

0354

Report SAM-TR-82-11

AIR1.941130.030d

TEST AND EVALUATION OF SIEMANS HELIODENT 70 PORTARAY FIELD X-RAY UNIT FOR AIR FORCE AIR-TRANSPORTABLE-HOSPITAL USE

Joseph M. Powell, Colonel, USAF, DC
John M. Young, Colonel, USAF, DC
Albert C. Jerman, Colonel, USAF, DC

April 1982

Final Report for Period November 1979 - June 1980

~~Distribution limited to U.S. Government agencies only; test and evaluation of commercial products, 14 December 1981. Other requests for this document must be referred to the Dental Investigation Service, USAF School of Aerospace Medicine~~

USAF SCHOOL OF AEROSPACE MEDICINE
Aerospace Medical Division (AFSC)
Brooks Air Force Base, Texas 78235

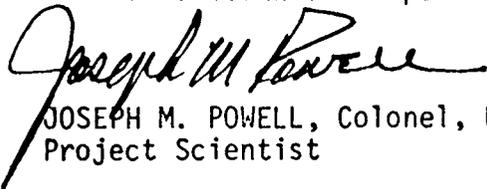


NOTICES

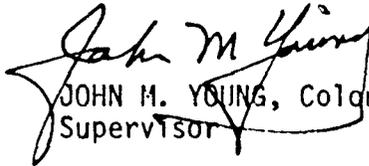
This final report was submitted by personnel of the Dental Investigation Service Branch, Clinical Sciences Division, USAF School of Aerospace Medicine, Aerospace Medical Division, AFSC, Brooks Air Force Base, Texas, under job order DSB38200.

When U.S. Government drawings, specifications, or other data are used for any purpose other than a definitely related Government procurement operation, the Government thereby incurs no responsibility nor any obligation whatsoever; and the fact that the Government may have formulated, furnished, or in any way supplied the said drawings, specifications, or other data is not to be regarded by implication or otherwise, as in any manner licensing the holder or any other person or corporation, or conveying any rights or permission to manufacture, use, or sell any patented invention that may in any way be related thereto.

This technical report has been reviewed and is approved for publication.



JOSEPH M. POWELL, Colonel, USAF, DC
Project Scientist



JOHN M. YOUNG, Colonel, USAF, DC
Supervisor



ROY L. DEHART
Colonel, USAF, MC
Commander

REPORT DOCUMENTATION PAGE		READ INSTRUCTIONS BEFORE COMPLETING FORM
1. REPORT NUMBER SAM-TR-82-11	2. GOVT ACCESSION NO.	3. RECIPIENT'S CATALOG NUMBER
4. TITLE (and Subtitle) TEST AND EVALUATION OF SIEMANS HELIODENT 70 PORTARAY FIELD X-RAY UNIT FOR AIR FORCE AIR- TRANSPORTABLE-HOSPITAL USE	5. TYPE OF REPORT & PERIOD COVERED Final report November 1979 - June 1980	
	6. PERFORMING ORG. REPORT NUMBER	
7. AUTHOR(s) Joseph M. Powell, Colonel, USAF, DC John M. Young, Colonel, USAF, DC Albert C. Jerman, Colonel, USAF, DC	8. CONTRACT OR GRANT NUMBER(s)	
9. PERFORMING ORGANIZATION NAME AND ADDRESS USAF School of Aerospace Medicine (NGD) Aerospace Medical Division (AFSC) Brooks Air Force Base, Texas 78235	10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS 87714F DSB38200	
11. CONTROLLING OFFICE NAME AND ADDRESS USAF School of Aerospace Medicine (NGD) Aerospace Medical Division (AFSC) Brooks Air Force Base, Texas 78235	12. REPORT DATE April 1982	
	13. NUMBER OF PAGES 39	
14. MONITORING AGENCY NAME & ADDRESS (if different from Controlling Office)	15. SECURITY CLASS. (of this report) Unclassified	
	15a. DECLASSIFICATION/DOWNGRADING SCHEDULE	
16. DISTRIBUTION STATEMENT (of this Report) Distribution limited to U.S. Government agencies only; test and evaluation of commercial products; 14 December 1981. Other requests for this document must be referred to the Dental Investigation Service, USAF School of Aerospace Medicine.		
17. DISTRIBUTION STATEMENT (of the abstract entered in Block 20, if different from Report)		
18. SUPPLEMENTARY NOTES		
19. KEY WORDS (Continue on reverse side if necessary and identify by block number) Portable X-ray, dental Field X-ray, dental Air-transportable dental X-ray		
20. ABSTRACT (Continue on reverse side if necessary and identify by block number) The Siemens Heliodent 70 Portaray field dental X-ray unit was evaluated to determine its suitability for use in the Air Force air-transportable-hospital dental module. Test included (clinical) maintenance, and radiation-safety evaluation. The unit proved acceptable for use as an Air Force field dental X-ray device.		

CONTENTS

	<u>Page</u>
INTRODUCTION.	3
METHODS AND RESULTS	9
Radiological Evaluation	9
Biomedical Equipment Maintenance Evaluation	12
Clinical Evaluation	13
Field Observations.	15
Technical Description	15
CONCLUSION.	26
APPENDIX A. PORTARAY ASSEMBLY AND REPACKING INSTRUCTIONS	27
APPENDIX B. ENVIRONMENTAL PROTECTION AGENCY FEDERAL GUIDANCE REPORT NUMBER 9 (SAMPLE).	35

List of Figures

Figure

1. Heliodent 70 Portaray.	4
2. Portaray components.	5
3. Portaray packed in carrying case	6
4. Built-in steel subframe for X-ray unit and chair support	7
5. Heliodent 70 wall-mounted version used for clinical evaluation	8
6. Oscilloscope recordings of high-tension transformer and X-ray detector waveforms	14
7. Portaray unit used in Red Flag Exercise 4.	16
8. Portaray film processor.	16
9. Film processor in operation.	17
10. Heliodent 70 control-unit panel.	18
11. Heliodent 70 control-unit component assembly	19
12. Heliodent 70 control-unit component layout for power and timer circuit.	20
13. Tube-head angulation scale for vertical and horizontal pivots.	22
14. Voltage-doubling circuit	23
15. DC-type waveform production of tube potential.	23
16. Cooling curve; anode	24
17. Cooling curve; tube housing.	24
18. Functional schematic	25
19. Sequence of function	25

TEST AND EVALUATION OF THE SIEMANS HELIODONT 70
PORTARAY FIELD X-RAY UNIT FOR AIR FORCE
AIR-TRANSPORTABLE-HOSPITAL USE

INTRODUCTION

The Siemens Heliodont 70 Portaray Field X-Ray Unit (Fig. 1)¹ was evaluated to determine its suitability for use in the dental module of the Air Force air transportable hospital (AFATH). The Portaray was designed specifically for the transportability necessary for field use. It is completely self-contained (except for an electrical power source) and includes a light alloy and steel carrying case with moisture seal, X-ray head and arm, X-ray chair, support assembly, levelers, control, film processor, and chemicals (Fig. 2). The entire assembly packs into a single carrying case (Fig. 3) for handling and transport. The unit can be set up for field use in 20 to 30 minutes depending upon the experience of user personnel. Setup and repacking instructions are packed with each unit (see Appendix A). The setup assembly is stabilized by a built-in steel subframe for X-ray unit and chair support (Fig. 4). Compensation for setup on uneven sites is possible with adjustable leveling feet (see Fig. 1). The carrying case is padded and compartmented for protection of component parts in transport.

The X-ray chair is of steel-frame construction with plywood seat and backrest covered with expanded vinyl. It is equipped with an occipital pad (prosthetic type) headrest which is adjustable horizontally and vertically. The chair is attached to the case-support system with dual steel-bar-stock members.

The X-ray head is of extruded aluminum and is oil cooled. The tube-head long cone (20 cm (8 in) subject to focal spot distance) is of high-impact plastic. The head is supported by a spring-counter-balanced scissor arm. The control box is of cast aluminum.

A wall-mounted version of the Heliodont 70 (Fig. 5) was installed for test and clinical evaluation of the X-ray unit in the Air Force Dental Investigation Service facility at the USAF School of Aerospace Medicine (USAFSAM). The control, head, and arms of this unit are identical with those of the Portaray with the following exceptions:

a. The Portaray has a line-adequacy digital test instrument (voltmeter) built into the front upper left corner of the control panel. This instrument is used to check field-available electrical power sources for sufficient load potential. The instrument is not required for fixed-facility installation where the electrical source and distribution system is of known load capacity.

b. The Portaray arm does not have the horizontal member needed for extra head reach required in fixed-facility installation. Elimination of this arm segment may enhance X-ray head stability.

¹Manufactured by Siemens Corporation Dental Division, 186 Wood Avenue,
Iselin NJ 08830.

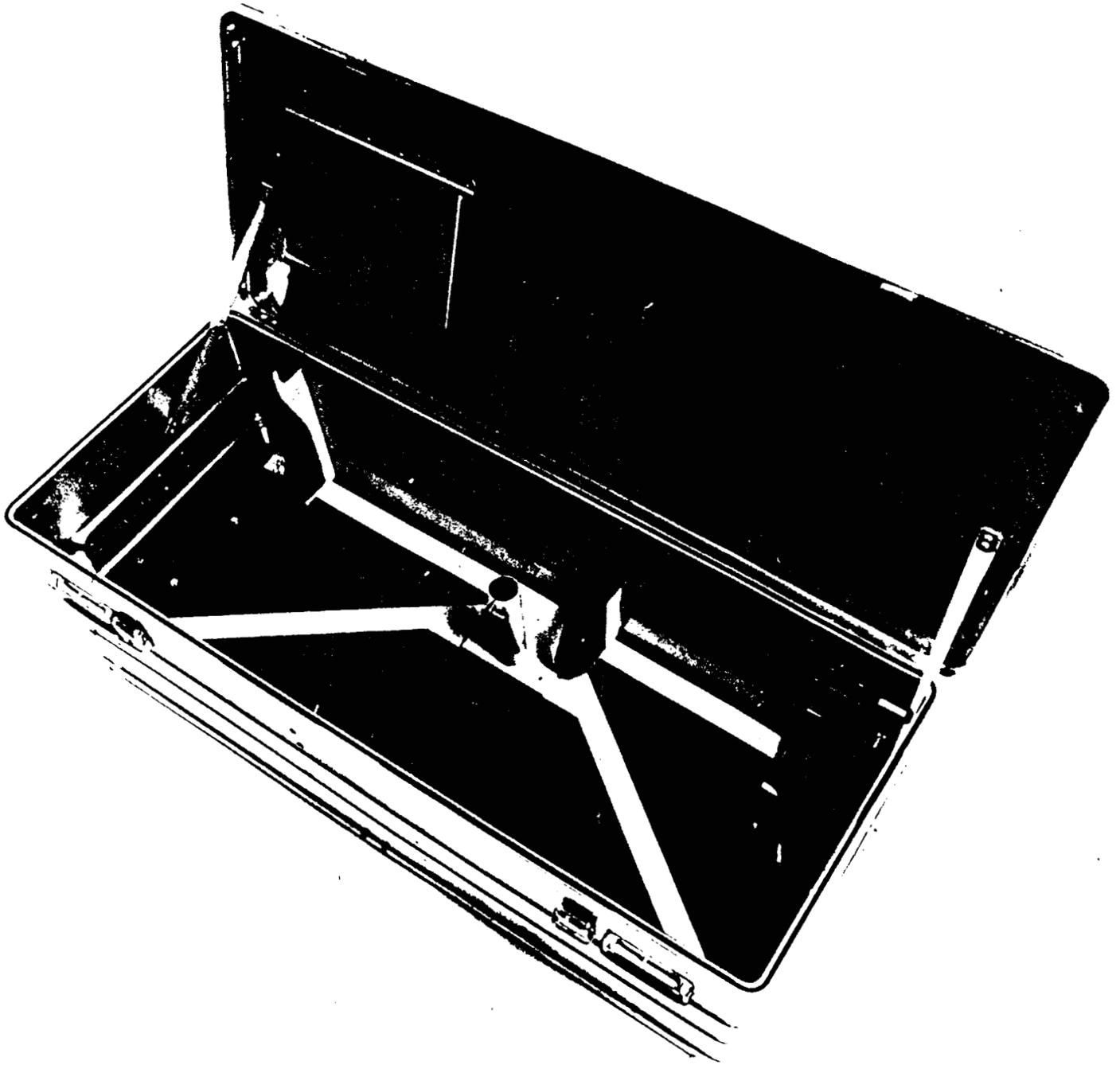


Figure 4. Built-in steel subframe for X-ray unit and chair support.

METHODS AND RESULTS

The unit was first evaluated by the Ionizing Radiation Branch of the USAF Occupational and Environmental Health Laboratory. Their evaluation included safety, leakage, timer accuracy, power reproducibility, tube output, beam quality, collimation, and compliance with Federal Guidance Report (FGR) No. 9 (see Appendix B) for dental X-ray devices.

Calibration adjustments and evaluation for quality of manufacture and ease of maintenance and repair were made by the USAFSAM Technical Services Division, Biomedical Maintenance Function.

The clinical evaluation was 6 months in duration, during which time the X-ray unit was used as the prime source of diagnostic periapical and bitewing X-ray film exposure for support of the USAFSAM Dental Patient Consultation Service. Specific evaluation items were ease of use, X-ray head stability, and film quality. Users provided further subjective evaluation as to adequacy of instructions and function under field use in four Red Flag exercises. During these exercises actual patient treatment was performed under simulated combat conditions.

Technical specifications are taken from appropriate manuals provided by the manufacturer.

Radiological Evaluation

The radiological evaluation consisted of a complete survey covering the facility, user personnel, and the specific X-ray unit. For the purpose of this report, only the data applicable to the item under evaluation is shown in the results. Instruments used in the evaluation were a model 1015 MDH X-ray monitor (measures exposure rate, integrated exposure, and on/off time of the X-ray beam) and a model 440 Victoreen survey meter (measures exposure rate in milliroentgens per hour). The following results are taken from the Radiation Evaluation Report No. 79327.

Safety Check:

	<u>Yes</u>	<u>No</u>	<u>NA</u>
a. Warning label on console clearly visible:	<u>X</u>	___	___
b. Angle of beam indicated:	<u>X</u>	___	___
c. Open-ended-beam limiting or spacer device:	<u>X</u>	___	___
d. Indication of tube selected at control panel:	___	___	<u>X</u>
e. Indication of tube selected at tube head:	___	___	<u>X</u>
f. Does tube head drift or vibrate:	___	<u>X</u>	___
g. Technique factors indicated before exposure:	___	___	<u>X</u>
h. Technique factors visible at operator's location:	___	___	<u>X</u>
i. Visible "beam-on" indication:	<u>X</u>	___	___
j. Audible indication of exposure termination:	<u>X</u>	___	___
k. Deadman exposure switch:	<u>X</u>	___	___

d. Reproducibility:

mA	Measured exposure (mR)				Average exposure
	mR1	mR2	mR3	mR4	
7.5	287	276	284	286	283

Fractional standard deviation (SD): 0.02

e. Is SD less than or equal to 0.05: Yes X No

Tube Output:

a. Technique: mA 7.5 Time 1.0 sec SCD 11.75 in

b. Measurements:

	kV _p	Exposure mR	R/mA-min
1.	<u>70</u>	<u>286</u>	_____
2.	<u>70</u>	<u>287</u>	_____
3.	<u>70</u>	<u>276</u>	_____
4.	<u>70</u>	<u>284</u>	_____
5.	_____	_____	_____

Beam Quality:

a. Technique: kV_p 70 mA 7.5 Time 1.0 sec SCD 11.75 in

b. Measurement:

Filter thickness added (mm Al)	Exposure (mR)
<u>0.0</u>	<u>286</u>
<u>1.5</u>	<u>179</u>
<u>2.5</u>	<u>137</u>
<u>4.5</u>	_____

c. Results:

- HVL: 2.333 mm Al
- Total filtration: 2.6 mm Al
- Minimum acceptable filtration: 2.5 mm Al
- Satisfies requirements: Yes X No Add mm Al

Collimation:

a. Source-to-cone-tip distance (SCTD):

- SCTD measured: 7.9 in
- SCTD greater than 7 in: Yes X No

TABLE 1. PULSE COUNT TEST RESULTS

<u>Timer setting (sec)</u>	<u>Equivalent pulse count</u>	<u>Actual pulse count</u>	<u>Deviation (pulse)</u>	<u>Allowable deviation (pulse)</u>
0.10	6	7	+1	+1 - 2
0.13	8	9	+1	+1 - 2
0.16	10	11	+1	+1 - 2
0.20	12	12	0	+1 - 2
0.25	15	16	+1	+1 - 2
0.32	19	20	+1	+1 - 2
0.40	24	27	+3	+1 - 2
0.50	30	32	+2	+1 - 2
0.64	38	34	-4	+2 - 4
0.80	48	51	+3	+2 - 4
1.00	60	62	+2	+3 - 6

All actual pulse counts fall into the allowable deviation except that recorded for the 0.40-second timer interval. By calculation, the actual pulse count should produce an actual exposure time of 0.45 second. This exposure time is a 12.5% difference over the timer setting (0.40), slightly above the recommended 10% limit imposed by the radiological evaluation format.

Output waveform of the primary transformer and X-ray output detector were recorded simultaneously for 0.10- and 0.13-second timer intervals (Fig. 6). The X-ray output detector waveform shows a lag in output level buildup in the first two exposure pulses. The pulse amplitudes are approximately 43% and 56% of that of the remaining mature pulses. This lag may demonstrate a rise time required for the buildup of current and/or potential in the X-ray tube, but does not appear to be a detriment to unit performance. Apparently the reduced output of these two initial spikes produces usable X-rays since the unit was acceptable in that phase of the radiology evaluation.

The manufacturer-supplied literature was judged excellent in quality of information. Documents included operating instructions, installation instructions, calibration procedures, schematic and wiring diagrams, preventive and definitive maintenance instructions, troubleshooting guide, and complete parts breakdown with exploded-view illustrations.

The unit is constructed primarily of lightweight materials such as cast aluminum and plastics. Steel parts are used in pivot and stress points. The tube-arm distance extension and stability appear excellent. The control box is well designed for easy maintenance access. Troubleshooting calibration and repairs are easily done. After calibration, unit accuracy was well with specifications.

Clinical Evaluation

The clinical phase of the evaluation lasted 6 months. The user personnel were AFSC 98150, skill level 5, dental assistant specialists with an average experience level of 3.5 years. Average workload was 20 films per week. Typical exposure time was 0.5 second.

Operators judged the Heliodent 70 easy to use. No complaint was recorded regarding arm or tube-head drift or vibration. The comparatively small diameter and cylindrical configuration of the tube head enhanced perpendicularity to the film plane when using film holders.

Films were judged to be of archival quality, with good-to-excellent density and contrast. All film exposed were either periapical or bitewing packets. No occlusal or extraoral film was used.

Field Observations

The Heliodent 70 Portaray equipment has been used in four simulated-combat man-casualty exercises in the CONUS and USAFE. Equipment is generally set up in tent shelters (Fig. 7) but is not limited to such cover and level working floor. When set up in tent cover, the unit should be as near as possible to a tent mast because of the scissor-arm height (see Fig. 7). An X-ray barrier wall with lead-glass window must be provided. This is not included with the Portaray assembly, nor is casework to support the film processor included. These items, as they appear in Figure 7, are supplied with the dental module of the AFATH of which the Portaray is a part.

All user comments regarding the Portaray have been extremely favorable relative to transportability, setup, ease of use, and repacking. No negative comments were received.

The Portaray film processor (Figs. 7 and 8) is unique in its film transport mechanism (Fig. 9). An electric motor-driven lead screw moves film clips laterally--raising, lowering, and transporting the film through the chemical-containing trays for development, fixing, and work. Each clip holds three films. The lead-screw drive rate (adjustable) determines development time. The lid of the processor enclosure is cuffed and provided with a safe-light window for daylight loading. Users made no negative comments concerning the Portaray film processor.

Technical Description

Control Unit--Panel controls and indicators for the wall-mount version of the Heliodent 70 are shown in Figure 10. The Portaray version has, in addition, a digital readout (voltmeter) located in the upper left corner of the panel front, to indicate adequacy or quality of the electrical power source. The exposure-time adjustment uses a symbol technique for simplicity. Settings are in 18 increments for film exposure. The Heliodent 70 is set up for ANSI class D ultra-high-speed film but can be adjusted from the front panel for other film speed classes. The control unit has an audible exposure signal in addition to the visual indicator on the panel face.

Modular-type assembly of the control-unit components can be seen in Figures 11 and 12. The unit is equipped with a control transformer (item 1, Fig. 11) which receives and compensates the electrical power supply within a range of 106 to 135 VAC to supply a constant primary of 125 VAC to the unit. The line-compensating rotary switch (item 2, Figs. 10 and 11) is used to center the indicator (item 3, Figs. 10 and 11) to provide line compensation.

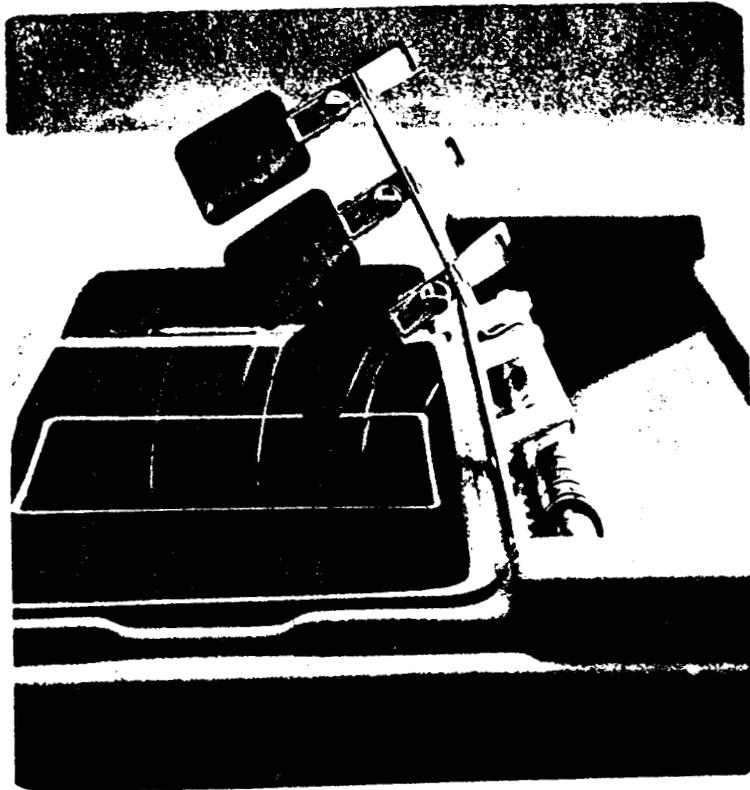


Figure 9. Film processor in operation.

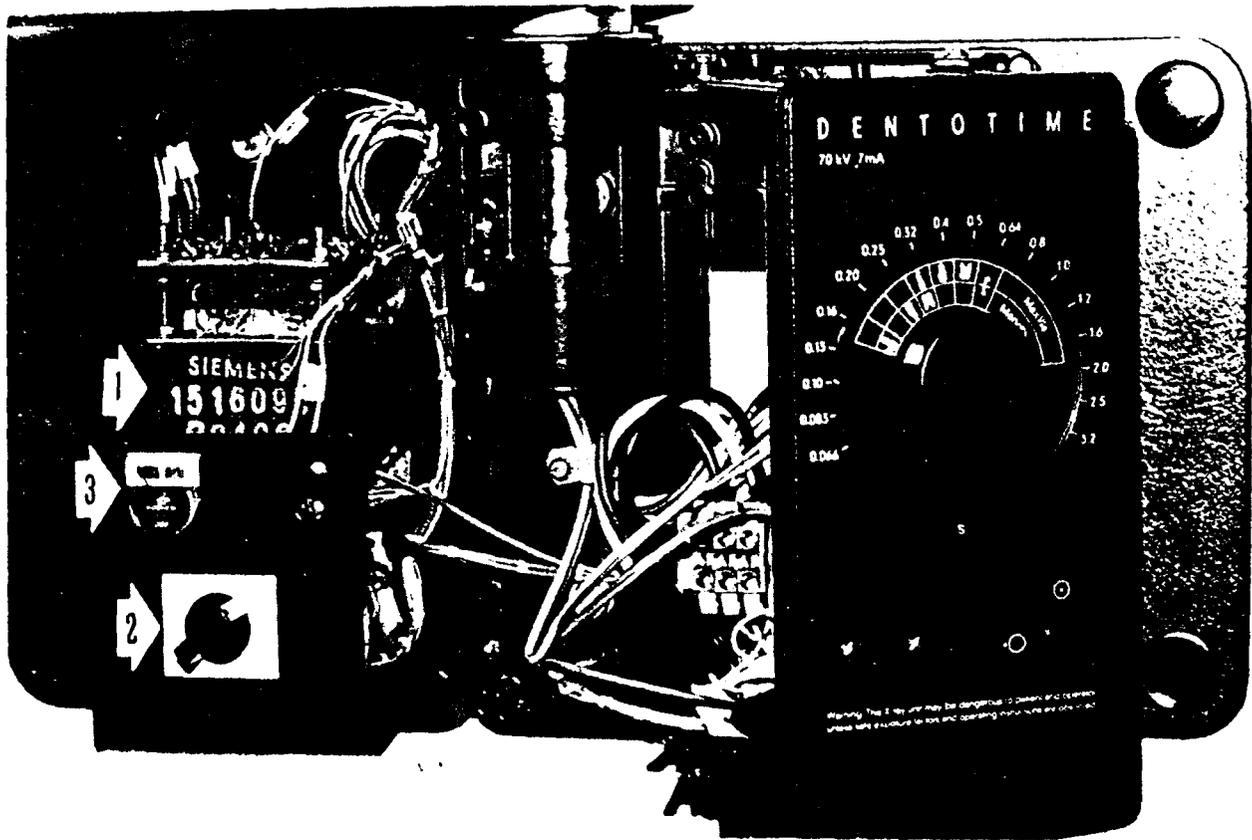


Figure 11. Heliodent 70 control-unit component assembly:
(1) line-compensation transformer
(2) line-compensation switch
(3) line-compensation indicator

Extension Arms--The extension system consists of two vertical segments pivoted from the top of the control unit (Fig. 1). The arm system swivels 180° about the pivot, and the suspended tube head has vertical-movement range of 0.89 m (35 in). The arm system has a horizontal reach adequate to position the tube head for any patient position in the assembly chair. Internal springs provide tension for the scissor-action arm system. The tension is adjustable to prevent vertical drifting of the tube head. To provide lateral tube-head stability, an adjustable brake acts upon the arm-system pivot axle within the control-unit enclosure.

Tube Head--The tube head has a horizontal range of rotation through 540° (1.5 turns) and a vertical range of 300° (stops 30° each side of vertical). Scales are provided for vertical and horizontal tube-head angulation (Fig. 13).

The tube has a grid-controlled stationary anode with an 0.8- x 0.8-mm focal spot. The secondary circuit in the tube head forms a voltage-doubling circuit (Fig. 14) to maximize the DC-type (Fig. 15) tube potential. The negative half of the transformer voltage wave charges the capacitor first. The positive half of the wave is folded and added to the capacitor charge, resulting in a tube potential nearly twice that of the original half-wave voltage. The nominal tube current and peak tube potential are fixed and are 7 mA and 70 kV_p respectively. The tube head is oil cooled and is equipped with a safety expansion membrane. Tube duty cycle is 1:60 in seconds (80 sec off for every 1 sec on) with a minimum cooling time of 20 seconds. Cooling curves for the anode and the tube housing are shown in Figures 16 and 17. An aperture diaphragm in the base of the head cone limits the X-ray beam to a 6-cm diameter on the skin. The source-to-skin distance is 20 cm. Total filtration in the useful beam is 2.7 mm of aluminum. The manufacturer's reported dose rate at 70 kV_p and 7.0 mA is 700 mR/sec ± 150 mR/sec.

Description of Function--The Heliodent 70 is equipped with three transformers (see Fig. 18): T3, the control transformer which supplies power to the entire unit; T1, a step-down transformer which supplies 22V to power the timer and other solid-state components; and H1, the high-tension transformer in the tube head, which provides the tube potential. When the exposure switch (S27) is depressed, the entire unit circuitry is powered. The base current in transistor V14 in the Schmitt Trigger causes relay ER to close (see Fig. 19 for time sequence). When relay ER is closed, a dampened voltage is placed on the high-tension transformer (H1) through the voltage-dividing resistors R18 and R20. At this point the audible (SU) and visual (B2) exposure indicators are turned on. These indicators will stay on for the duration of the exposure, as long as the exposure switch (S27) is closed. During the next 150-250 ms the cathode heater warms up and after approximately 350 ms causes tube current to flow (Fig. 19). As soon as the tube current reaches a predetermined value, relay AR is closed, triggering the time circuit (R10, C3, V12, and V14). At the same time, relay AR drops the voltage-dividing resistors R18 and R20 out of the circuit and allows H1 to draw 125 VAC undampened. When capacitor C3 in the time circuit is charged to the value set on the Schmitt Trigger (time setting), the relay ER is opened, terminating the exposure. Relay AR remains closed until the exposure switch (S27) is opened. Points D1.9 and D1.10 are provided for measuring the tube current in service procedures. In case of component failure where no tube current is available to trigger the timer through relay AR, a charging capacitor activates transistor V6, in 0.7-1.0 second, and triggers the time circuit.

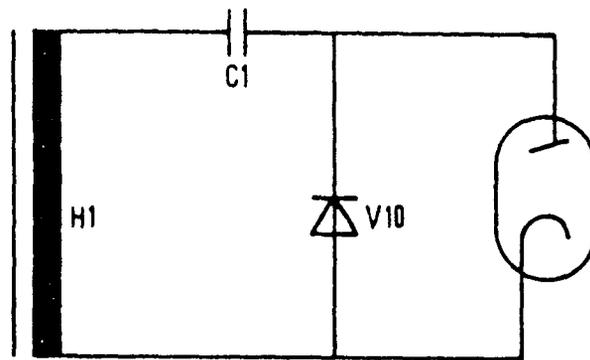


Figure 14. Voltage-doubling circuit--H1: high-tension transformer; C1: capacitor; V10: diode.

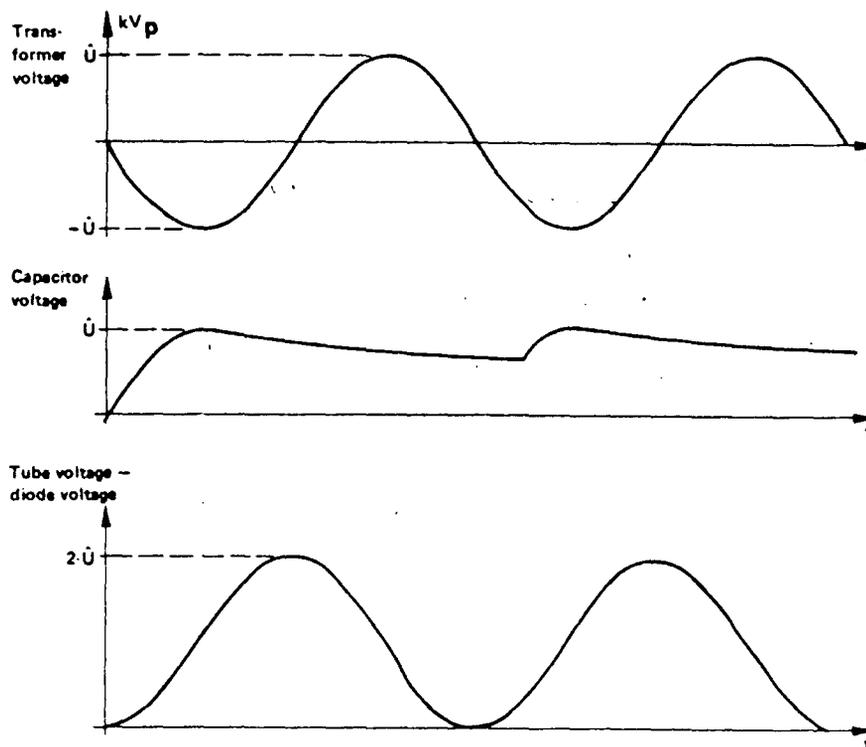


Figure 15. DC-type waveform production of tube potential.

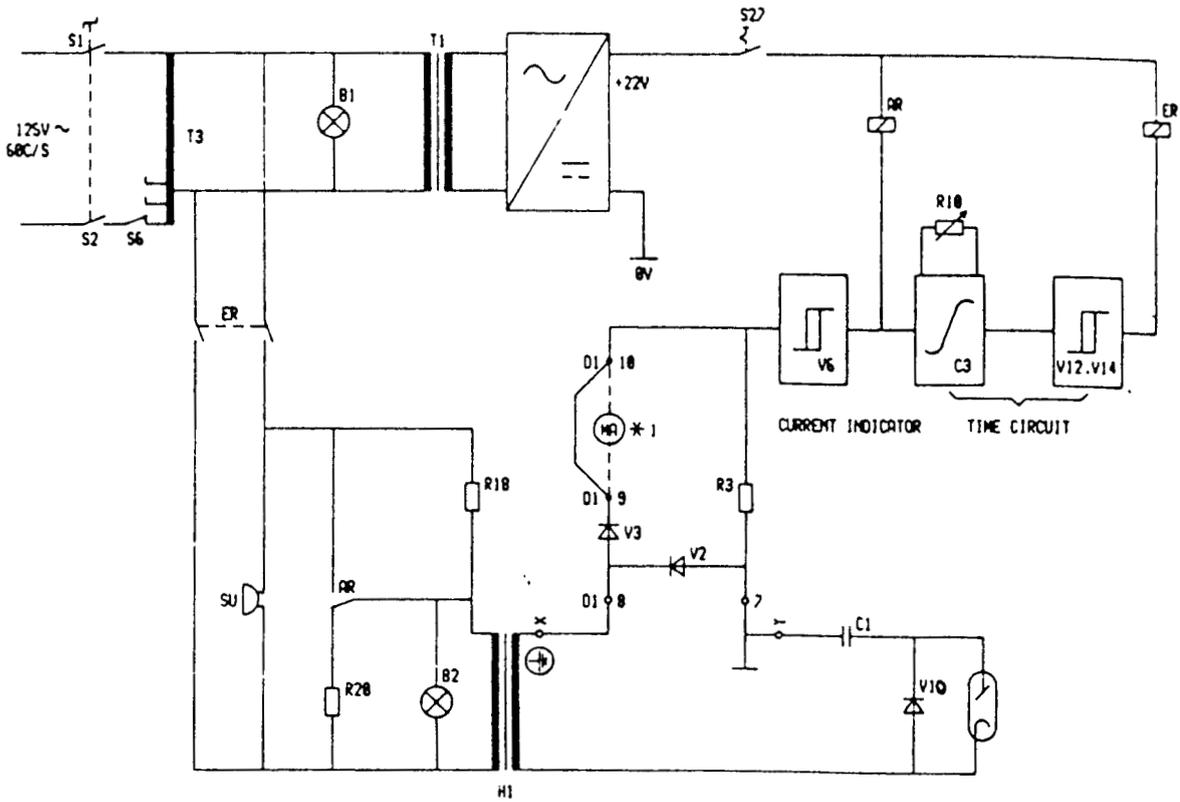


Figure 18. Functional schematic.

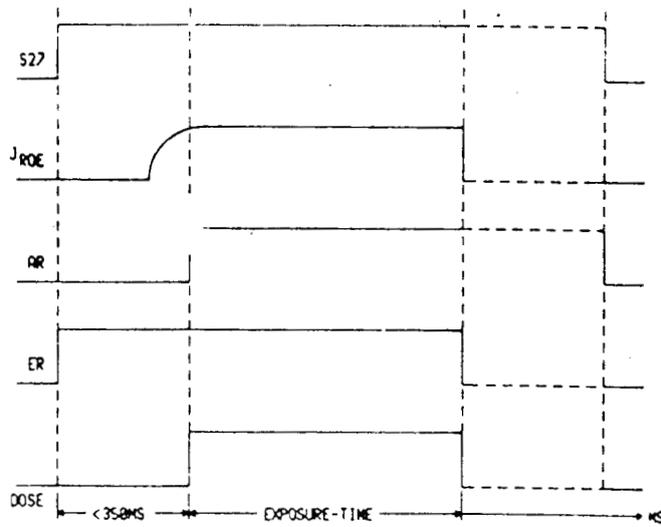
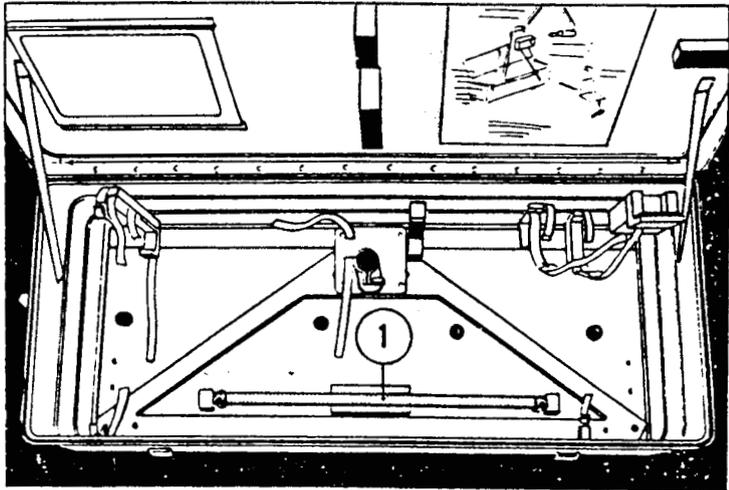
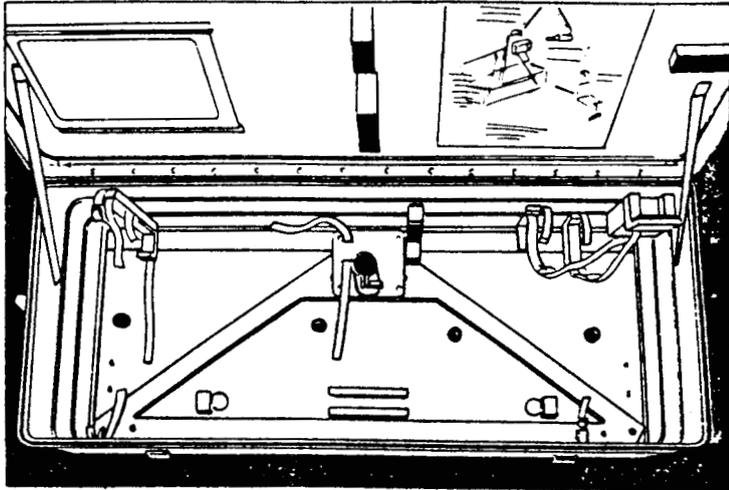


Figure 19. Sequence of function.

APPENDIX A

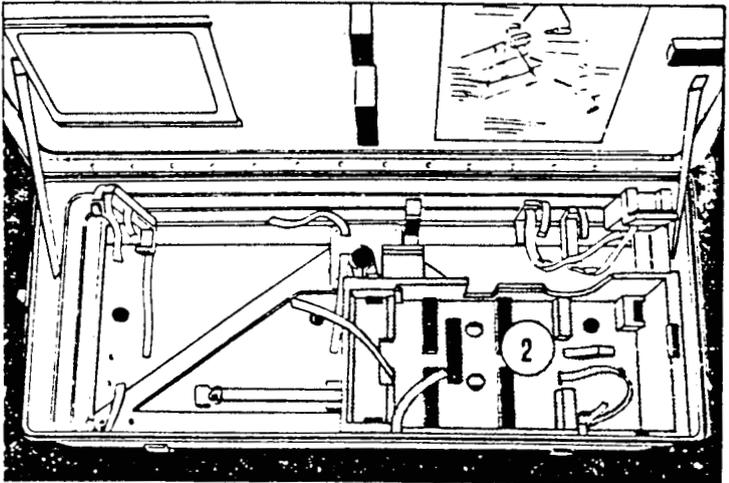
PORTARAY ASSEMBLY AND REPACKING INSTRUCTIONS

REPACKING INSTRUCTIONS



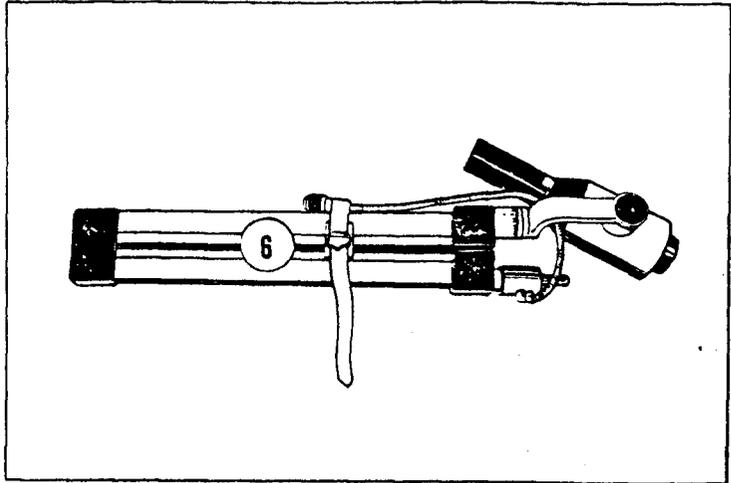
1

insert the support rod for the back rest and seat.



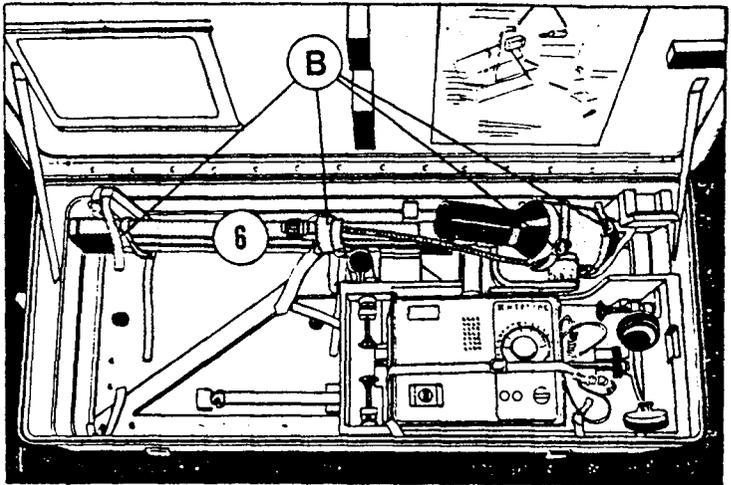
2

Place the wooden insert in position.



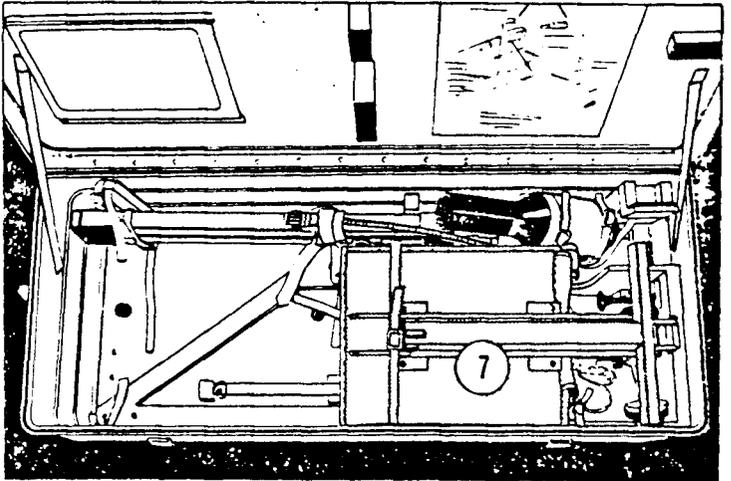
Secure the HELIODENT and scissor arm with the belt, as shown in the diagram.

6



Insert the HELIODENT and the scissor arm and fasten with belts (B).

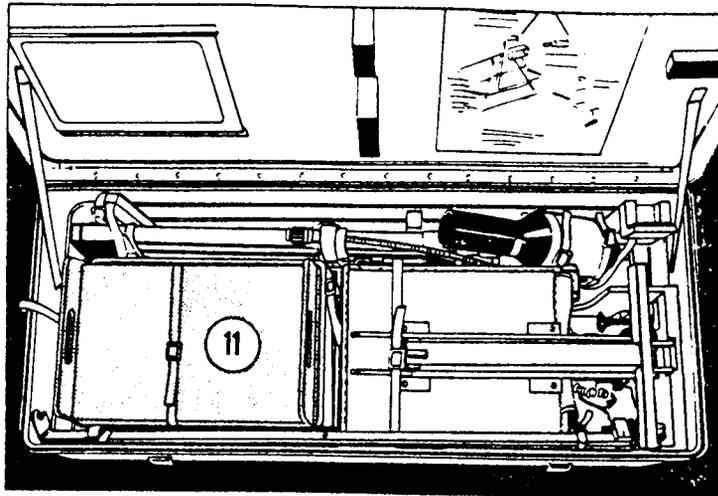
7



Fold the seat together, place in position and secure with belt.

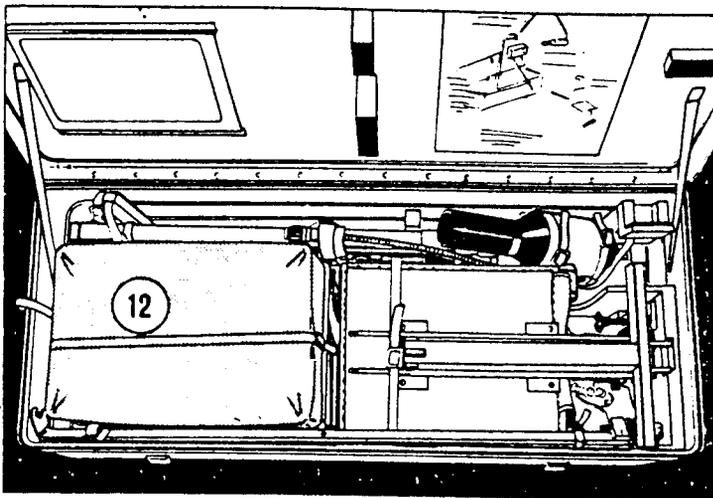
11

Place the wooden insert in position.



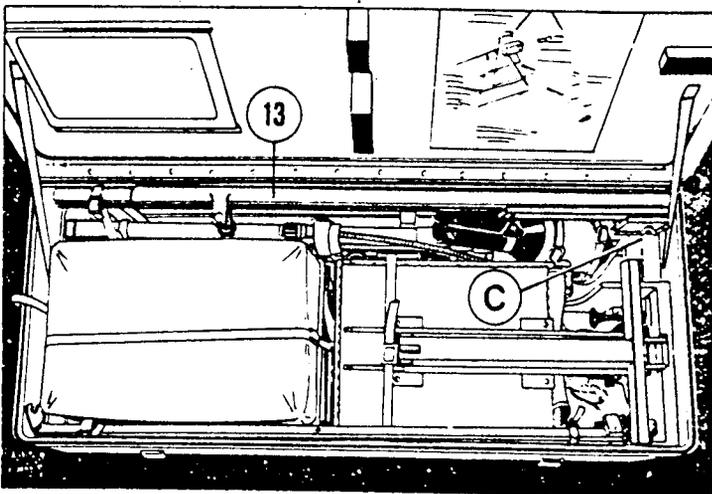
12

Position the PROCOMAT lid, cover with the protective hood and secure with belt.



13

Insert the mounting rod secure with belt and tighten the fly nut (C).



APPENDIX B

ENVIRONMENTAL PROTECTION AGENCY
FEDERAL GUIDANCE REPORT NUMBER 9

(SAMPLE)

monitor the performance of X-ray examinations, and, where practicable, direct examinations to obtain diagnostic objectives stated by clinicians by appropriate addition, substitution, or deletion of prescribed views. Technic protocols for performing medical and dental X-ray examinations should detail the operational procedures for all standard radiographic projections, patient preparation requirements, use of technic charts, and image receptor specifications.

6. RADIOGRAPHIC EQUIPMENT:

X-ray equipment used in federal programs should meet, where practicable, federal performance standards (21 CFR Subchapter J) sooner than required, or in the interim, the 1974 "Suggested State Regulations for Control of Radiation." General-purpose fluoroscopy units should provide image-intensification; fluoroscopy units for nonradiology specialty use should, when practicable, have electronic image-holding features. Photofluorographic X-ray equipment should not be used for chest radiography.

7. QUALITY ASSURANCE PROGRAM:

X-ray facilities should have quality assurance programs designed to produce radiographs that satisfy diagnostic requirements with minimal patient exposure; such programs should contain materials and equipment specifications, equipment calibration and preventive maintenance requirements, quality control of image processing, and operational procedures to reduce retake and duplicate examinations.

8. QUALIFICATION OF TECHNICIANS:

Operation of medical or dental X-ray equipment should be by individuals who have demonstrated proficiency to produce diagnostic quality radiographs with the minimum of exposure required; these individuals should be qualified by didactic training and practical experience identical to or equivalent to those programs approved by the council on medical education of the American Medical Association or the American Registry of Clinical Radiography Technologists for medical X-ray equipment operators, or for dental equipment operators, the guidelines of the oral radiology section of the American Association of Dental Schools.

9. PATIENT SHIELDING:

Proper collimation should be used to restrict the X-ray beam as much as practicable to the clinical area of interest and within the dimensions of the image receptor; shielding should be used to further limit the exposure of the fetus and the gonads when such exclusion does not interfere with the examination being conducted.

10. PATIENT SKIN EXPOSURE GUIDES:

Technic appropriate to the equipment and materials available should be used to maintain exposures as low as is reasonably achievable without loss of requisite diagnostic information; measures should be undertaken to evaluate and reduce, where practicable, exposures for nonspecialty examinations which exceed the following Entrance Skin Exposure Guides (ESEG):

QUESTIONNAIRE ON DENTAL RADIOGRAPHIC PROCEDURES

Facility: _____
 State: _____

Date: _____
 Command: _____

Are the Following Statements
 TRUE or FALSE for your Facility

	TRUE	FALSE	N/A
1. All dental X-rays are prescribed by a dentist only after examination of the patient:	_____	_____	_____
2. Dental bitewing X-rays or full-mouth series are not accomplished for routine preventive dental care:	_____	_____	_____
3. Positive means exist for identifying pregnant or potentially pregnant patients prior to X-rays:	_____	_____	_____
4. All possible methods are employed to reduce the exposure to the fetus:	_____	_____	_____
5. X-ray technique charts are readily accessible in all X-ray rooms:	_____	_____	_____
6. X-ray technique charts are routinely employed:	_____	_____	_____
7. All X-ray units are in compliance with federal standards:	_____	_____	_____
8. There is a written quality assurance program:	_____	_____	_____
9. It provides for regularly scheduled			
a. Equipment calibration and preventive maintenance:	_____	_____	_____
b. Image processing evaluation:	_____	_____	_____
c. Evaluation of procedures to reduce retakes:	_____	_____	_____
10. All personnel who operate X-ray equipment are properly trained and qualified:	_____	_____	_____
11. Gonadal shielding is available in all X-ray rooms:	_____	_____	_____
12. Gonadal shielding is routinely employed on all patients:	_____	_____	_____
13. All collimators are open-ended and shielded:	_____	_____	_____
14. The film used is speed "D" or faster:	_____	_____	_____