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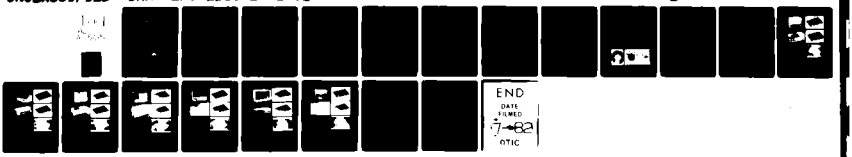

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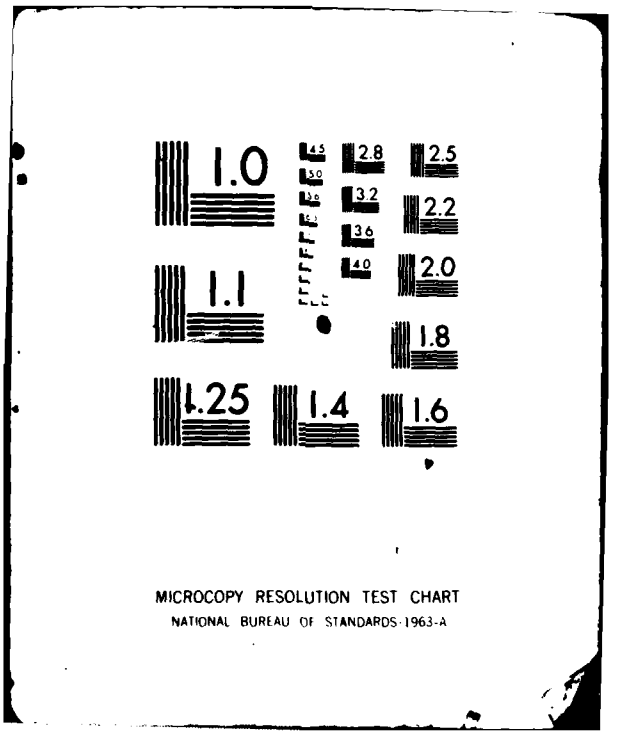
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Review 1-82

AEROMEDICAL REVIEW

ULTRASONIC CLEANERS

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March 1982

USAF SCHOOL OF AEROSPACE MEDICINE
Aerospace Medical Division (AFSC)
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NOTICES

This final report was submitted by 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 number DSB38200.

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This report has been reviewed by the Office of Public Affairs (PA) and is releasable to the National Technical Information Service (NTIS). At NTIS, it will be available to the general public, including foreign nations.

This report has been reviewed and is approved for publication.

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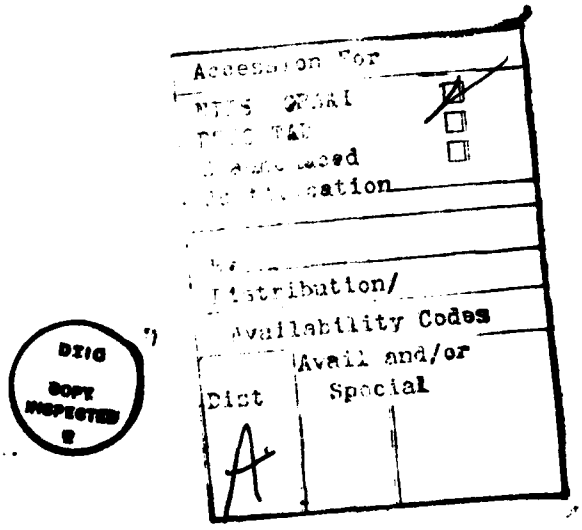

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20. ABSTRACT *(Continue on reverse side if necessary and identify by block number)*

This document discusses the rationale for using ultrasonic cleaners in an infection control regimen, and it briefly describes the principles of cavitation. Seven units are compared based on the following criteria: cost, aluminum foil erosion, pitting of type IV stone, heat production in 3 hours, noise levels, weight, basket water drainage, fit of lid, presence or absence of externally accessible fuse, and cement removal in 1 minute. Guidelines for proper use are provided.

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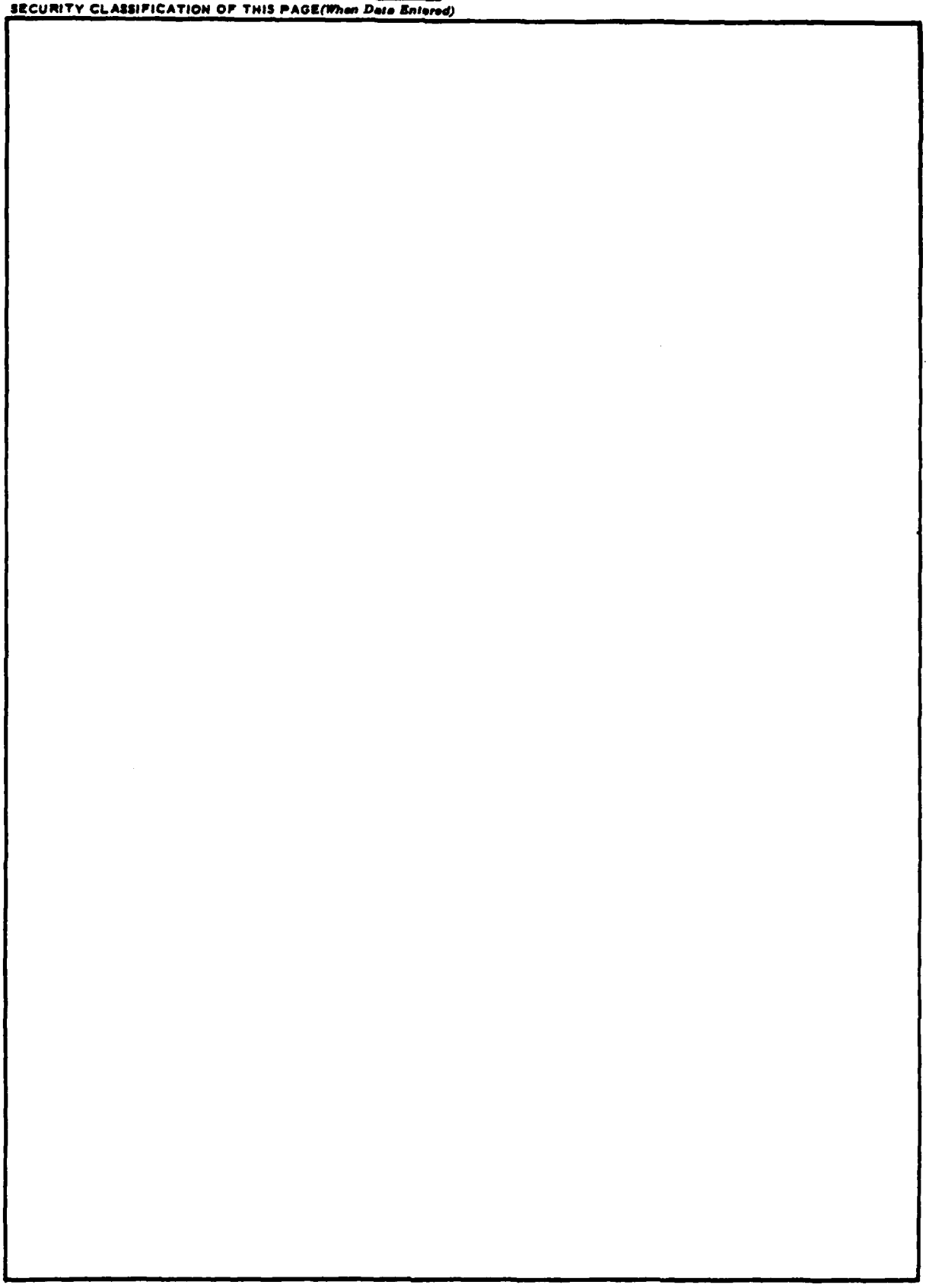

ULTRASONIC CLEANERS

INTRODUCTION

The selection of an ultrasonic cleaner for use in Air Force dental facilities depends on several factors. Determining the primary use of the unit prior to purchase is important because different units may be better suited to different tasks. Traditionally, dental laboratories use ultrasonic cleaners to remove cements, polishing compounds, and waxes from prostheses. These units, however, can also be used to clean contaminated dental instruments, thus reducing the chances of cross-contamination. Hinged instruments and aspirator tips often have foreign material build up in areas inaccessible or difficult to clean. According to the American Dental Association (1), all practical methods of sterilization or disinfection can be overchallenged by soiled or heavily contaminated instruments.

Because they reduce the likelihood of injury and infection of the hands, ultrasonic cleaners are safer than manual scrubbing. They are 16 times more effective in their cleaning ability (2) and significantly reduce the aerosolization of potentially pathogenic organisms during the instrument-cleaning process.

The purpose of this report is to help base dental surgeons decide which ultrasonic cleaner(s) will best suit their needs. All units were evaluated with the concept of dental treatment room use.

NATURE OF ULTRASONIC CLEANING

An ultrasonic cleaning system consists of an electronic generator which generates an alternating current of the desired frequency and a transducerized tank to contain the cleaning solution. The cleaning tank is the heart of the system and is the only truly ultrasonic part of it.

The term "ultrasonic" is used to describe sound above the audible range. Most humans can hear sounds up to about 16,000 Hz. The normal frequency range for ultrasonic cleaning is from 20,000 to 90,000 Hz.

The generator creates an electrical current at a selected frequency. This electrical energy is then changed into mechanical energy by transducers that expand and contract in frequency with the alternating current. These transducers, bonded to the bottom or side of the tank, set up alternating

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1. American Dental Association Accepted Dental Therapeutics, 1979, p. 55.
2. Sandord, J. E. Cleaning with ultrasonics. Am. Machinist 110:87-98 (1966).

pressure waves which create the so-called cavitation phenomenon--the formation and collapse of microscopic cavities (bubbles) in liquid, creating a scrubbing action.

A sound wave passing through liquid carries high pressure ahead of it and low pressure in back of it. As the wave passes, the trailing low pressure is below that of the liquid, and millions of bubbles or cavities are formed. Almost immediately, the high-pressure area in front of the next wave causes the bubbles to implode (collapse inward), releasing a very intense level of energy impingement by the cleaning liquid against the submerged ware. This results in the scrubbing action, which is given the term "ultrasonic cleaning."

TEST AREAS AND EVALUATION

A protocol identified ten specific areas to be evaluated for each of the following instruments:

Unit	Manufacturer	Telephone
Steele's SS-4	Columbus Dental Co. 634 Wager Street Columbus OH 43206	(614) 445-8192
Health Aids T3.3B	Health Sonics Corp. 6575 Trinity Ct. P.O. Box 2698 *Dublin CA 94566*	(415) 828-5803
Vector 55	J. F. Jelenko Dental Health Products 99 Business Park Drive Armonk NY 10504	(800) 431-1785
Buffalo 773	Buffalo Dental Mfg. Co., Inc. 2911 Atlantic Avenue Brooklyn NY 11207	(212) 277-5400
L&R T-14	L&R Manufacturing Company 577 Elm Street Kearny NJ 07032	(201) 991-5330
Vibraclean 100	MDT Corporation Suite 1175, One Continental Plaza 101 Continental Boulevard El Segundo CA 90245	(213) 516-0516
Vale-1	Esmadent Chemicals Inc. P.O. Box 162 Highland Park IL 60035	(314) 433-6116

Scores were assigned on the basis of 1 through 7 for each area evaluated, with 1 being the best or most desirable. The results are explained individually in the succeeding sections and then summarized in Tables 1 and 2. The instruments--with results of some evaluations--are shown at the end of this section (Figs. 2-8).

(1) Cost: All costs were current as of 28 May 1981. The Steele's, Buffalo, L&R, and Vale have basket and/or lid listed as accessory equipment, but all costs shown here include an ultrasonic unit with a basket and lid. Jelenko's main emphasis in ultrasonic cleaners has been for laboratory use and they manufacture only a double-beaker holder, so the Vector price includes the Buffalo lid and basket. All machines are covered by a 12-month warranty except the Health Aids which has an 18-month warranty.

Rating:	1	2	3	4	5	6	7
	Steele's	Health Aids	Vector	Buffalo	L&R	Vibraclean	Vale-1
	$177.75	$185.30	$238.64	$249.62	$262.95	$341.25	$425.00

(2) Aluminum Foil Erosion: A sheet of heavy-duty aluminum foil was secured horizontally 3.18 cm (1.25 in) above the tank floor and touching the walls of the tank. Ultrasonic cleaning solution was added to bring the level of the fluid to a height of 9.52 cm (3.75 in). the ultrasonic unit was turned on for 4 minutes. Erosion of foil illustrates intensity and distribution of energy. A score of 1 was given to the cleaner exhibiting the greatest amount of erosion, as measured by voids and wrinkling of aluminum foil (see "f" in instrument illustration).

Rating:	1	2	3	4	5	6	7
	Health Aids	Buffalo	Steele's	Vibraclean	L&R	Vector	Vale-1

(3) Pitting of Diekeen Stone: According to manufacturer's instructions, 50 mg of type IV stone (Diekeen Stone: Modern Materials, Columbus Dental Co., St. Louis, Mo.) was vacuum spatulated with 22 cc of distilled water. The prepared stone was vibrated into a 5- x 7.5-cm mold. All seven molds were allowed to set overnight. When removed from the molds, the stone casts were 7 mm thick.

Deionized/distilled water was added to the ultrasonic tank to a level 7.62 cm (3 in) above the bottom of the basket. The stone cast was placed in the center of the basket, and the machine was turned on for 5 minutes of cavitation.

Pitting by implosion indicates the power of an ultrasonic cleaner. Uniform distribution of pitting is desirable because it indicates equal cavitation throughout the tank. The evenness and depth of pitting were subjectively evaluated. A score of 1 was given to the unit exhibiting the deepest and most uniform pitting of the same blocks (see "b" and "d" in instrument illustrations).

Rating:	1	2	3	4	5	6	7
	Steel's	Vector	Buffalo	Health Aids	Vale-1	Vibraclean	L&R

(4) Heating: All units were filled with 2000 ml of ultrasonic cleaning fluid and were adjusted to run continuously for 3 hours. A thermometer was placed inside each tank, and periodic temperature readings were recorded. Elevated temperatures cause more rapid deterioration of the solid-state components (i.e., transistors, diodes, and transducers). A score of 1 was given to the coolest unit after 3 hours of continuous testing (see "e" in instrument illustrations).

Rating:	1	2&3	4	5	6	7
	Vale-1	Vector & L&R	Health Aids	Buffalo	Steele's	Vibraclean
	38°C	45°C	50°C	53°C	54°C	59°C

(5) Noise: Noise levels on ultrasonic cleaners with proper levels of degassed distilled water were measured using two different methods. The first was a subjective evaluation conducted independently by four health care practitioners. The second was a decibel-scale reading measured with a calibrated instrument. According to AFR 161-35, the maximum allowable Air Force level is an 84-dBA average for an 8-hour day. The USAF Occupational and Environmental Health Laboratory/ECH measured decibel levels using the A-weighted band on a General Radio 1982 sound-level meter (calibrated 9 Mar 81). The meter was at a height horizontal to an operator's ear (1.22 m (4 ft) above floor level) and 0.28 m (11 in) from the top of the ultrasonic unit. (The Vale unit was not available for the second evaluation--the dBA measurement.) A score of 1 was given the unit that produced the noise level deemed by the health care practitioners to be least objectionable to dental patients.

Rating:	1	2	3	4	5	6	7
Subjective:	L&R	Vector	Vibraclean	Steele's	Health Aids	Buffalo	Vale-1
dB Levels:	Vector	L&R	Health Aids	Buffalo &	Vibraclean	Steele's	
	70 dBA	71dBA	73 dBA	both 74 dBA		80 dBA	

(6) Weight: A lightweight ultrasonic unit has an advantage because of the periodic need to empty solution from the tank and to move the unit for cleanup purposes. Weight is not as critical in units that have a drain (i.e., Vibraclean and Health Aids). A score of 1 was given to the unit lightest in weight.

Rating:	1	2-4	5	6	7
	Health Aids	Steele's, Buffalo, Vector	L&R	Vibraclean	Vale-1
	6 lbs	8 lbs	8.5 lbs	14 lbs	15.5 lbs

(7) Water Drainage from Baskets: A basket should drain rapidly when lifted out of an ultrasonic cleaning tank filled with solution. Solution is apt to spill with slow draining baskets because most baskets have minimal clearance from the inside of the tank. A score of 1 was given to the unit whose basket drained of cleaning solution most rapidly when lifted from the ultrasonic cleaner.

Rating:	1&2	3&4	5	6	7
	Vale-1 & L&R	Health Aids & Buffalo	Steele's	Vibraclean	Vector

(8) Fit of Lid: Ultrasonic units should be operated with the lid in place because the solution will aerosolize during operation. The fit of the lid was subjectively evaluated. A score of 1 was given to the unit with the best fitting lid (see "a" in instrument illustration).

Rating: 1	2&3	4&5	6	7
Steele's	Vibraclean & Buffalo	Health Aids & L&R	Vector	Vale-1

(9) External Access to Fuse: The first item to fail in an ultrasonic unit will probably be the fuse. External access to the fuse allows convenient replacement. One ultrasonic unit (Buffalo) has a circuit breaker that is externally accessible.

Rating:	Yes	No
	L&R, Vibraclean, Health Aids, Buffalo	Steele's, Vale-1, Vector

(10) Removal of Dental Cement: Zinc phosphate cement (Fleck's Cement, Mizzy Inc., Clifton Forge, Va.) was mixed according to manufacturer's instructions. The faces of seven black #2 condenser points (2 mm in diameter) were filled with cement. The cement was allowed to set for 48 hours (see Fig. 1). The condensers were identified by multicolored bands and placed in ultrasonic units that were activated for 1 minute. All units removed the cement (also blood dried overnight on cotton forceps) within 1 minute. Spherical dental amalgam was condensed into the black #2 condenser points and allowed to set overnight. None of the ultrasonic cleaners was able to dislodge the amalgam in 10 minutes on sonication.

Rating: Cement removal by all units within 1 minute.

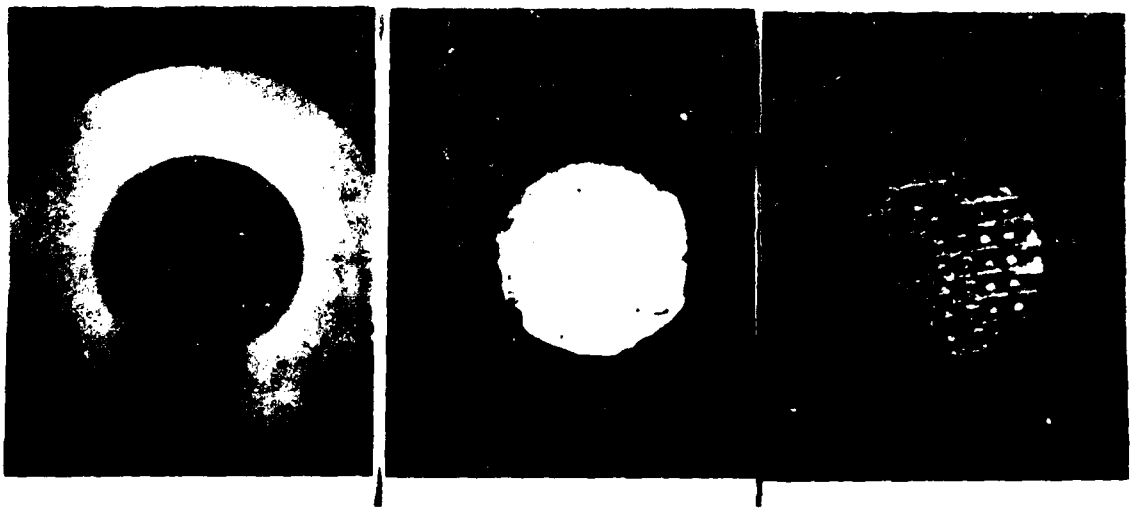

Figure 1. Condenser point before filling with cement, after cement was hardened, and after 1 minute of sonication (left to right).

TABLE 1. COMPARISON RATINGS OF SEVEN ULTRASONIC CLEANERS

	Steele's	Health Aids	Vector	Buffalo	L&R	Vibra-clean	Vale-1
Cost[a]	1 ($177.75)	2 ($185.30)	3 ($238.62)	4 ($249.62)	5 ($262.95)	6 ($341.25)	7 ($425.00)
Aluminum foil (erosion)	3	1	6	2	5	4	7
Pitting of type IV stone	1	4	2	3	7	6	5
Heat in 3 hr	6 (54°C)	4 (50°C)	2 (45°C)	5 (53°C)	2 (45°C)	7 (59°C)	1 (38°C)
Noise - Subjective	4	5	2	6	1	3	7
Decibel level	6	3	1	4&5	2	4&5	--[d]
(dBA)	(80)	(73)	(70)	(74)	(71)	(74)	--
Weight	2-4 (8 lbs)	1 (6 lbs)	2-4 (8 lbs)	2-4 (8 lbs)	5 (8.5 lbs)	6 (14 lbs)	7 (15.5 lbs)
Drain	No	Yes	No	No	No	Yes	No
Basket water drainage	5	3&4	7[b]	3&4	1&2	6	1&2
Fit of lid	1	4&5	6[b]	2&3	4&5	2&3	7
Externally accessible fuse	No	Yes	No	Yes[c]	Yes	Yes	No
Cement removal in 1 minute	Yes	Yes	Yes	Yes	Yes	Yes	Yes

[a]Includes basket and lid.
[b]Unit tested with basket and lid manufactured by Buffalo Dental Mfg. Co., Inc.
[c]Unit has circuit breaker that can be reset externally.
[d]Unit not available for decibel-level measurements.

TABLE 2. MECHANICAL EVALUATION OF UNITS BY BIOMEDICAL EQUIPMENT MAINTENANCE PERSONNEL

	Disadvantages	Advantages
Steele's SS-4	*Soldered-in fuses. *Components difficult to reach for trouble-shooting. Strain relief poorly engineered. Pads glued on bottom and front metal plate.	Modular board replaceable. RF-output tunable.
Health Aids T3.3B	Strain relief improperly sized with respect to power cord. Tank not removable without PVC drain destruction.	Modular circuit replaceable. No water seepage possible. Fuse rating on panel.
Vector 55	Internal fuse with leads on end--odd item. Serial number taped on. ID plate glued with foam tape. No light with hold button.	Heavy-duty input wiring. Tank well-sealed to one piece top panel. Clamps attach tank to bottom panel for heat and sound-conduction control.
Buffalo 773	*Power transistors in back not protected. Gap of 1.3-1.4 cm (1/2- 3/4 in) between lower and upper control panel. Unit difficult to clean because of wrinkle painting. Potential for water seepage--may cause RF shock.	Transistors plug in.
Vibraclean 100	Front panel glued on. Timer knob could allow moisture to enter unit. Solution trap around joint of pan to tank. Heat sink held on by two screws. Drain pipe could break off easily. Marginal drain plug.	Power transistors plug in. Tank insulated well for noise.
Vale-1	*Very difficult to troubleshoot because of short leads. Seepage around top tank and top panel through raised edges. Strain relief had 0.6-1.3 cm (1/4-1/2 in) gap where solution could enter internal compartment. Fuse very difficult to change.	Unit can be power tuned externally by visual means. Heat control far in unit. Integrated circuits plug in.

*Major disadvantages which Biomedical Equipment Maintenance personnel feel will increase downtime to repair or reservice the specified units.

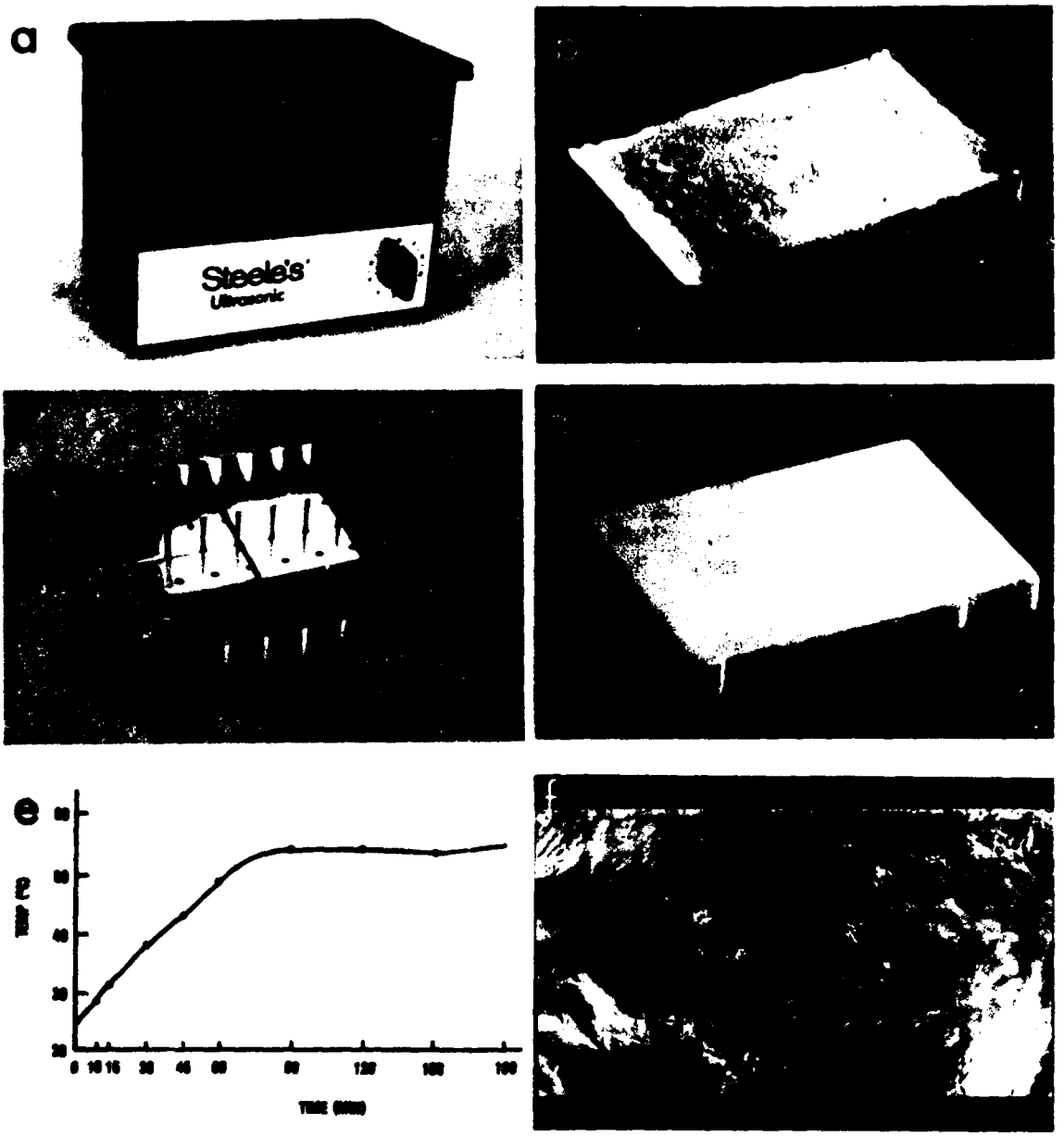

Figure 2. Steele's SS-4 ultrasonic unit:
a - Ultrasonic cleaner with basket and lid in place.
b - Superior surface of type IV stone slab placed in cleaner 5 min.
c - Basket.
d - Inferior surface of stone slab showing effect of sonication through basket.
e - Temperature elevation during 3 hr of continued use.
f - Erosion of aluminum foil after 4 min of sonication.

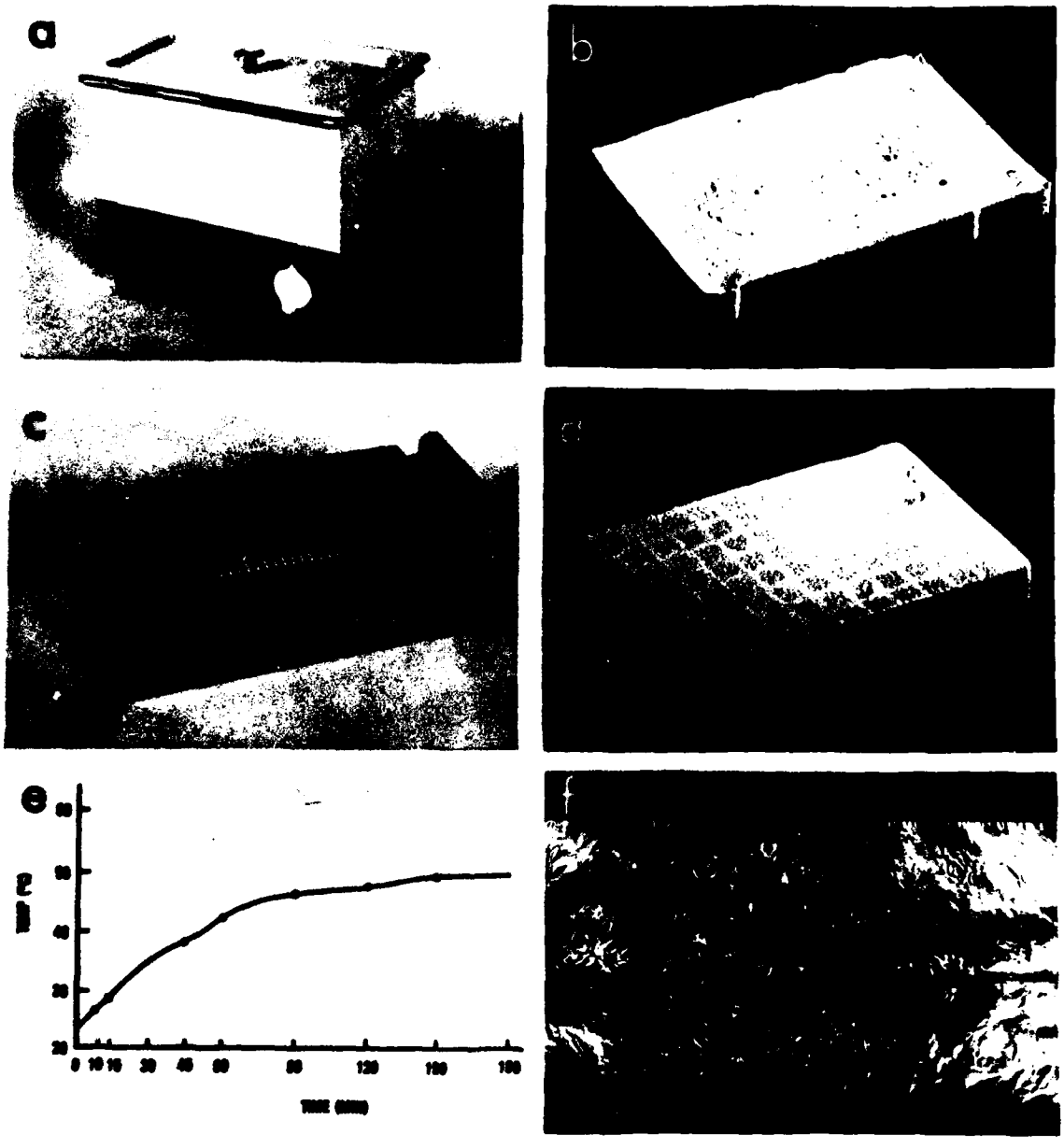

Figure 3. Health Aids T3.3B ultrasonic unit:
a - Ultrasonic cleaner with basket and lid in place.
b - Superior surface of type IV stone slab placed in cleaner 5 min.
c - Basket.
d - Inferior surface of stone slab showing effect of sonication through basket.
e - Temperature elevation during 3 hr of continued use.
f - Erosion of aluminum foil after 4 min of sonication.

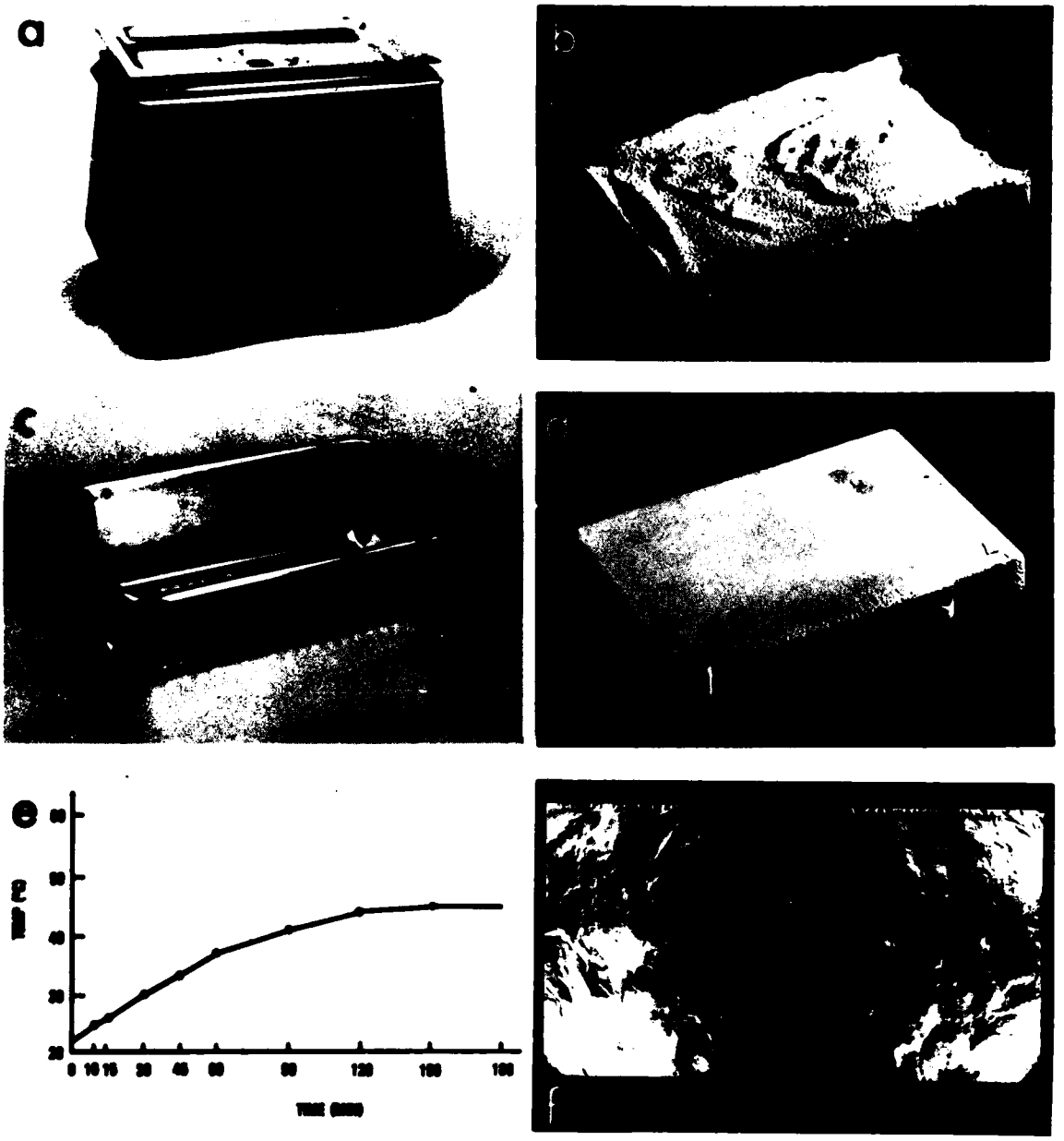

Figure 4. Vector 55 ultrasonic unit:
a - Ultrasonic cleaner with basket and lid in place.
b - Superior surface of type IV stone slab placed in cleaner 5 min.
c - Basket.
d - Inferior surface of stone slab showing effect of sonication through basket.
e - Temperature elevation during 3 hr of continued use.
f - Erosion of aluminum foil after 4 min of sonication.

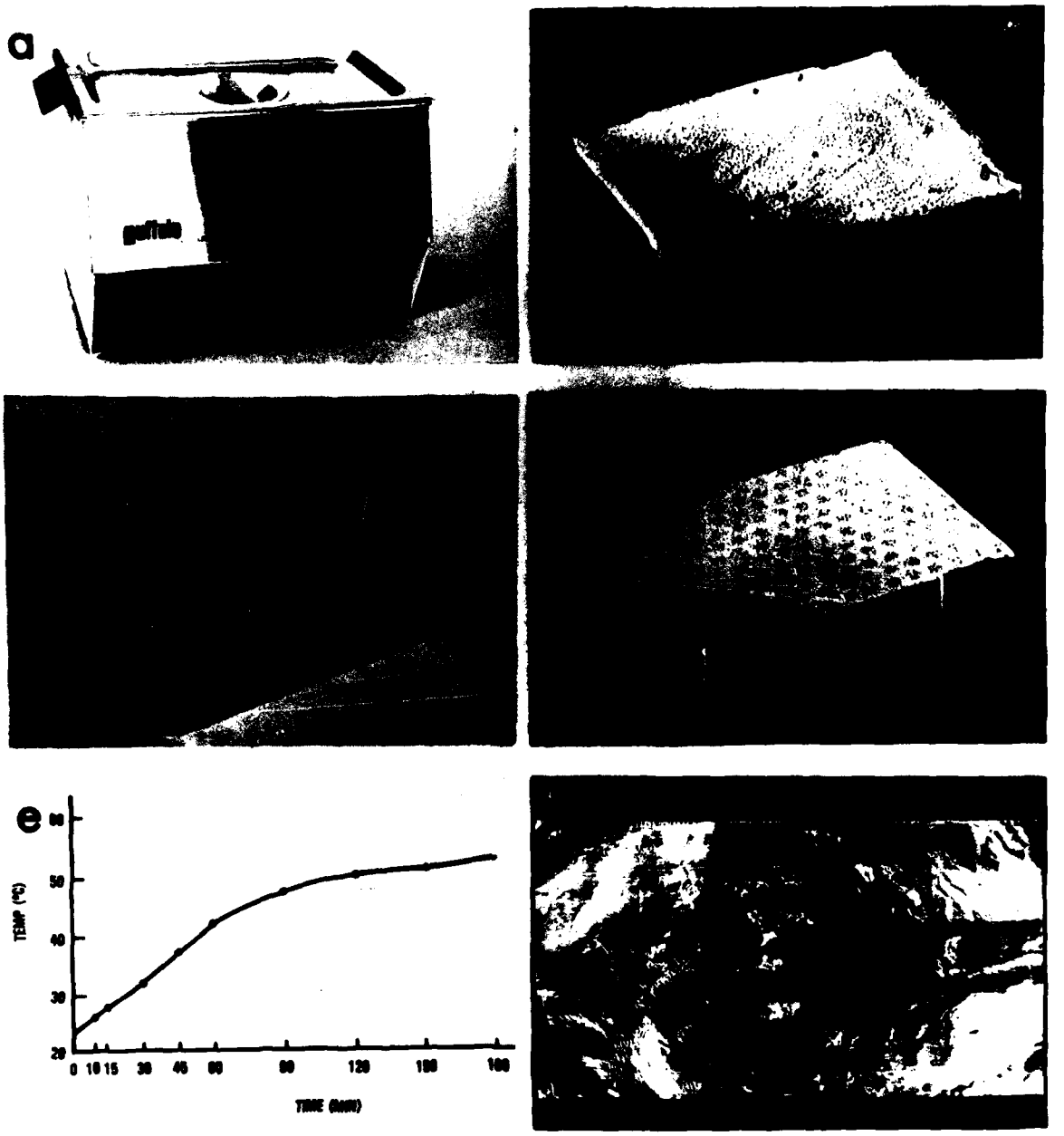

Figure 5. Buffalo 773 ultrasonic unit:
a - Ultrasonic cleaner with basket and lid in place.
b - Superior surface of type IV stone slab placed in cleaner 5 min.
c - Basket.
d - Inferior surface of stone slab showing effect of sonication through basket.
e - Temperature elevation during 3 hr of continued use.
f - Erosion of aluminum foil after 4 min of sonication.

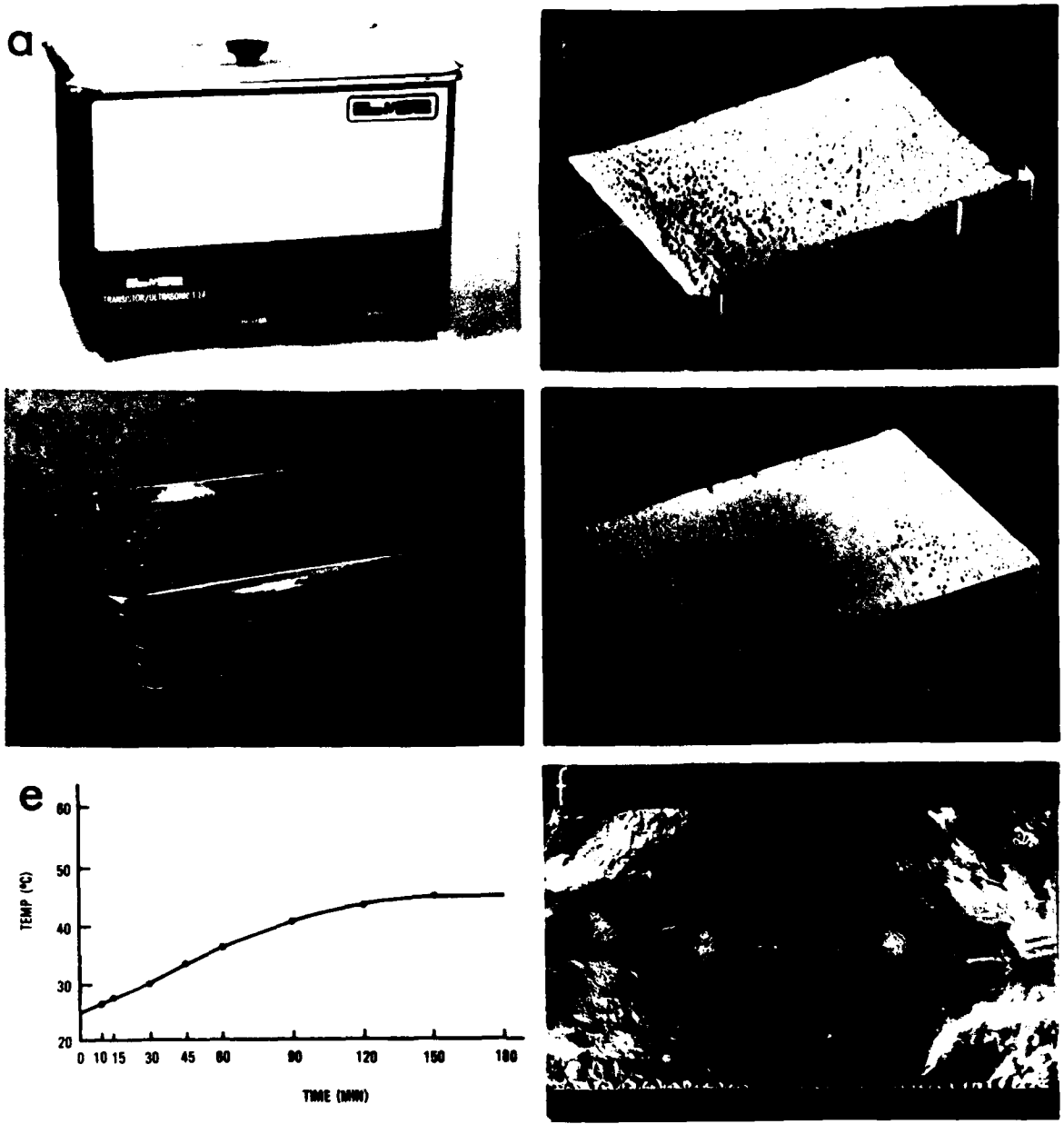

Figure 6. L&R T-14 ultrasonic unit:
a - Ultrasonic cleaner with basket and lid in place.
b - Superior surface of type IV stone slab placed in cleaner 5 min.
c - Basket.
d - Inferior surface of stone slab showing effect of sonication through basket.
e - Temperature elevation during 3 hr of continued use.
f - Erosion of aluminum foil after 4 min of sonication.

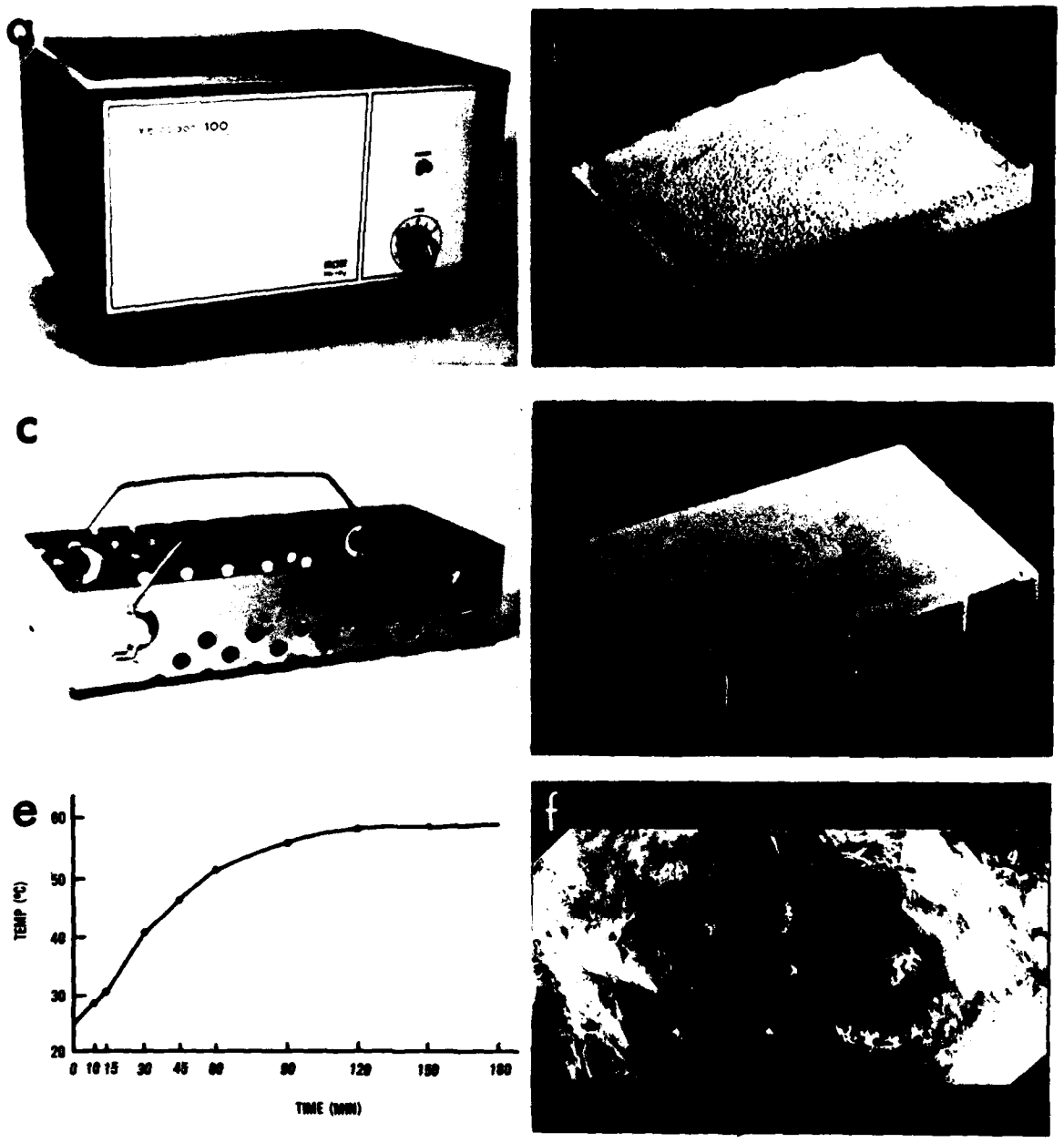

Figure 7. Vibraclean 100 ultrasonic unit:
a - Ultrasonic cleaner with basket and lid in place.
b - Superior surface of type IV stone slab placed in cleaner 5 min.
c - Basket.
d - Inferior surface of stone slab showing effect of sonication through basket.
e - Temperature elevation during 3 hr of continued use.
f - Erosion of aluminum foil after 4 min of sonication.

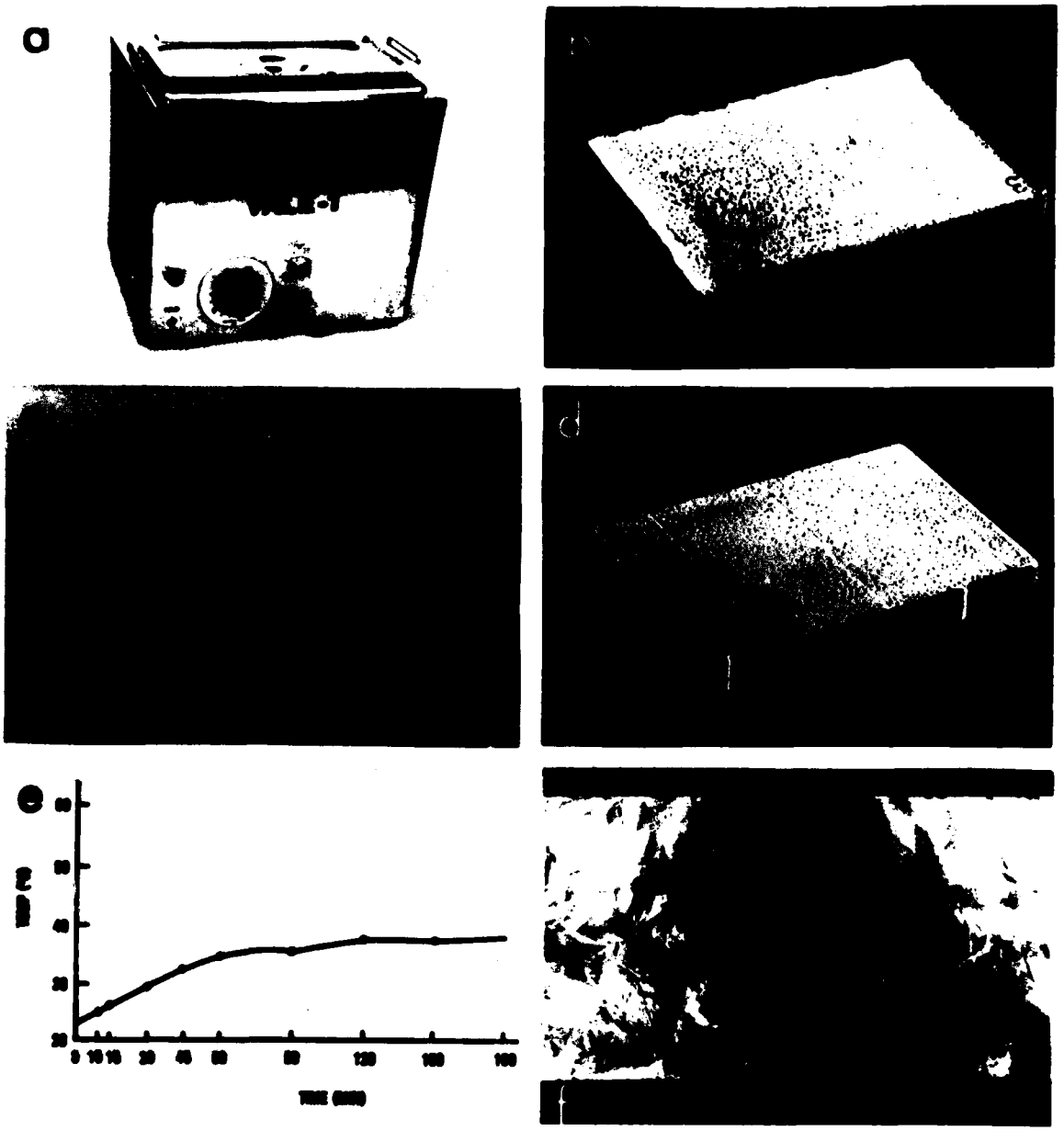

Figure 8. Vale-1 ultrasonic unit:
a - Ultrasonic cleaner with basket and lid in place.
b - Superior surface of type IV stone slab placed in cleaner 5 min.
c - Basket.
d - Inferior surface of stone slab showing effect of sonication through basket.
e - Temperature elevation during 3 hr of continued use.
f - Erosion of aluminum foil after 4 min of sonication.

USE OF ULTRASONIC UNITS

Ultrasonic units should be placed close to the sink but far enough away to allow only minimal splashing onto or pooling underneath the unit by water, soaps, etc. Select a location close to a grounded outlet since all ultrasonic cleaners must be grounded.

Liquid must always be in the stainless-steel tank before the ultrasonic cleaner is turned on. Pour only room-temperature liquid into a cool unit. The solution should be placed in the tank to at least a three-quarters-full level. The units should not be operated with less than a half-full tank. Do not change solution immediately after heavy use of the unit, while the unit is hot. After prolonged use, an empty tank, without solution to dissipate the heat, will significantly shorten the life of the transistors.

Allow a tank of fresh solution to degas by operating the unit for 5 minutes before processing soiled instruments. This will let the implosions occur on the surface of instruments instead of on entrapped air pockets. Rinse gross debris from instruments before placing them in the ultrasonic cleaner basket. Instruments are cleaned much faster when rinsed and placed in solution before saliva or other contaminants dry. The recommended time of ultrasonic action for instruments that have been immersed immediately in the basket or in other holding solution is only 3 to 5 minutes (3). A large load will increase the time required for cleaning.

Instruments should be suspended in the solution, not allowed to sit on the bottom of the tank. Items placed on the bottom of the tank will interfere with the transducer action. Any flat surface placed against the solid surface of a basket will not be cleaned properly because implosion, or scrubbing action, cannot take place.

Before placement into the ultrasonic cleaner, small dental instruments such as burs and reamers can be put on magnetic strips or into separate containers such as bur blocks or beakers. Also, a liquid disinfectant (e.g., glutaraldehyde) can be placed in an auxiliary container, covering only the items to be cleaned. When this container is placed in the main tank, cavitation will occur in the disinfectant as well as in the tank's solution.

When baskets are removed from the ultrasonic cleaner, care should be taken not to spill and drip solution from the main tank onto the units and countertops. The basket should be taken to the sink and the instruments carefully rinsed. The instruments can be dried by dipping them in an alcohol solution or patting them dry with a towel. Only dry instruments should be placed in the sterilizer, especially a chemical vapor sterilizer.

The ultrasonic cleaning solution should be changed approximately once a week in the average treatment room. Solutions will not readily break down

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3. Palenik, C. J., and C. H. Miller. Use of an ultrasonic cleaner in the dental office. J Ind Dent Assoc 59:11-12 (1980).

chemically when used, but they will become contaminated and less effective. The solution can be filtered through medium filter paper to reduce foreign debris. The mechanism of ultrasonic cleaning can operate in liquids that are completely neutral, such as water, but detergents are usually added to reinforce dissolving action (4). When changing the solution, avoid submerging the unit in water or allowing splatter onto the louvers. Any liquid in the casing will shorten the useful life of the ultrasonic unit considerably.

Remember, ultrasonic cleaners do not sterilize; they only prepare instruments for sterilization.

SELECTION OF EQUIPMENT

Base dental surgeons should use the comparison rating for each criterion as well as the evaluation by Biomedical Equipment Maintenance Personnel to choose a unit that best suits their needs.

Any questions concerning this technical review should be directed to the Dental Investigation Service, USAFSAM/NGD, Brooks AFB TX 78235, AUTOVON 240-3502, Commercial (512) 536-3502.

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4. Eames, W. B., S. O. Byrington, and N. B. Suway. A comparison of eight ultrasonic cleaners. Operative Dentistry 5:118-124 (1980).


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