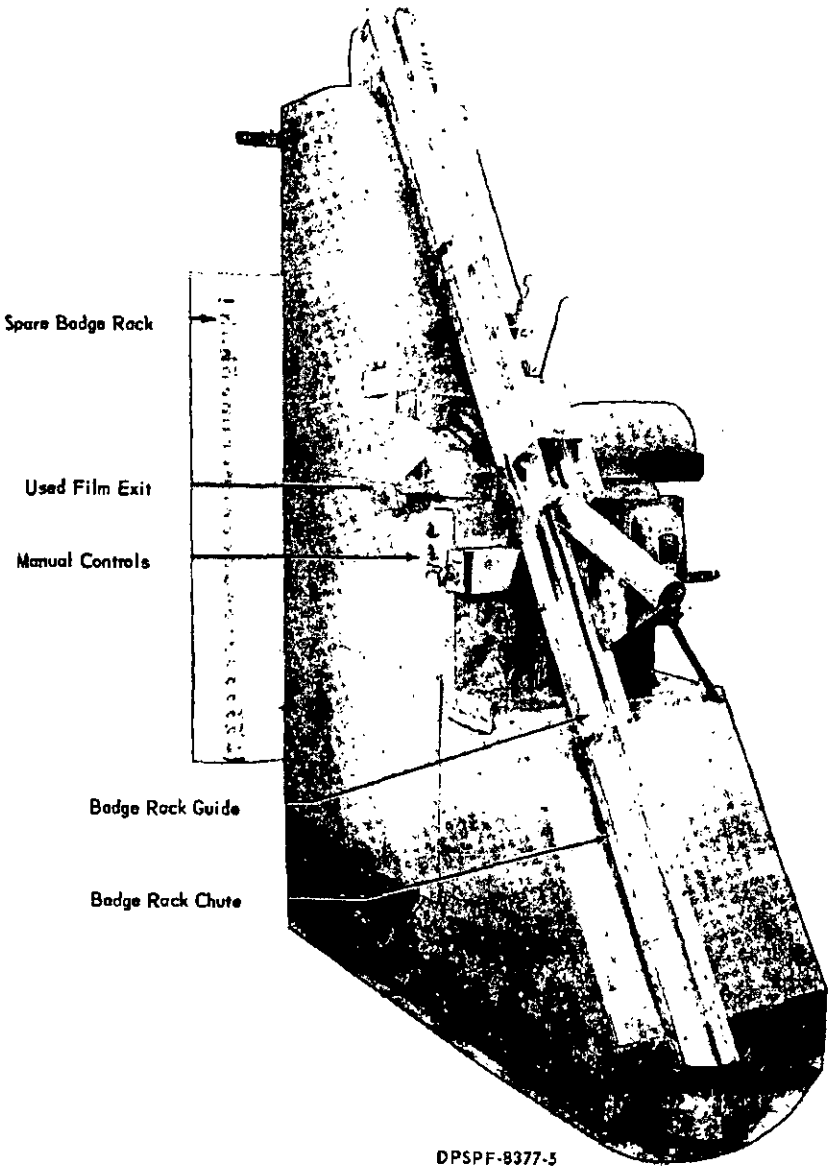

FIG. 5 LOADER-MARKER – LEFT SIDE

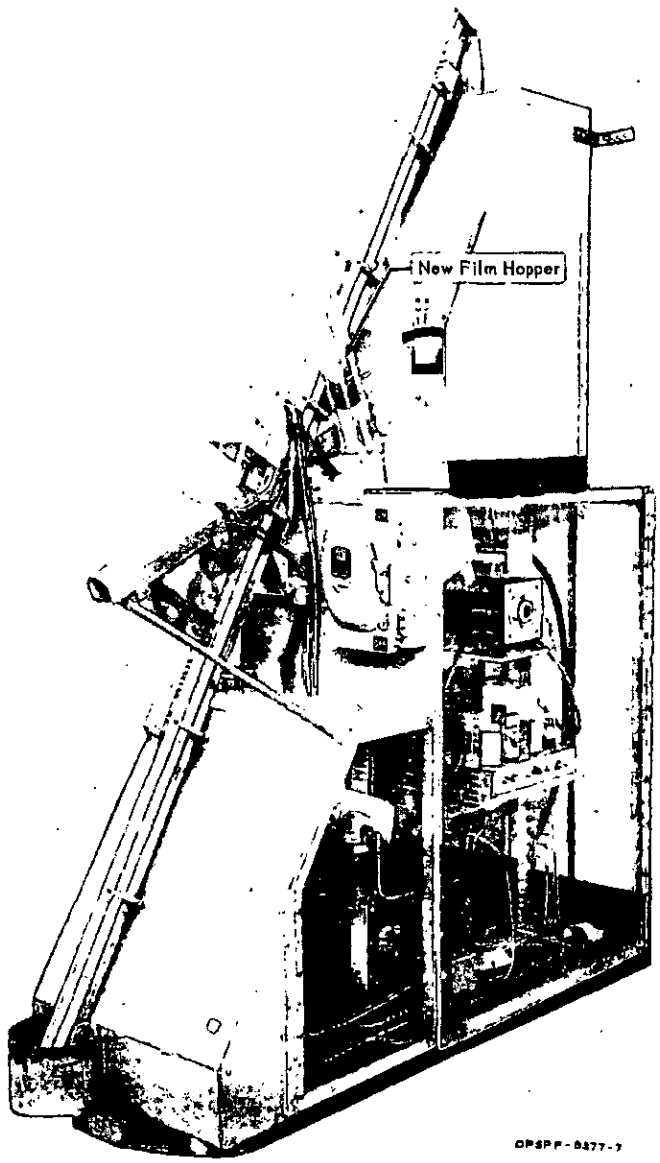

FIG. 6 LOADER-MARKER – RIGHT SIDE

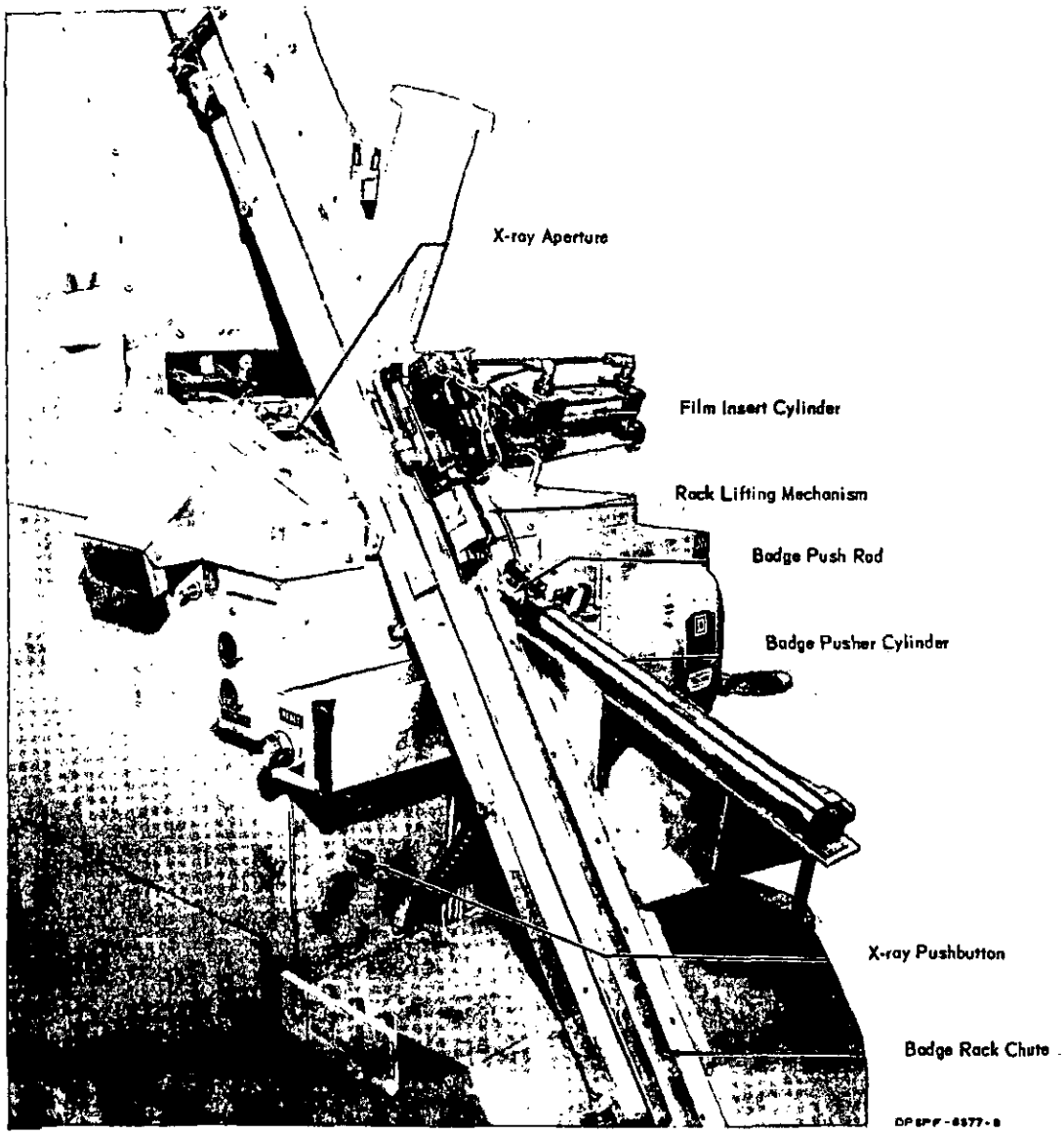

FIG. 7 LOADER-MARKER – LEFT SIDE WITH COVERS REMOVED

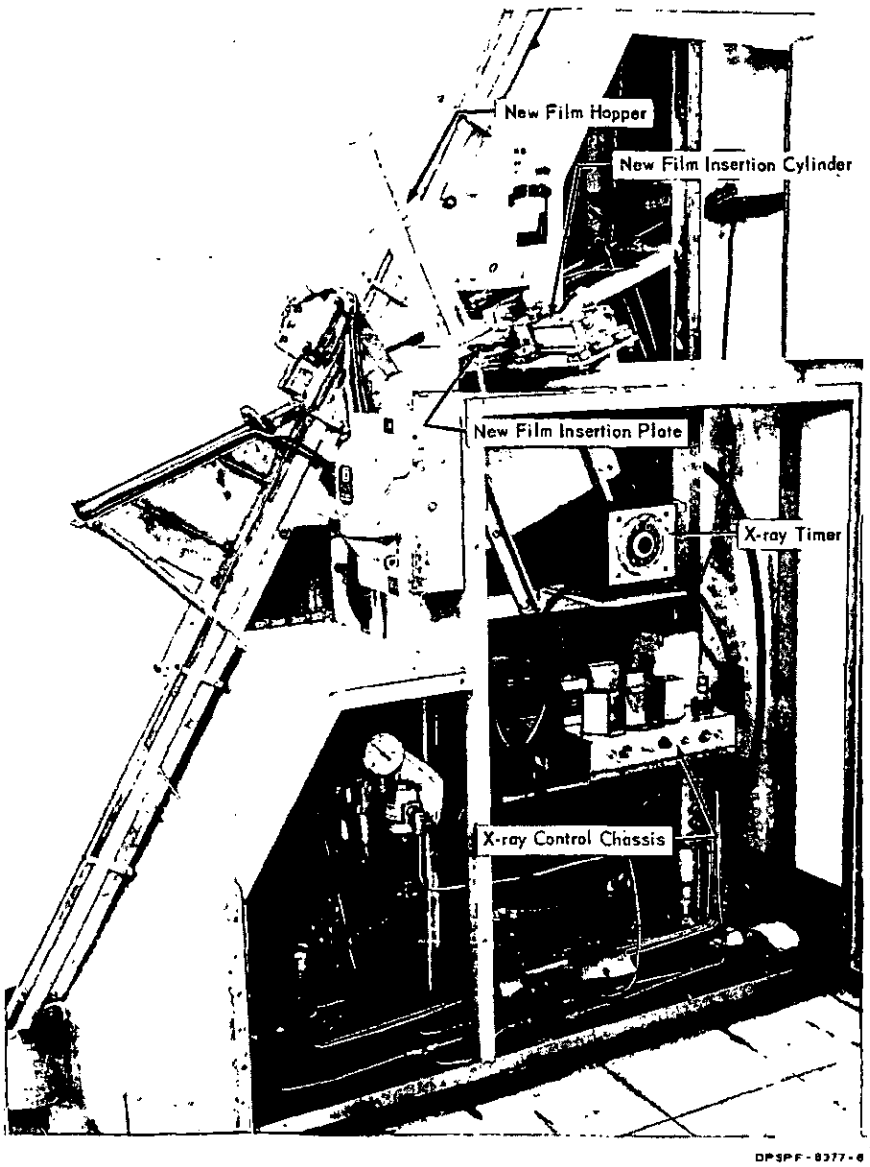

FIG. 8 LOADER-MARKER – RIGHT SIDE WITH COVERS REMOVED

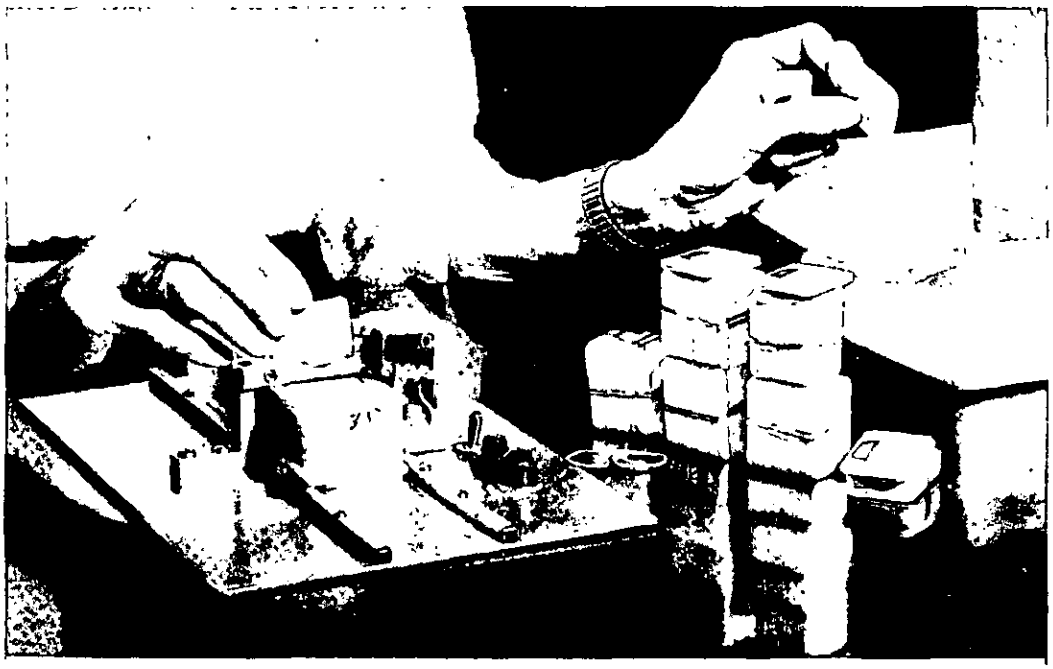

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FIG. 9 DARKROOM FILM LOADER

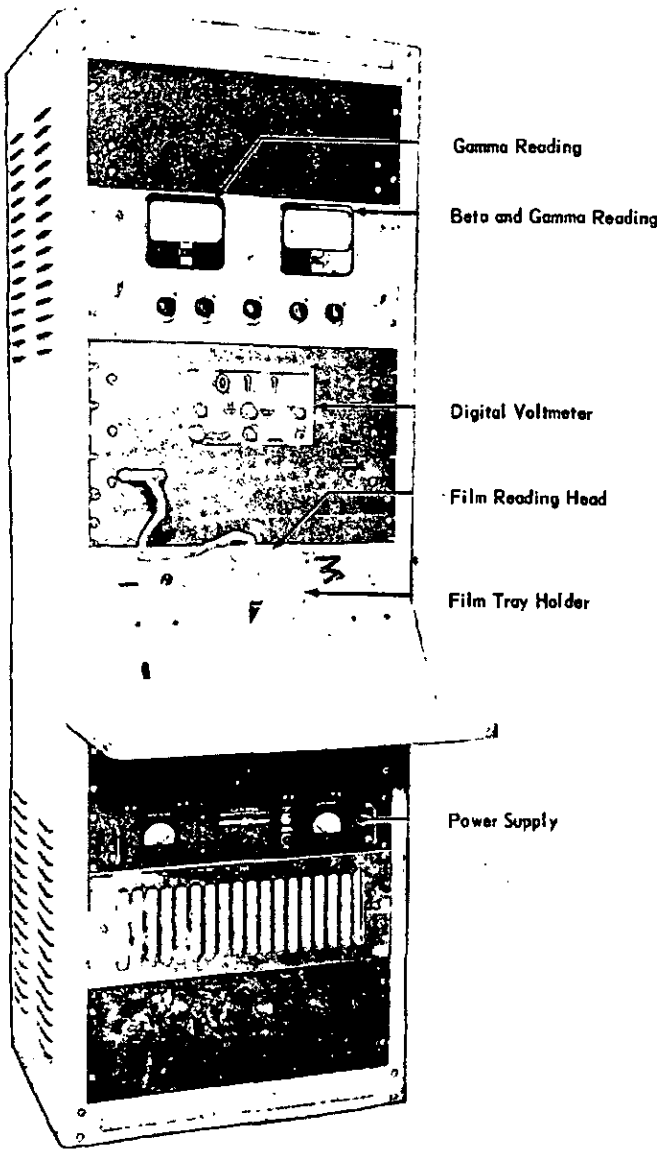

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FIG. 10 FILM READER

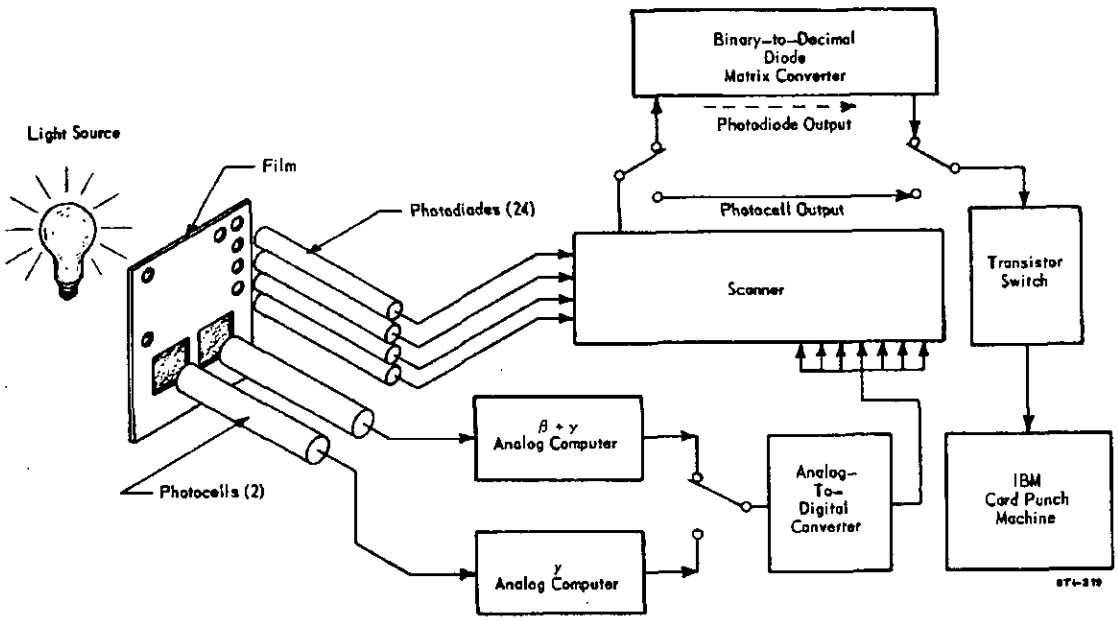

FIG. 11 BLOCK DIAGRAM OF FILM READER SYSTEM

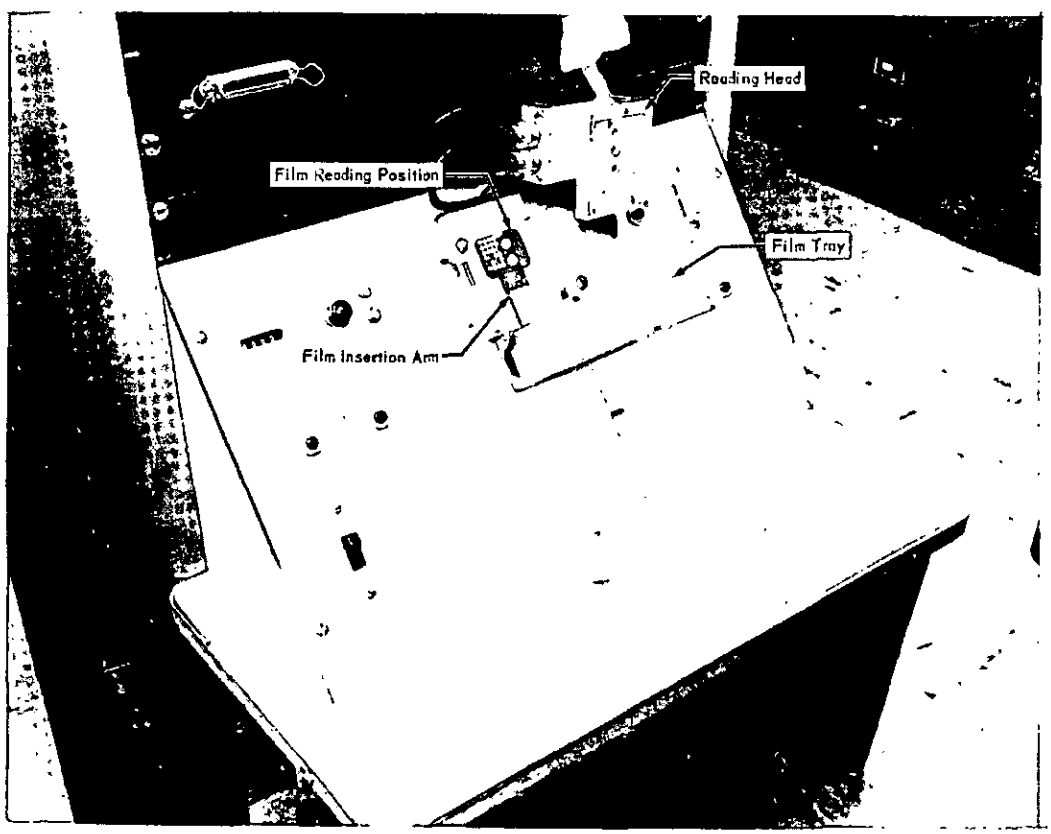

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FIG. 12 CONTROL PANEL WITH READING HEAD
SET ASIDE TO SHOW FILM IN READING POSITION

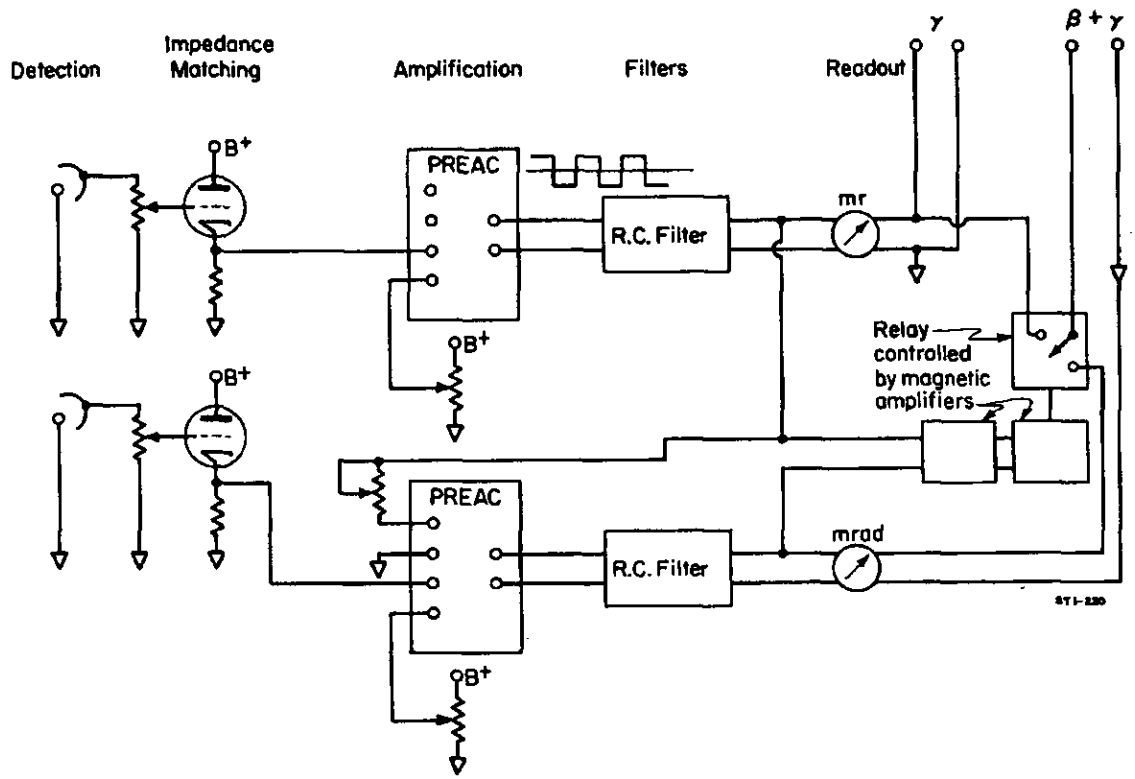

FIG. 13 BLOCK DIAGRAM OF DOSE COMPUTER

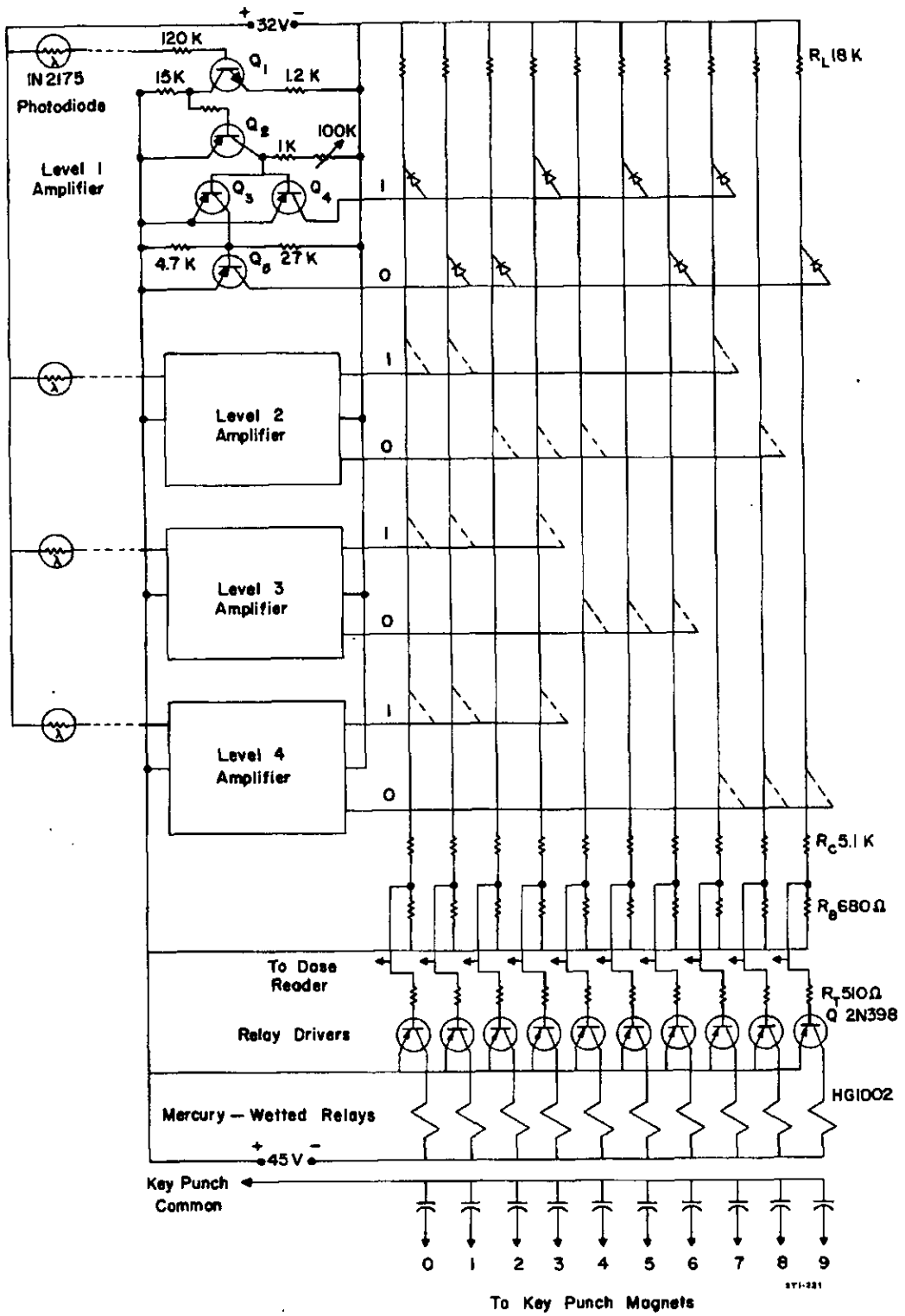

FIG. 14 NUMBER READER SCHEMATIC

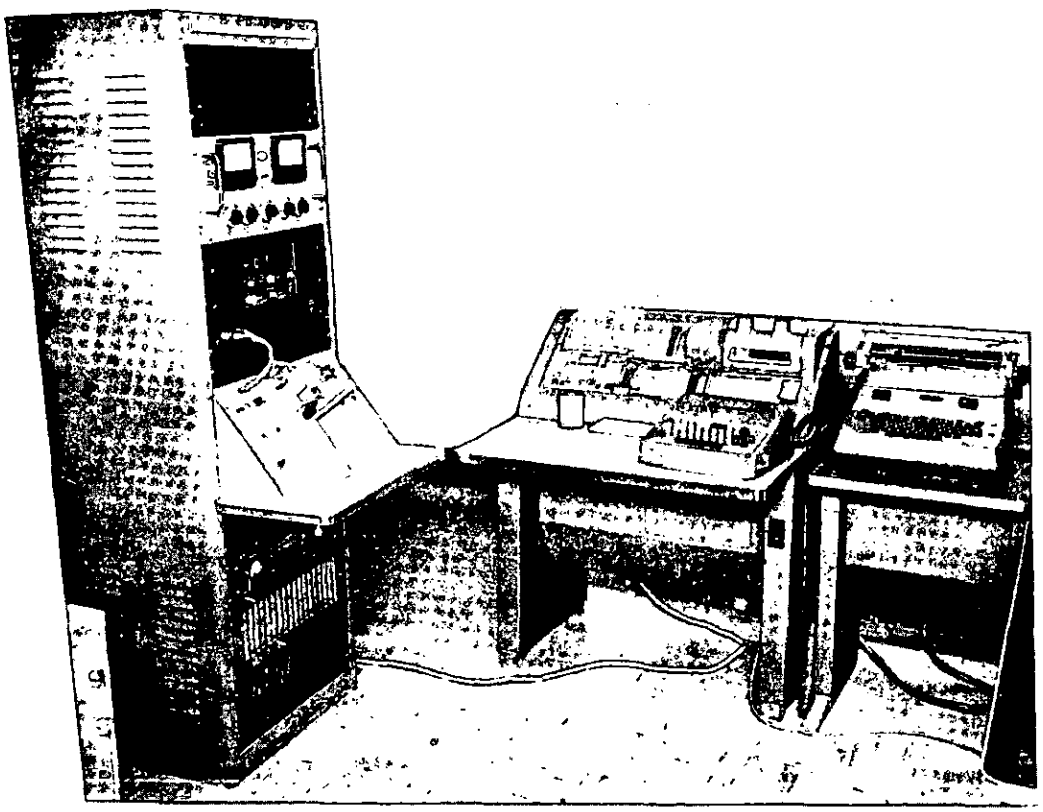

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FIG. 15 FILM READER AND CARD PUNCH ARRANGEMENT

DP 783

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Author(s) J. W. Adams Contract No. AT(07-2)-1

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PARK 4-6311

TELEGRAM ADDRESS
AUGUSTA, GA.

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October 12, 1960

Mr. Hood Worthington, Director
Technical Division, AED
Explosives Department
E. I. du Pont de Nemours & Company
Wilmington, Delaware

Dear Mr. Worthington:

The following unclassified document transmitted by your letter of October 5, 1960, has been reviewed for classification and patent considerations and may be released as proposed:

DP-[illegible] - "[illegible]" - by [illegible]

Mr. O'Rear's office was so notified by telephone this date.

Sincerely yours,

Paul J. Hagelston, Director
Safety & Technical Services Division

cc: W. P. Overbeck, SRL (2)

August 14, 1962

TECHNICAL DIVISION
SAVANNAH RIVER LABORATORY

MEMORANDUM

TO: J. N. WILSON

FROM: J. E. BEACH JEB

DOCUMENT REVIEW

Document:	Report DP-783
Title:	Automatic Film Badge Processing System
Author:	J. W. Adams
Contractual Origin:	AT(07-2)-1
Present Classification:	Unclassified

References:
1) Document Review (dated Oct. 20, 1961) of drawings relating to the Film Badge System
2) Adams, J. W. and C. N. Wright, A Modernized Film Badge System, a paper presented at the Health Physics Society Annual Meeting in Boston, Mass. (June 1960) DPSPU-60-30-6
3) Bancroft, L. C., Automatic Film-Badge Processing, AECL-802, June 1960
4) Davis, J. E., Automatic Dose Computer for Radiation Film Badges, DP-471 (April 1960) OUO
5) Wilhelmsen, et al., Automatic Film Badge Reader, Nucleonics Vol 18, No. 4, pp 84-88 (April 1960)

No items were noted that, in my opinion, should be called to the attention of the AEC for patent consideration.

JEB:pa

CHANGE SHEET

Record on this sheet all changes made to manuscripts after receipt by TIS.

Document No. DP-783

Author J. W. Adams

Title Automatic Film Batch Processing System

Change Requested by JW Adams

Date of change 9/21/62

List details of change and notes below.

DP 783
Pg 5
Line 6 Standard dental x-ray film is used. This statement is not correct. Please remove.

10/23 Title change - held at ps.
corrected - OK'd by JWH, SWO, and JWM

OSR-24-A116

E. I. DU PONT DE NEMOURS & COMPANY
INCORPORATED
AIKEN, SOUTH CAROLINA
(TEL. & TEL. ADDRESS, AUGUSTA, GA.)

EXPLOSIVES DEPARTMENT
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CC: R. M. Poteat, SROO
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M. H. Smith
L. C. Evans - H. Worthington
W. P. Overbeck - J. W. Morris -
S. W. O'Rear - TIS File

T. C. Evans

OCT 3 1962

Mr. P. J. Hagelston, Director (2)
Safety and Technical Services Division
Savannah River Operations Office
U. S. Atomic Energy Commission
Post Office Box A
Aiken, South Carolina

Dear Mr. Hagelston:

PROPOSED PUBLICATION - DP- 783

Attached for review as to classification and patent matter are three copies of the following report:

Automatic Film Badge Processing System
by J. W. Adams

We propose to release the report for standard external distribution.

To facilitate the release of this report, it would be appreciated if you would telephone your comments to W. P. Overbeck's office and send a confirming letter to me with a copy to W. P. Overbeck. The report will be released when approval is received, but not until after 14 days from the date shown above.

If any technical clarification is needed, we suggest you get in touch with

T. C. Evans, Superintendent
Engineering Assistance Section
Works Technical Department
Savannah River Plant

As a possible aid to you in your patent review, we are attaching a document review by J. E. Beach. If you decide to pursue a patent on any development covered in the attached material, I shall be happy to supply additional information required such as appropriate references and the name of the person responsible for the development.

Very truly yours,

Hood Worthington, Director
Technical Division

HW/ pa
Enc.

SWOR

OSR 24-A148 (Rev. 8/62)

EX-1184

bcc: H. Worthington. - L. C. Evans
M. H. Smith
J. W. Morris - S. W. O'Rear
W File

E. I. DU PONT DE NEMOURS & COMPANY
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WILMINGTON, DELAWARE

EXPLOSIVES DEPARTMENT

October 9, 1952

Mr. T. B. Niland, Chief (2)
Classification and S. S. Accountability
Safety and Technical Services Division
Savannah River Operations Office
U. S. Atomic Energy Commission
Aiken, South Carolina

Dear Mr. Niland:

CLASSIFICATION CONSIDERATIONS - DP-733

The above report, "Automatic Film Badge Processing System," by J. W. Adams, which was transmitted to your office by letter of October 3, 1952 from Hood Worthington, has been reviewed for classification.

This report appears to be unclassified by topics 3.1 of CG Doc-74 and 734.1 of the DMA Classification Guide.

Yours very truly,

S. A. McNeight

S. A. McNeight
Technical Assistant
ATOMIC ENERGY DIVISION

SAMcN:hbw

Note to S. W. O'Rear:

This report should be approved by C. M. Patterson before release.

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Report Number DP 15 S C (U) Approved by

Author J. W. Adams

Title Automatic Film Badge Processing System

Automatic Processing System for Film Badges JWM - WPB - SWO 10/23/62

Department Engineering Assistance Section - WTD - SRP

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INTER-OFFICE MEMORANDUM

SAVANNAH RIVER PLANT

CC: J. W. Adams
TPO File

July 25, 1962

(1) G. M. Nichols For technical review. Reviewed JWA 7/30/62

(2) TO: S. W. O'REAR, 773-A

FROM: TECHNICAL PROCEDURES OFFICE
J. E. GREGORY JEG

DP REPORT
AUTOMATIC FILM BADGE PROCESSING SYSTEM

Accompanying this memo is the rough draft of a DP report for TIS processing. The author is J. W. Adams. The draft has been approved by J. W. Croach.

Please call on TPO for any help that we may give in the processing of this report.

JEG:jh