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ELECTRON MICROSCOPIC OBSERVATIONS ON THE LUMINAL SURFACE OF TEAT CUP LINERS OF MILKING MACHINES USED UNDER SOUTH AFRICAN CONDITIONS

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ABSTRACT

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An investigation undertaken with the aid of scanning electron microscopy (SEM) on new and used teat cup liners revealed the generally poor quality of luminal surfaces. Even those of the brand-new distributor controls showed significant faults in the evenness and continuity of the liner surface. A hundred and 500 milkings apparently tend to aggravate faults like cracks, pores, grooves and pits, because of the general brittleness of some of the teat cup liners.

The poor quality of the liners investigated raises various questions about the method of distribution of teat cup liners and serious concern about the role they play in predisposing bovine udders to mastitogenic infections, spreading mastitis, affecting the production and quality of milk, increasing the cost of milk production and reducing profits of dairy farming.

INTRODUCTION

During the past decade, the milking of dairy cows in South Africa has been extensively mechanized, so that most commercial fresh milk producers and a rapidly increasing number of industrial milk producers are using milking machines of various types. During the period January–December 1982 alone, some 910 milking machines with 4662 milking units were purchased at the cost of R7,686 million (Division of Agricultural Engineering, personal communication, 1982).

The significance of this development (Van Rensburg, 1971; Veenstra, 1971) and the importance of the technical aspects of milking machines were the subjects of a detailed investigation on the milking machines available in South Africa (Division of Agricultural Engineering, 1973). During that investigation, determinations were carried out on fatigue of certain teat cup liners after an average of 724–1 800 working hours (i.e. ± 2,5 × 10^6 to 5,4 × 10^6 pulsations). Liner fatigue was measured in terms of deterioration to collapse. Gross changes were noted, whereas less obvious changes remained undetected.

However, more recent overseas investigations (Heckmann & Noorlander, 1980; Noorlander & Heckmann, 1980; Heckmann, Coleman & Noorlander, 1981; Noorlander, Heckmann, Gardner & Checketts, 1981) have drawn particular attention to microscopic changes affecting the integrity of the inner surface (= luminal surface) of the tubular teat cup liners. The integrity of that surface is of major importance to the cleaning and disinfecting of the liners, the microbiological quality of milk, and the prevention and control of bovine mastitis. Collectively, they determine the chemical, microbiological and cytological quality and yield of the milk produced. It should thus be appreciated that soundness of the luminal surface of teat cup liners is of as much importance as the normal health of the udders.

Contaminated liners are an acknowledged source of bacterial contaminations of milk. The luminal surface of teat cup liners has been further incriminated as a major source of potentially mastitogenic bacteria, such as *Staphylococcus aureus*, *Streptococcus* spp. and *Pseudomonas* spp. isolated from liners (Heckmann *et al.*, 1981) and the most prevalent type of mastitis (i.e. *S. aureus*) or the most unfavourable types of mastitis (i.e. *Pseudomonas* spp.). Factors related to individual liners (e.g. design, elasticity, tension), to cluster units (e.g. design, flooding, venting) and to the milking machine unit as a whole (e.g. design, air flow, stability of vacuum, reverse flow of milk) can promote the infection of the mammary gland by bacteria causing mastitis (Heckmann & Noorlander, 1980; Noorlander *et al.*, 1981).

Bacterial colonization of the luminal surface of teat cup liners depends on cleaning and disinfecting procedures and on the condition of the surface. The latter may be affected by the deposition of mineral, lipid and proteinaceous matter and erosion (e.g. pitting, cracking, scaling, sloughing). These factors are of significance under South African conditions where several thousands (i.e. ± 200 000 to 300 000) of teat cup liners are used during at least 2 milking periods per day for the milking of the national dairy herd. Bacteriological investigations on some 600 new and used liners (Erasmus, unpublished data, 1982) have shown frequent contamination with potentially mastitogenic bacteria in spite of regular cleaning and disinfecting of milking machines. The replacement of used liners with new ones has resulted in marked improved by udder health.

The generally rather poor udder health of South African dairy cattle (Giesecke, Van den Heever & Du Toit, 1971; Giesecke, 1979; Van den Heever & Giesecke, 1979; Giesecke, 1981) prompted an investigation on the luminal surface of teat cup liners. Unfortunately, only limited information on such liners is available from international and none from South African veterinary literature. The investigation was thus initially aimed at screening for possible problems and examining the chain involved in the manufacture, distribution and eventual use of teat cup liners. As such liners were very readily available from dairy farmers and distributors, the investigation did not include newly manufactured teat cup liners but was limited to unused liners sold as brand-new in South Africa (= distributor control), unused (= farmer control) and used liners obtained from dairy farms.

MATERIALS AND METHODS

Teat cup liners

The investigation was carried out on the liners of a variety of models (Table 1).

Distributor controls were purchased directly from distributors as sets of 4 liners per liner model. Farmer controls and used liners were collected on dairy farms, labelled, placed in new disposable plastic bags, sealed and transferred to the laboratory at the Veterinary Research Institute (VRI).

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TABLE 1 Manufacture and laboratory identification of teat cup liners investigated as distributor controls (DC), farmer controls (FC) and used liners (UL)

Manufacture identifications*		Laboratory identifications					Total number of liners under investigation	Number of liners referred to in text (Fig. 3–19)
				Classification of liners investigated				
Name of firm	Model of teat cup liner	Batch No.	Code letter	DC	FC	UL		
Milkrite	M-10	1,2,3,5	A**			+	6	3
		4	A		+		1	1
		14,21	A	+			8	1
Milkrite	M-7	13	K	+			4	
Alfa Laval	960000-80*	1,2,5,21	B			+	10	4
	(960000-01)	4	B		+		1	1
		15	B	+			4	2
Alfa Laval	960017-83	16	L	+			4	
Alfa Laval	960016-83	17	M	+			4	
Alfa Laval	960016-01	1,2,3,5,21	C			+	11	1
		4	C		+		1	1
Boumatic	8506712 (P-1)	10	H	+			4	
Boumatic	8506624 (F1-A)	11	I	+			4	
Boumatic	7709003 (AAA)	12	J	+			4	
Fullwood	20114	6	D	+			4	
Fullwood	20124(SL-4)	7	E	+			4	
Fullwood	20122(SL-2)	8	F	+			4	
Fullwood	20123(SL-3)	9	G	+			4	
Nu-Pulse	Fullflo Nr. 1	18	N	+			4	
Nu-Pulse	Fullflo Nr. 4	19	O	+			4	
Smiths	Nr. 16 EL	20	P	+			4	

* As indicated on teat cup liners recieved for investigation
** A code letter (e.g. A) with a number (e.g. A2) indicated model A/liner 2

Identification and storage of teat cup liners at the laboratory

On receipt of the liners, records were made of the make and model and the identification code (Table 1). The code consists of an initial number (= laboratory batch number), followed by a letter (= code of manufacturer of liner model involved); for example, liner 14A = 14th batch of liners involving liner model M-10 from Milkrite. Other letters and numbers on the micrograph refer to laboratory particulars not necessary for tracing a particular liner.

The laboratory identifications (Table 1) remained unchanged during the processing and analysis of liners.

After identification, a liner was repacked in a plastic bag, labelled, sealed and stored in the dark at 4 °C for processing.

Processing of teat cup liners

Four liners of each make and model were processed for SEM. The chilled liners were left for 60 min on the laboratory bench to acquire ambient temperatures. Thereafter, each liner was dissected longitudinally by means of a sharp scalpel. The cutting was performed from the outside towards the inside of the liner, starting at its orifice and finishing at its milk tube end. During the cutting, particular care was taken to keep the luminal surface of the liners intact for SEM.

One half section of each liner was placed luminal surface up on a wooden board and sampled by means of a sharp cork-borer with a diameter of 13 mm. The excision was always performed from luminal towards peripheral surface. Four samples were excised from each of the halves, 1 each from the edge of the orifice, the proximal, central and distal third of the liner wall (Fig. 1).

After excision, the luminal surface of the samples was clearly indicated by markings on the opposite surface. Each sample was then carefully placed, by means of tweezers, into a properly identified sample bottle. The bottle was then closed and transferred to the Section of Electron Microscopy, VRI, where the samples were finally processed for SEM.

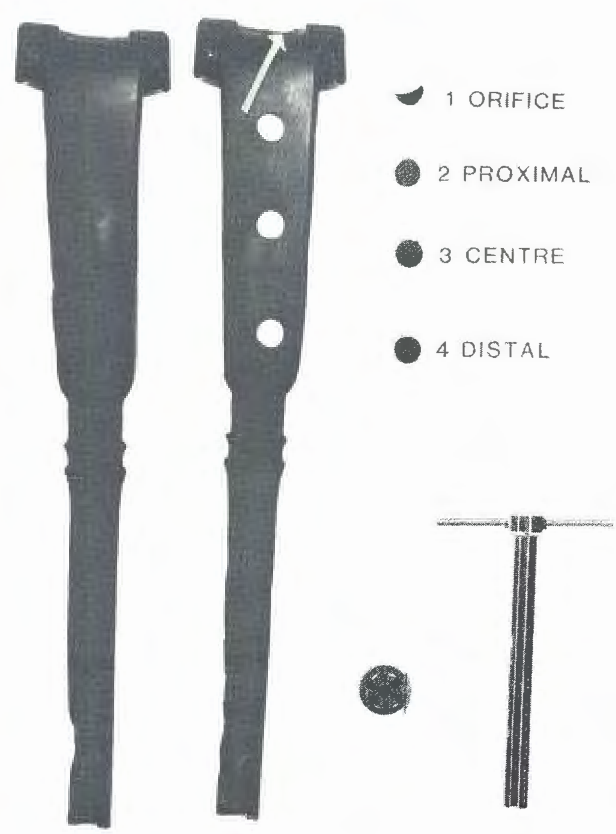

FIG. 1 Halves of teat cup liner (left not sampled; right sampled); sample No. 1 and 2–4 excised from orifice and respectively proximal, central and distal third of liner wall; cork borer; small sample bottle viewed through its bottom towards star-shaped portion of stopper

Processing of samples for SEM work

Each of the samples was mounted with silver paint on a specimen stud, ion-sputtered with gold applied to a thickness of 10 nm with a SCD-020* gold coater, and viewed with an ISI**-100 high resolution SEM operating at 30 Kv.

Evaluation of samples by means of SEM

The luminal surface of each sample was pre-screened at 50 × for determining the area most representative of the whole surface under investigation. Micrographs of the area were routinely taken at 400 ×, and at other magnifications where warranted. Permanent records (i.e. identification, magnification) were recorded on the micrographs by means of a keyboard system attached to the ISI-100.

Further evaluations of samples were performed by viewing the micrographs.

Evaluation of results

As the investigation was aimed at determining and defining possible problems, the results were obtained by qualitatively comparing micrographs of different liners, samples of a liner with each other, and with those of an industrial reference chart (Fig. 2).

Differences between liners were always evaluated from micrographs of the central portion (Fig. 1) of the liner wall.

RESULTS

The surface condition of distributor controls

The luminal surfaces of teat cup liners from different manufacturers sold during 1982 as brand-new show marked qualitative differences (Fig. 3 & 4).

The differences observed suggest that liners sold as brand-new to South African dairy farmers are not necessarily up to an acceptable standard quality.

The surface condition of farmer controls

The unused farmer controls, like the distributor controls, indicated a variety of surface qualities (Fig. 5).

It should be noted that liners 4A and 4B (Fig. 5), though apparently identical in make and model with those of liners 14A and 15B (Fig. 4), differed markedly from their respective distributor control.

The differences in quality observed could be due to conditions affecting the teat cup liners during their manufacture (e.g. formulations, quality controls), at the distributor (e.g. storage) and at the user (e.g. storage) end.

The surface condition of used liners

The luminal surfaces of used liners, collected on dairy farms after 100 and 500 milkings, indicate that considerable changes are brought about by wear and tear (Fig. 6 & 7).

The micrographs (Fig. 6 & 7) suggest that surface features of corresponding distributor (Fig. 4) and farmer controls (Fig. 5) had apparently been worn during 100 milkings.

The surface of liner 2A (Fig. 6) shows multiple shallow cracks which, after 500 milkings of the corresponding liner 3A (Fig. 7), became even more pronounced.

Granular surface features, prevalent on corresponding distributor and farmer controls (Fig. 4 & 5), became scarcer on the surface of liner 1B (Fig. 6) after 100 milkings, apparently owing to a general, superficial and rather uniform wearing of the surface. Except for some blob-like features, the surface of liner 1 B (Fig. 6) thus seems more even than that of its brand-new (Fig. 4) and unused (Fig. 5) counterparts. At 500 milkings the surface of the corresponding liner 3B (Fig. 7) suggests advanced stages of general deterioration, due mainly to granular disintegration and the deposition of unidentified foreign matter.

The surface condition of different parts of the same liner

The condition of the luminal surface of different parts of the same liner was assessed on 1 specimen each of a distributor control (Fig. 8 & 9), farmer control (Fig. 10 & 11) and liners after 100 and 500 milkings (Fig. 12–19) respectively.

The pitted, grooved and cracked surface of distributor control 14A already has been described (Fig. 4). Though the condition of its surface differed considerably at the orifice (Fig. 8, top) and the proximal (Fig. 8, bottom), central (Fig. 9, top) and distal third (Fig. 9, bottom) of its wall, all the parts showed distinct cracking and various other changes.

The surface of farmer control, liner 4C, was generally smooth and slightly ridged and perforated by rather evenly distributed pores of varying diameter. Pores of small diameter were general, intermediate ones few at the orifice (Fig. 10, top), but frequent in the proximal (Fig. 10, bottom) and central portions (Fig. 11, top), whereas the distal one (Fig. 11, bottom) showed some pores with larger diameters.

The liners 1B and 2B (Fig. 12 & 13), used for 100 milkings, had comparatively good solid surfaces at the orifice (Fig. 12, top), proximal (Fig. 12, bottom), central (Fig. 13, top) and distal parts (Fig. 13, bottom). The opposite seemed applicable to corresponding surface parts (Fig. 14, top, bottom; Fig. 15, top, bottom) of liner 2A after the same number of milkings.

The surfaces of teat cup liners after 500 milkings showed more advanced stages of deterioration (Fig. 16–19) than after 100 milkings (Fig. 14 & 15).

The surface of used liner 3C (Fig. 16 & 17) was in a considerably better condition than that of other liners assessed under similar conditions (Fig. 18 & 19). Nevertheless, liner 3C showed marked erosion of surfaces of the proximal (Fig. 16, bottom) and central parts (Fig. 17, top), presumably because these parts are subject to particularly erosive factors (e.g. friction while attached to the teats).

Compared with liner 3C, the surface conditions of used liner 3A in general showed severe deterioration (Fig. 18 & 19).

The disintegration of liner 3A by cracking and granular deterioration (Fig. 18 & 19) is apparently caused by brittleness of the liner, as the micrographs indicate (e.g. Fig. 5, 7, 8, etc.). The consistency of such changes, similar in nature but differing in magnitude, might be related to the composition and formulation of the material(s) used in the manufacture of the teat cup liner.

Evaluation of surfaces of teat cup liners by an industrial standard (Fig. 2)

The luminal surfaces of teat cup liners (Fig. 3–19) were evaluated by an industrial standard for classifying the suitability of the condition of liner surfaces for dairy farming (Table 2).

From the data in Table 2 it is apparent that the industrial standard used for the above classifications is of limited practical importance for the following reasons:

(1) The standard is applicable only to used liners but not to distributor and farmer controls.

* Balzers Instruments, Switzerland

** International Scientific Instruments, USA

Condition of liner surface	Measures recommended
Smooth and clean	Congratulate!
Over-used, flex-cracks	Replace
Over-used, flex-cracks	Replace
Grooved due to excessive, hard brushing	Replace
Crazed milkstone layer, poor cleaning	Investigate cleaning
Deposits, poor cleaning	Investigate cleaning

Scanning electron micrographs*

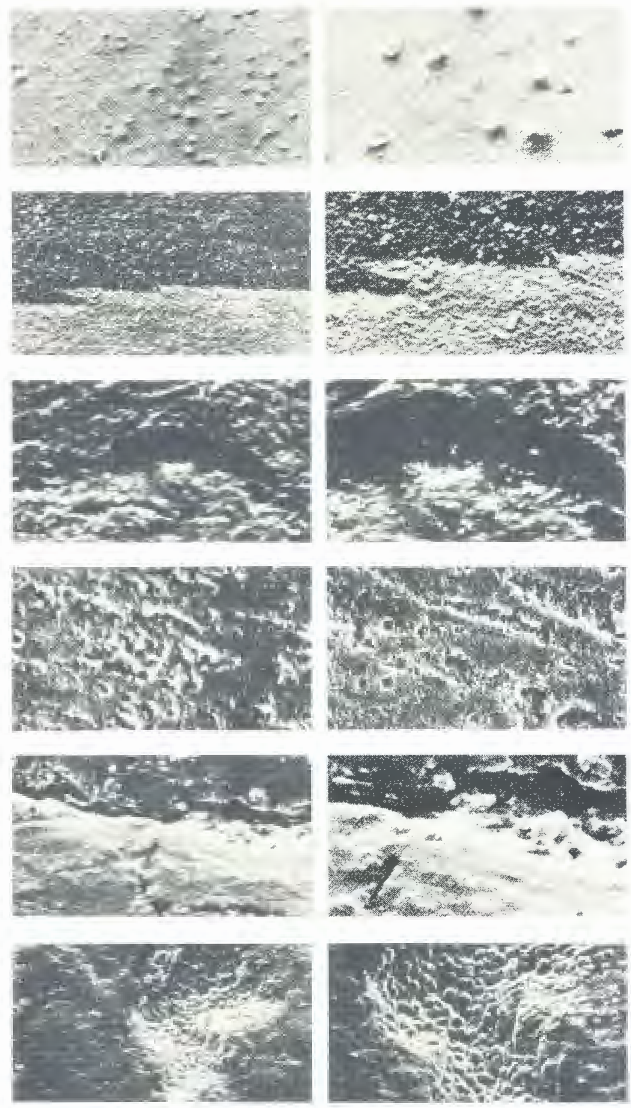

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FIG. 2 Comparison chart of typical liner surfaces

(2) The surfaces of used liners, classified as clean and smooth (Fig. 6, bottom; Fig. 12, bottom; Fig. 13; Fig. 16, top), may be neither smooth nor solid but, instead, granular (Fig. 6, bottom), ridged (Fig. 12, top), blobby (Fig. 13, top) or porous (Fig. 16, top).

(3) The surfaces of used liners indicating poor cleaning and deposits (Fig. 7, bottom; Fig. 16, bottom) may mainly show general granular disintegration of the liner wall rather than the prevalence of deposits.

(4) Several conditions were observed which cannot be defined/classified (Fig. 13, top; Fig. 17, top).

The industrial standard used for the above evaluations is designed to call attention to malconditions affecting teat cup liners. From the findings on distributor controls, farmer controls and used liners, it is clear that brand-new and unused liners available in South Africa are not necessarily flawless. The major problems in both unused and used liners may possibly be solved if a standard for teat cup liners were developed. The industrial standard used during the investigation could thus serve as a generally useful starting point for developing a standard for liner surfaces with a high level of evenness and continuity.

Faults observed on the luminal surface of different teat cup liners

The above evaluations suggest that the luminal liner surface may show that unevenness and discontinuity are due to faults much more diverse than those indicated in the reference chart (Fig. 2). A more complete collection of micrographs suitable for future reference on the major faults of liner surfaces seems desirable (Fig. 20; Table 3).

Further investigations may extend the range of faults (Fig. 20; Table 3) and supply quantitative data on acceptable limits of faults affecting the quality and usefulness of surfaces of teat cup liners and the suitability of liners for milking by machine.

TABLE 2 Evaluation in terms of industrial standards of surfaces of the teat cup liners investigated

Identification of surfaces analysed		Type of specimen	Evaluation of surfaces in terms of industrial standards (Fig. 2)	
Fig. No.	Liner No.		Description of surface condition	Classification in terms of suitability for milking
3 (top)	15B	Distributor control	Not applicable	Not applicable
3 (bottom)	7E	Distributor control	Not applicable	Not applicable
4 (top)	14A	Distributor control	Not applicable	Not applicable
4 (bottom)	15B	Distributor control	Not applicable	Not applicable
5 (top)	4A	Farmer control	Not applicable	Not applicable
5 (bottom)	4B	Farmer control	Not applicable	Not applicable
6 (top)	2A	Used liner	Over-used; flex cracks	Unsuitable
6 (bottom)	1B	Used liner	Clean; smooth	Suitable
7 (top)	3A	Used liner	Over-used; flex cracks	Unsuitable
7 (bottom)	3B	Used liner	Poor cleaning; deposits	Unsuitable
8 (top)	14A	Distributor control	Not applicable	Not applicable
8 (bottom)	14A	Distributor control	Not applicable	Not applicable
9 (top)	14A	Distributor control	Not applicable	Not applicable
9 (bottom)	14A	Distributor control	Not applicable	Not applicable
10 (top)	4C	Farmer control	Not applicable	Not applicable
10 (bottom)	4C	Farmer control	Not applicable	Not applicable
11 (top)	4C	Farmer control	Not applicable	Not applicable
11 (bottom)	4C	Farmer control	Not applicable	Not applicable
12 (top)	1B	Used liners	Undefined ridging	Undefined
12 (bottom)	2B	Used liners	Clean; smooth	Suitable
13 (top)	1B	Used liners	Undefined blobs	Undefined
13 (bottom)	2B	Used liners	Undefined blobs	Undefined
14 (top)	2A	Used liners	Over-used; flex cracks	Unsuitable
14 (bottom)	2A	Used liners	Over-used; flex cracks	Unsuitable
15 (top)	2A	Used liners	Over-used; flex cracks	Unsuitable
15 (bottom)	2A	Used liners	Over-used; flex cracks	Unsuitable
16 (top)	3C	Used liners	Clean; smooth	Suitable
16 (bottom)	3C	Used liners	Poor cleaning; deposits	Unsuitable
17 (top)	3C	Used liners	Undefined surface condition	Undefined
17 (bottom)	3C	Used liners	Over-used; flex cracks	Unsuitable
18 (top)	3A	Used liners	Over-used; flex cracks	Unsuitable
18 (bottom)	3A	Used liners	Over-used; flex cracks	Unsuitable
19 (top)	3A	Used liners	Over-used; flex cracks	Unsuitable
19 (bottom)	3A	Used liners	Over-used; flex cracks	Unsuitable

TABLE 3 Faults of the luminal surface of teat cup liners (Fig. 20) investigated at 400 × magnification by means of SEM

No. of micrographs	Characteristics of liner surface			Proposed classification on suitability of liner surface for milk production
	Evenness of surface	Continuity of surface	Major faults of surface	
1	Slightly lumpy	Good	Infrequent blobs	Suitable
2	Markedly uneven	Unsatisfactory	Generally cracked	Unsuitable
3	Slightly ridged	Satisfactory	Few ridges	Suitable
4	Distinctly uneven	Satisfactory	Generally granular and blobby	Less suitable
5	Markedly uneven	Satisfactory	Generally granular, blobby and scaly	Less suitable
6	Markedly uneven	Unsatisfactory	Generally sloughing	Unsuitable
7	Slightly ridged	Unsatisfactory	Frequent cracks	Unsuitable
8	Markedly uneven	Unsatisfactory	Extensive foamy eruptions	Unsuitable
9	Slightly ridged	Limited	Infrequent pores	Less suitable
10	Distinctly uneven	Unsatisfactory	Frequent pits, cracks and grooves	Unsuitable
11	Markedly uneven	Unsatisfactory	Extensive pitting, cracking and grooving	Unsuitable
12	Markedly uneven	Unsatisfactory	Extensive flex-cracking	Unsuitable

DISCUSSION

Mastitits affecting South African dairy cattle and measures for the prevention and control of this costly disease have been subjects of numerous discussions (Giesecke *et al.*, 1971; Giesecke, 1979; 1981; Van den Heever & Giesecke, 1979). The prevention and control of mastitis depend mainly on the motivation of the dairy farmer and on an efficient veterinary and technical service with specialized knowledge of how to tackle this highly complex erosive condition (Giesecke *et al.*, 1971; Van den Heever & Giesecke, 1979; Giesecke, 1981). Just how specialized and versatile such a service should be has become apparent from recent work by Noorlander & Heckmann (personal communication, 1981), who estimate that as much as 50% of mastitis related to *S. aureus* may result solely from the unsatisfactory condition of used teat cup liners.

Practical experience under South African conditions (Erasmus, unpublished data, 1982) indicates that the replacement of used liners with new ones may result in markedly improved udder health of dairy cows. However, such improvement would depend not only on the condition of teat cup liners in daily use on dairy farms but, even more significantly, on the quality of the available brand-new liners.

From the present investigation it is obvious that the condition of the luminal surface of the majority of teat cup liners examined is poor to unacceptable, not only because of factors related to their practical use but also to their manufacture, method of distribution and storage prior to use. The poor quality of the surface of several distributor controls (Fig. 3 & 4), the inconsistent surfaces of the same liners examined as farmer and distributor controls (Fig. 5), advanced surface deteriorations after only 100–500 milkings (Fig. 6, 7, 14–19) and differing surfaces at different parts of the same liners (Fig. 9–12), in fact, clearly indicate the doubtful standards of quality control during manufacture and distribution. Faults already persent in brand-new liners (Fig. 20, micrograph 2, 7–12) are aggravated during their use (Fig.

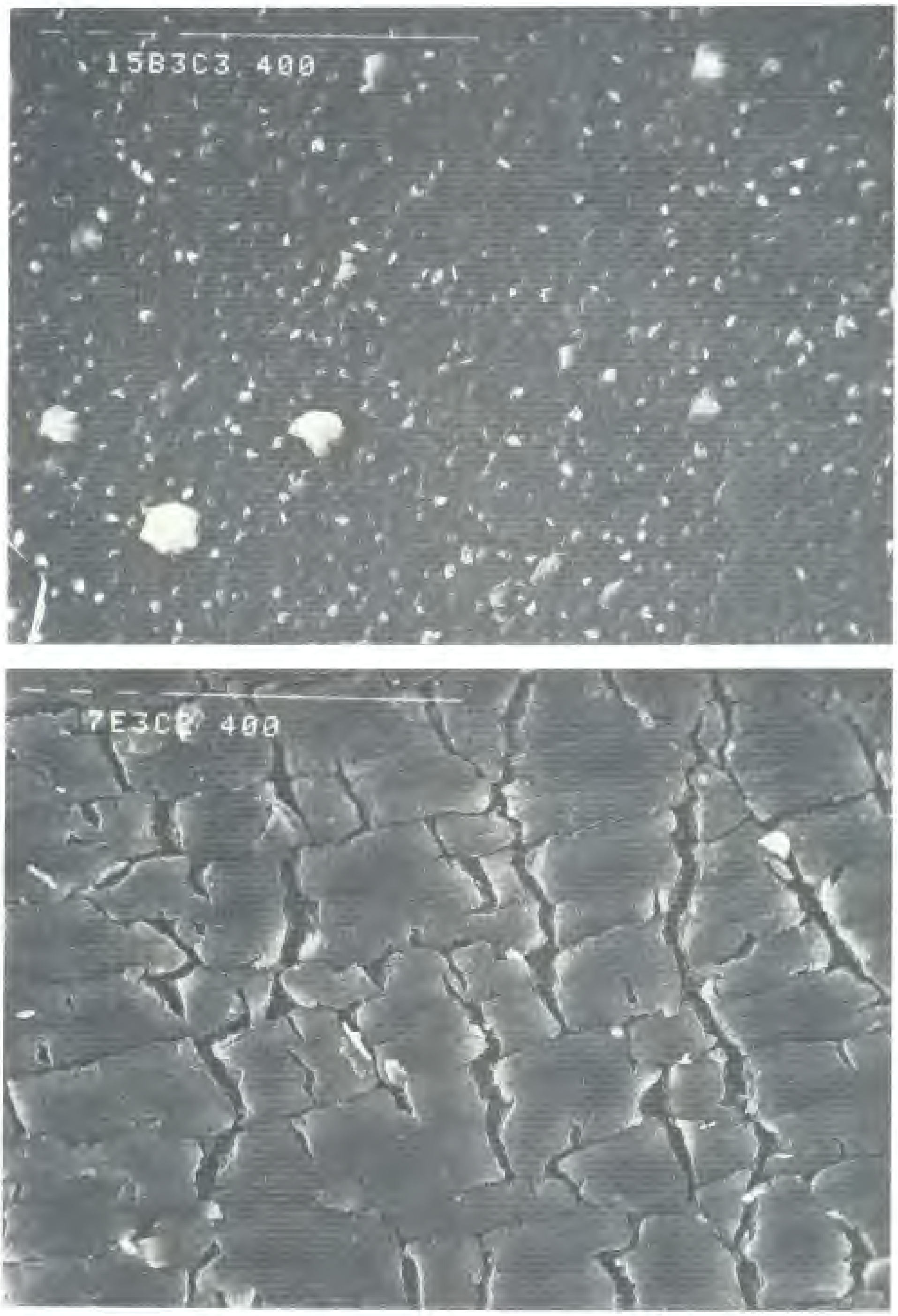

FIG. 3 Distributor controls 15B (top) and 7E (bottom) with generally solid, though rather uneven surface and cracked surface respectively

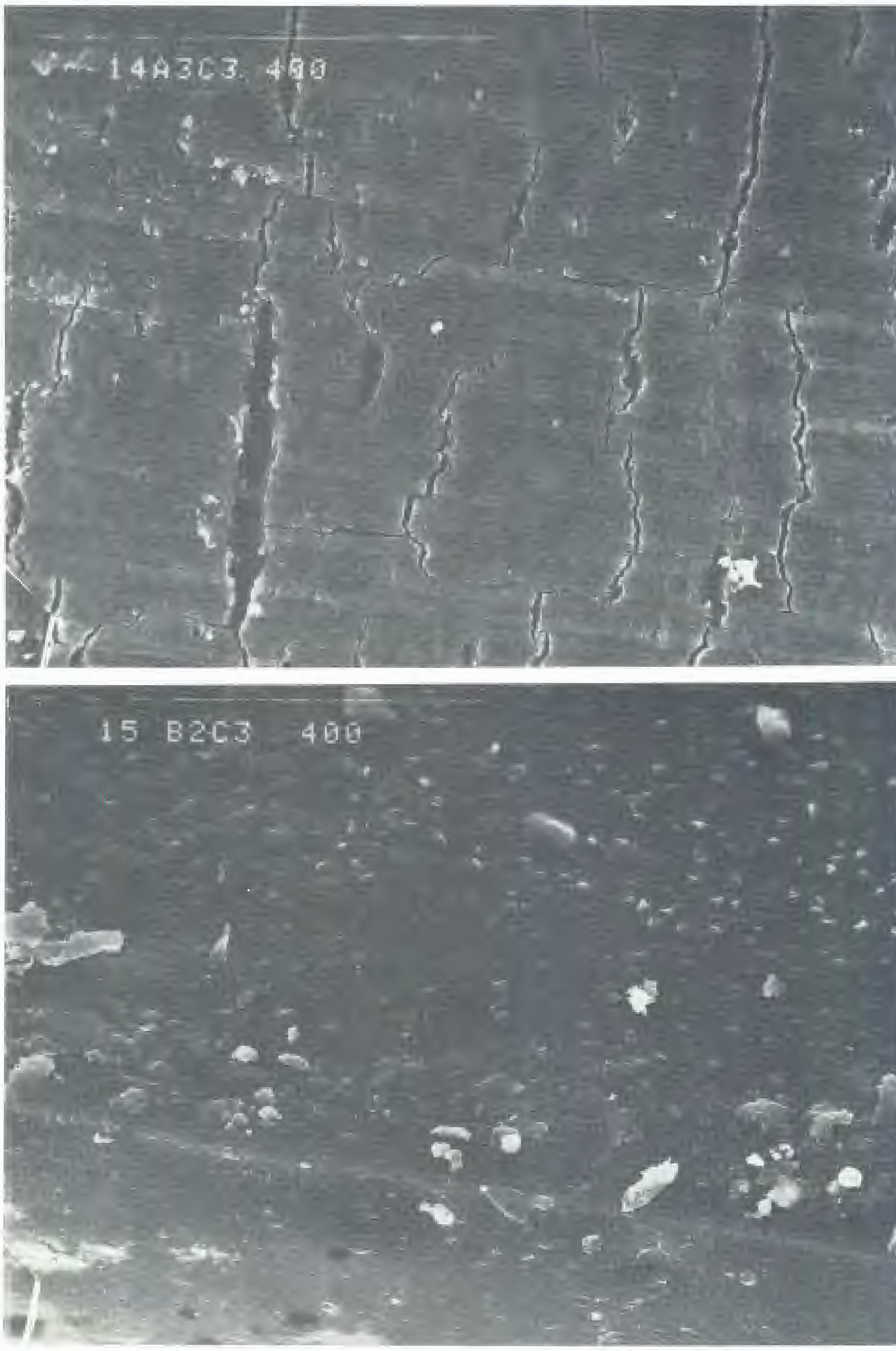

FIG. 4 Distributor controls 14A (top) and 15B (bottom) with 14A surface generally cracked, pitted and creviced, and 15B surface solid, though rather uneven, as examples of the condition of brand-new liners further investigated as farmer controls and used liners

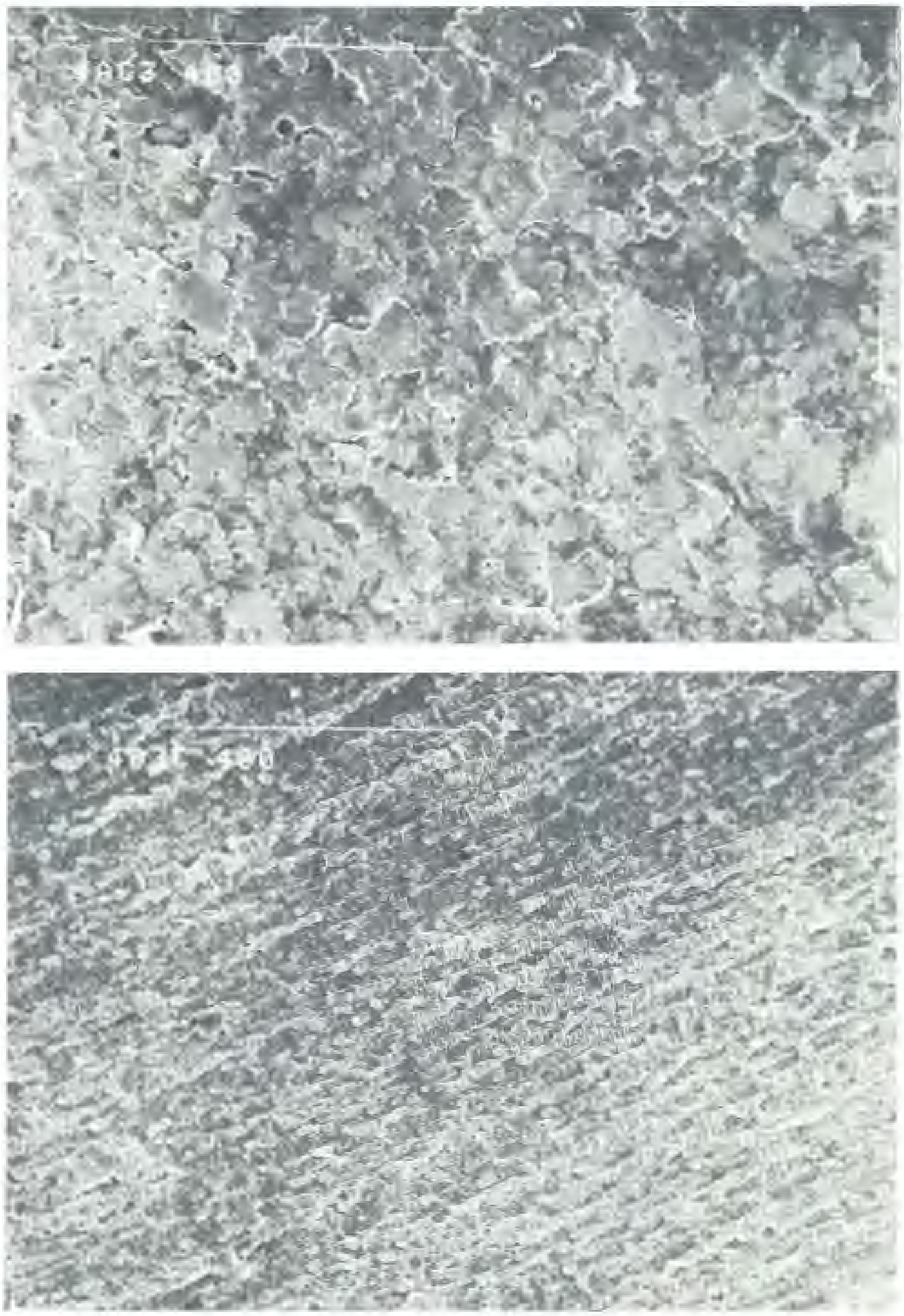

FIG. 5 Farmer controls 4A (top) and 4B (bottom) with 4A generally porous and scaly, and 4B coarsely ridged, markedly differing from the corresponding surfaces of brand-new liners 14A and 15B (Fig. 4), apparently identical with the former, but investigated as distributor controls

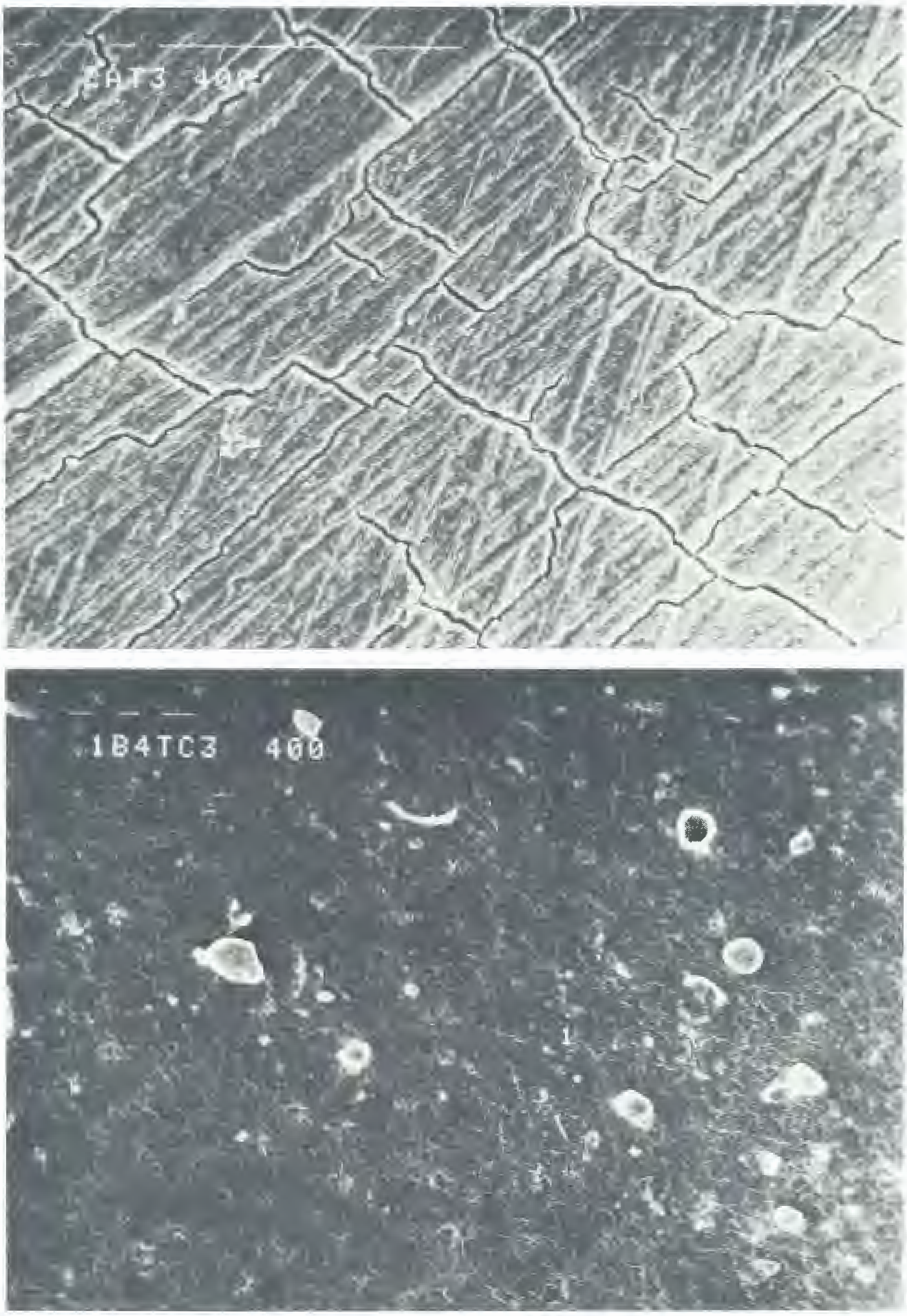

FIG. 6 Used liners 2A (top) and 1B (bottom) after 100 milkings each. Make and model of the 2 liners are apparently identical with those of corresponding distributor controls 14A and 15B (Fig. 4) and farmer controls 4A and 4B (Fig. 5) respectively

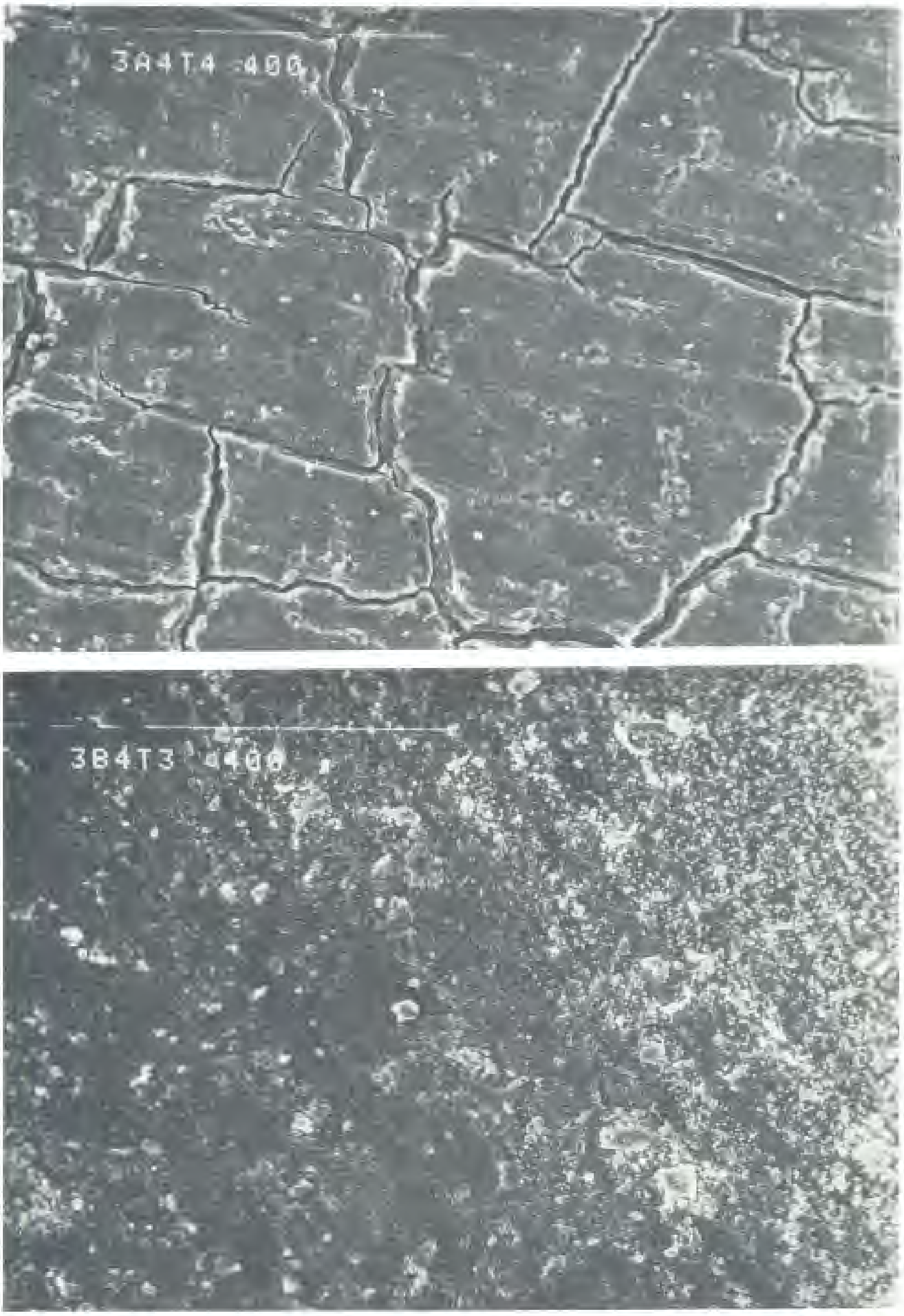

FIG. 7 Used liners 3A (top) and 3B (bottom) after 500 milkings each. Make and model of the 2 liners apparently identical with those of used liners 2A and 1B (Fig. 6)

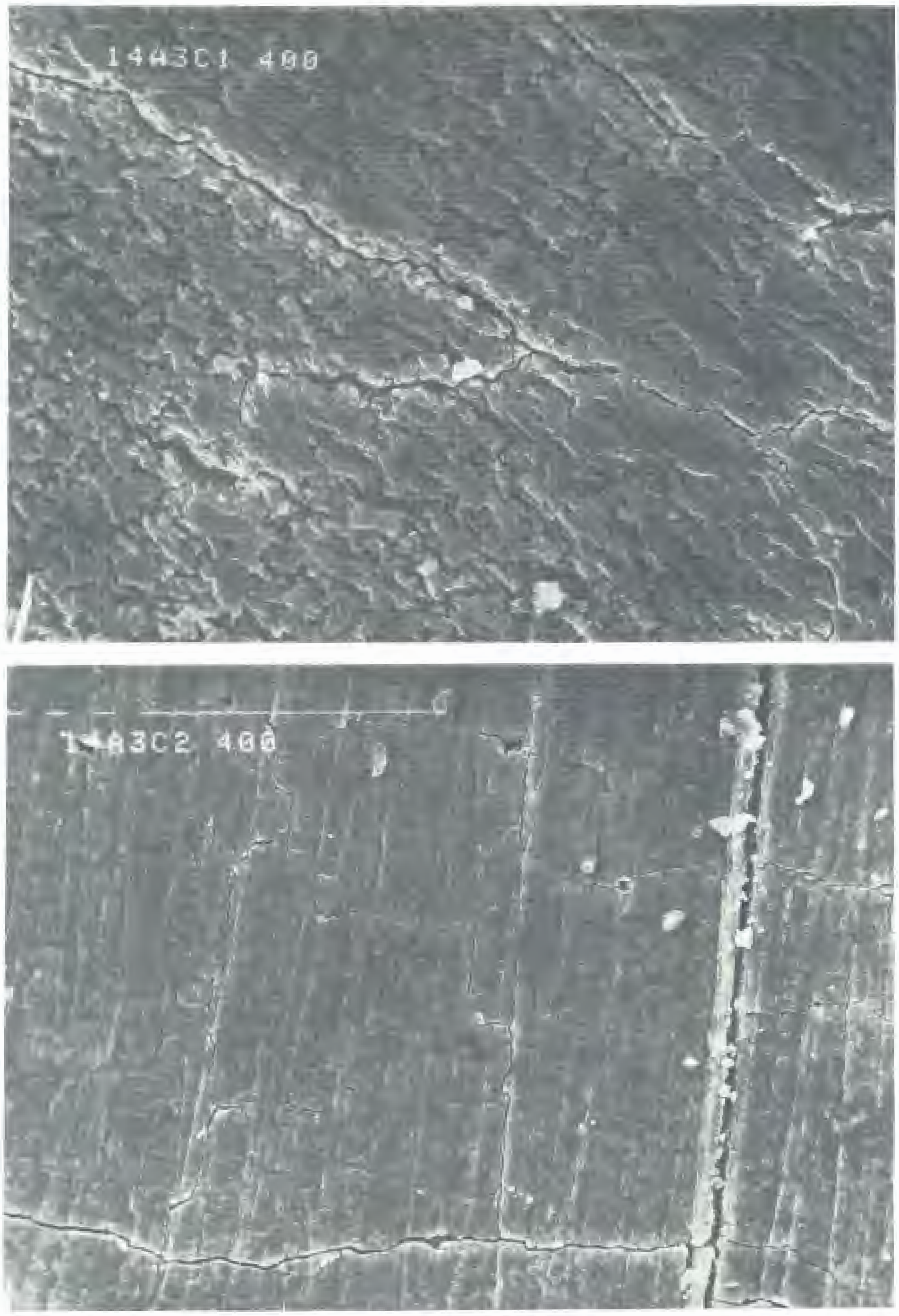

FIG. 8 The surface of the same liner (i.e. distributor control 14A) investigated at the orifice (top) and proximal third (bottom) of liner wall

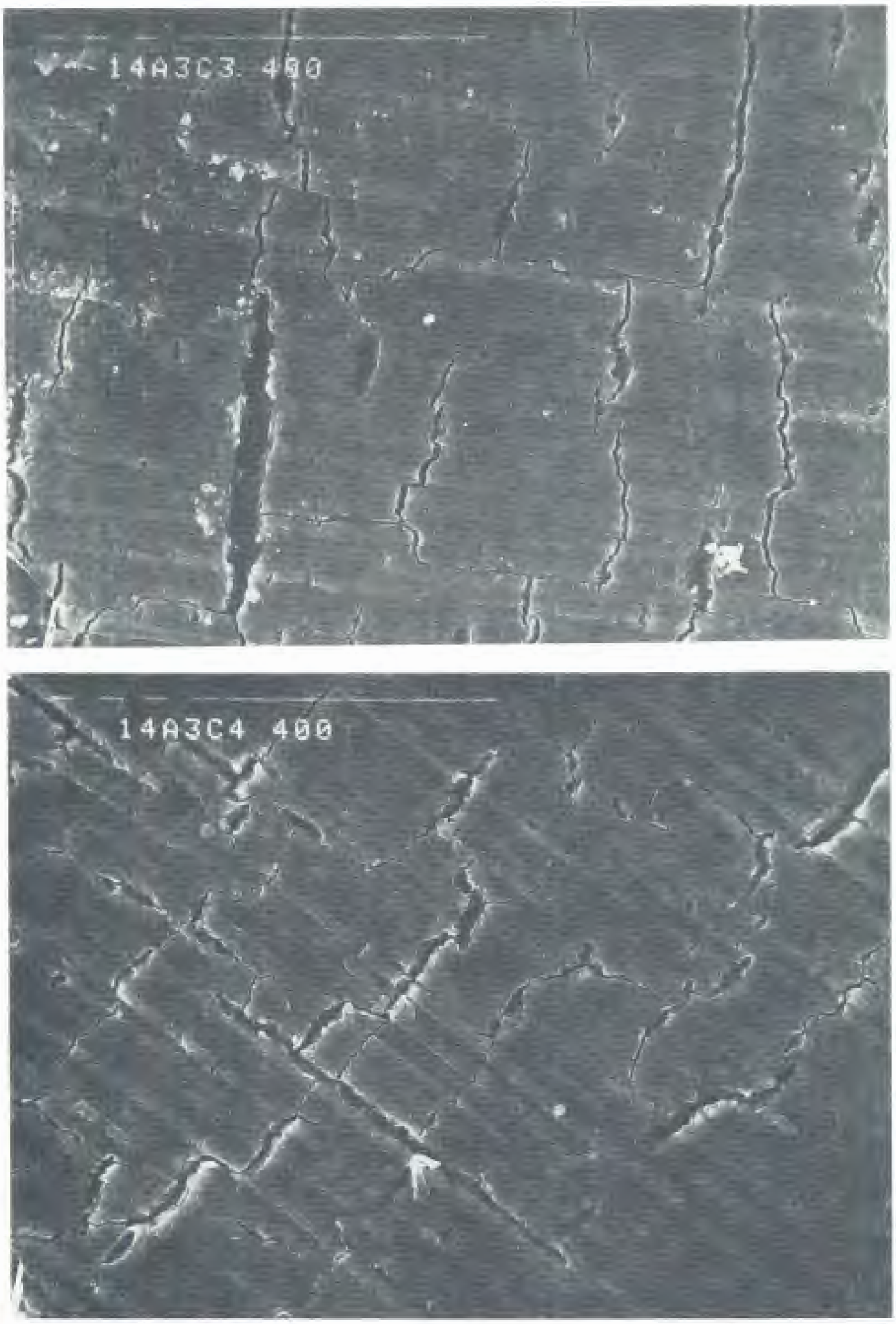

FIG. 9 The surface of the same liner (i.e. distributor control 14A; Fig. 10) investigated at central and distal third of liner wall

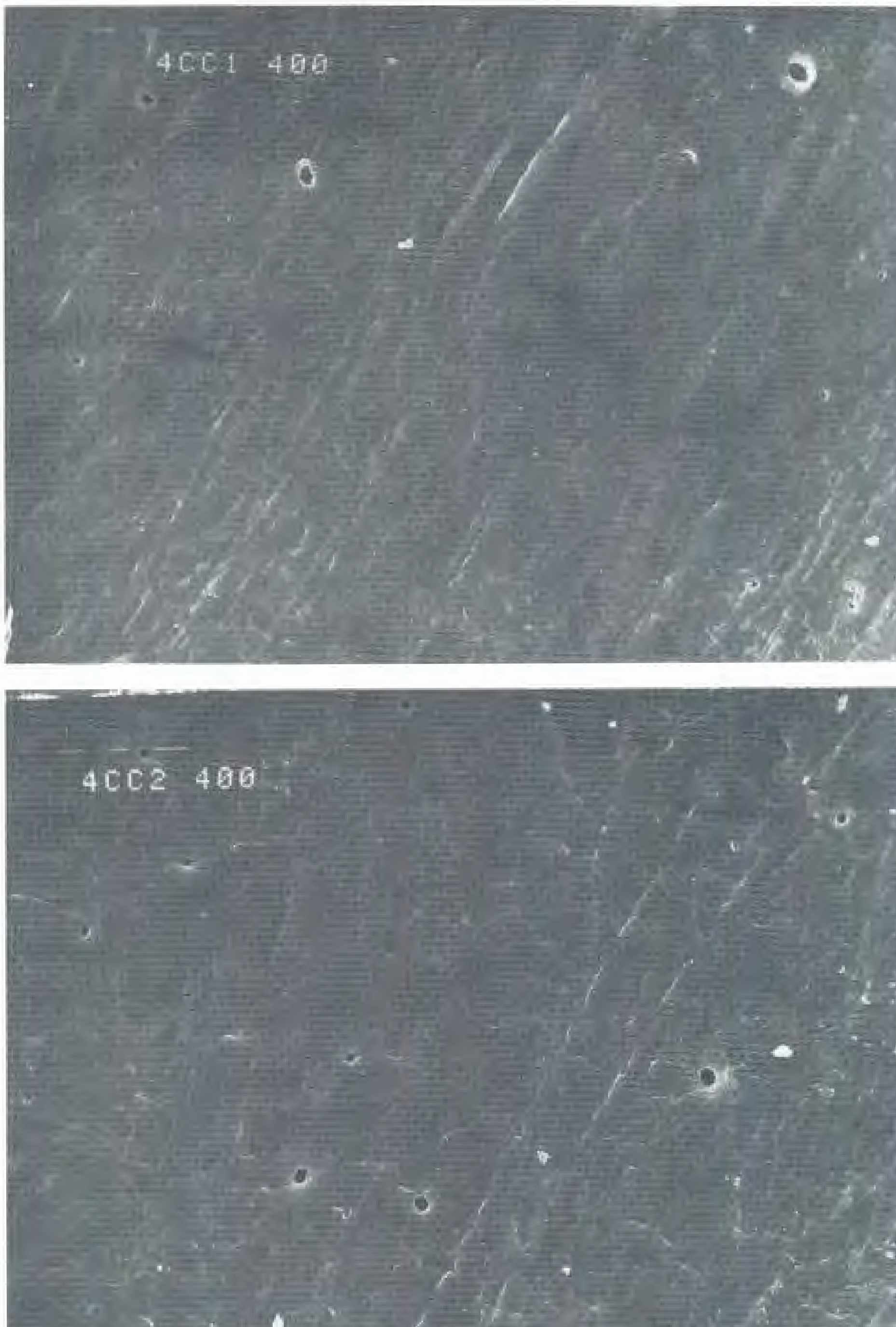

FIG. 10 The surface of the same liner (i.e. farmer control 4C) investigated at the orifice (top) and proximal third (bottom) of liner wall

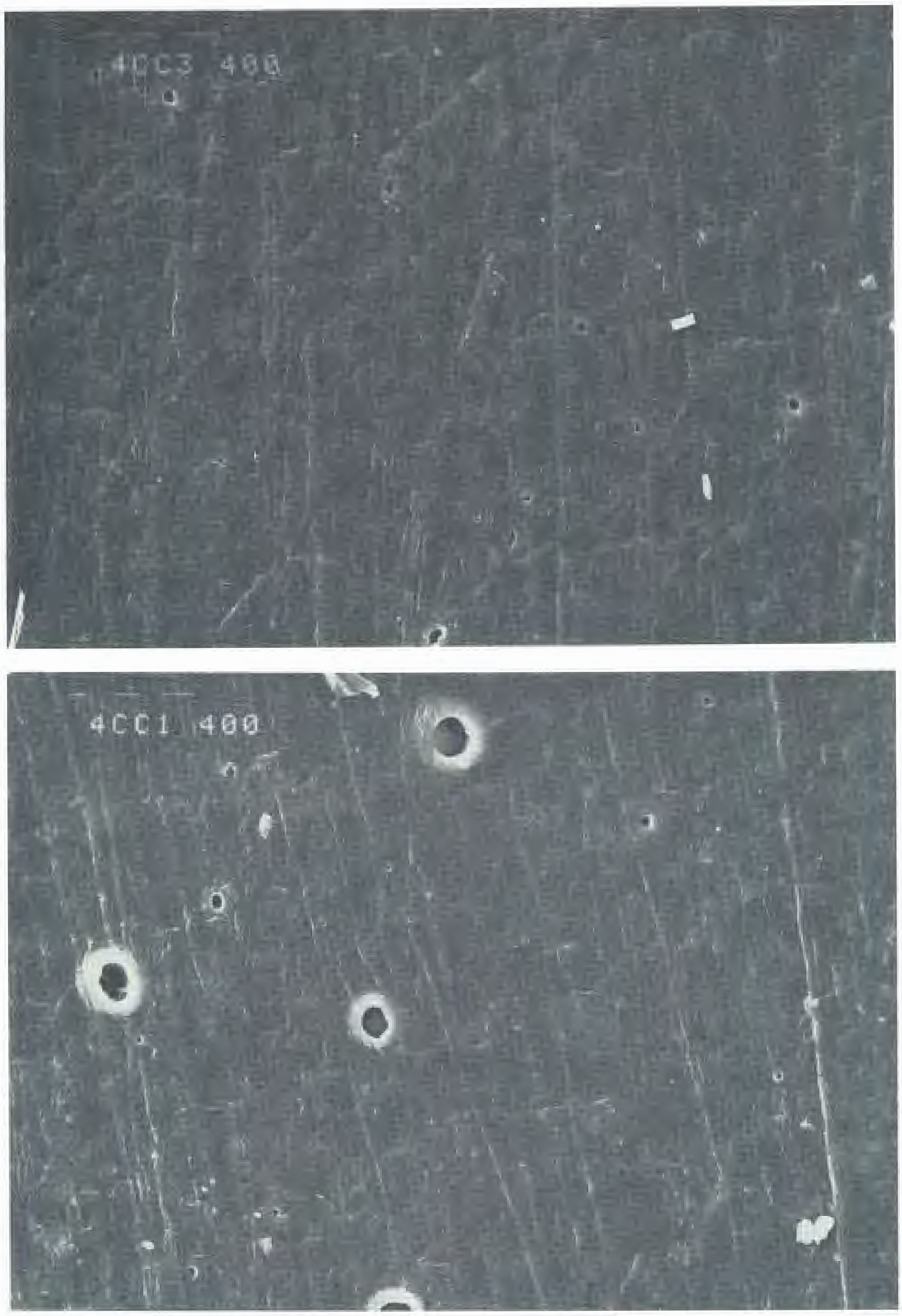

FIG. 11 The surface of the same liner (i.e. farmer control 4C; Fig. 8) investigated at the central (top) and distal third (bottom) of liner wall

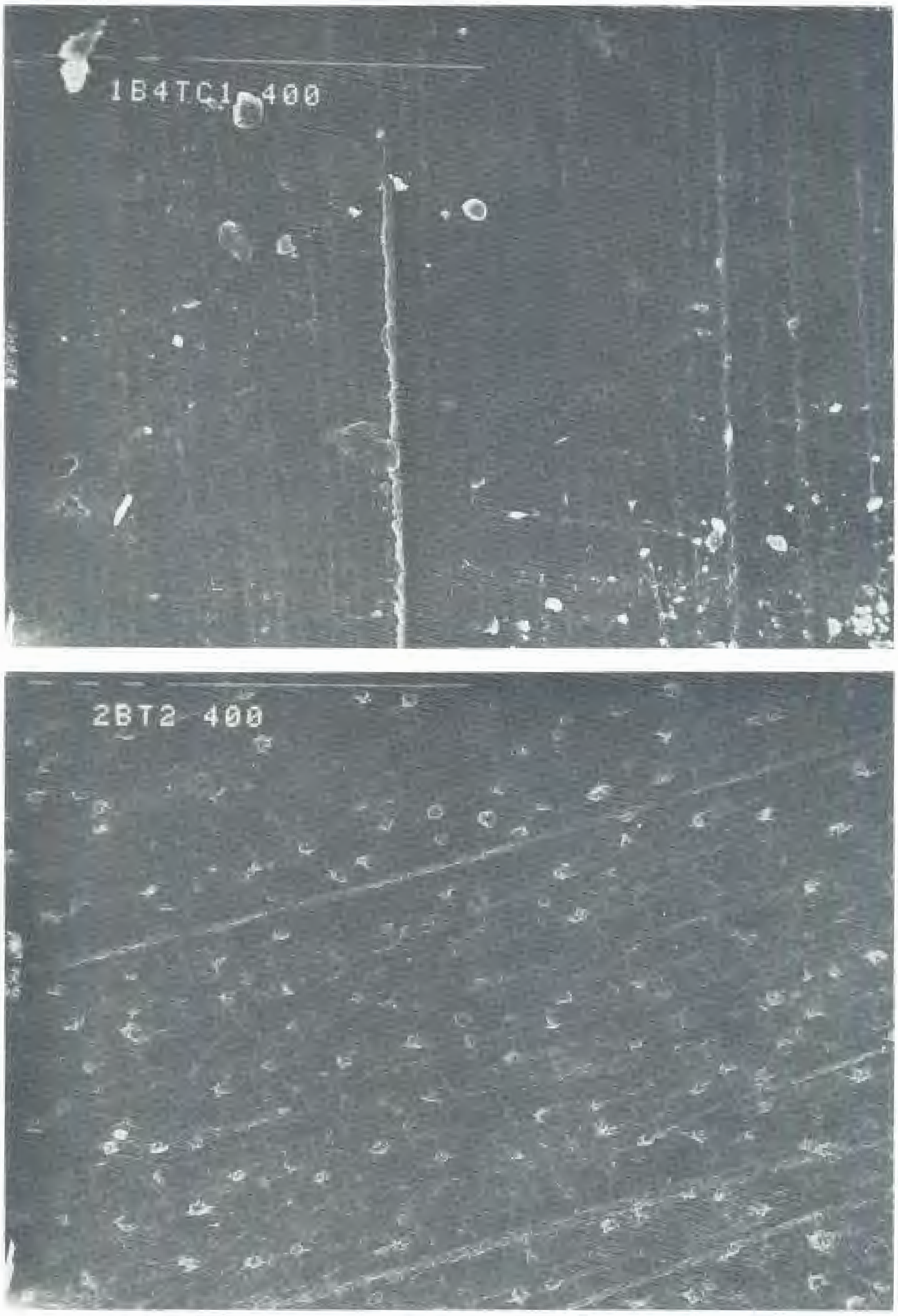

FIG. 12 The surface after 100 milkings of the same liner (i.e. used liner B) investigated at the orifice (top) and proximal third (bottom) of liner wall

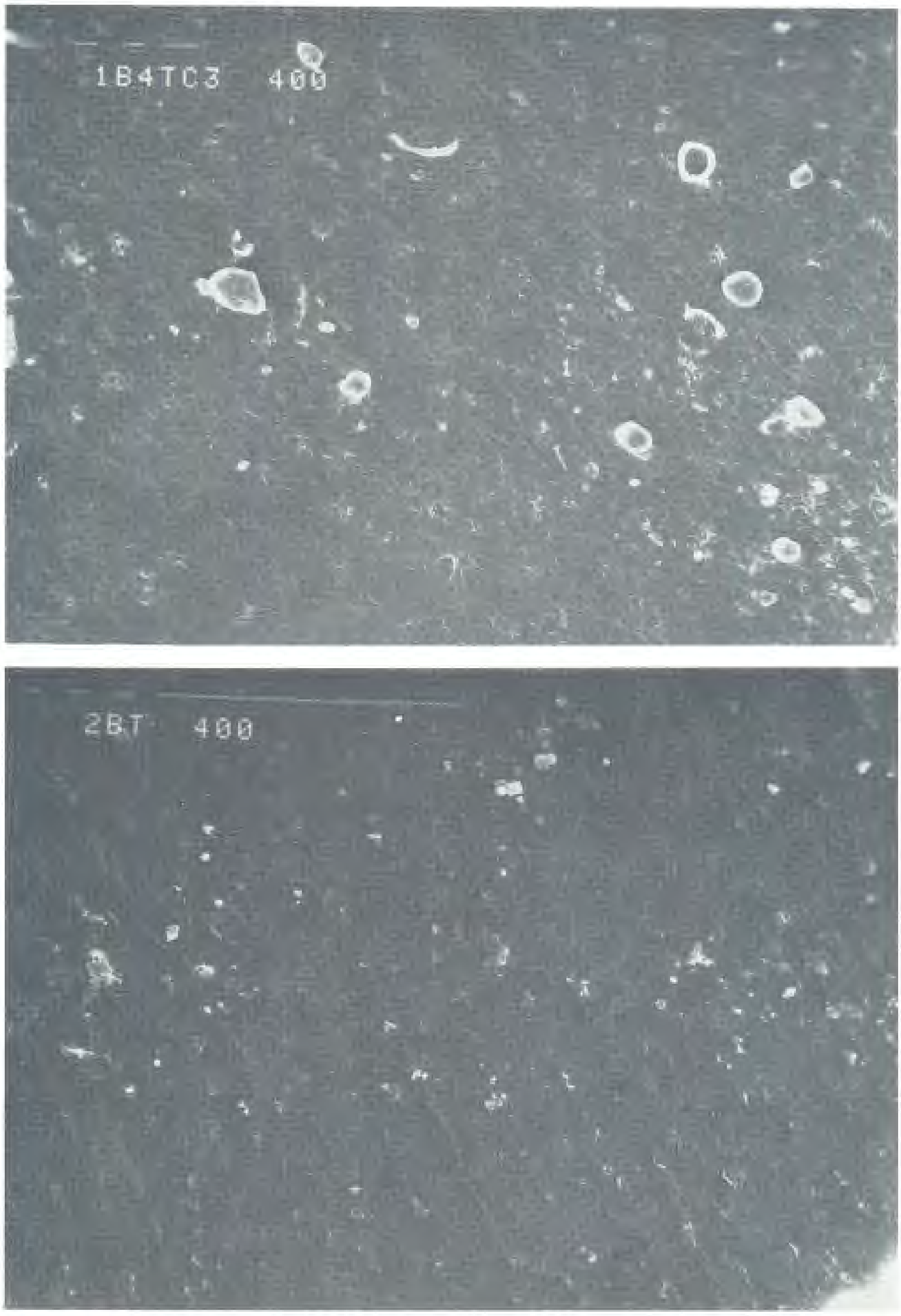

FIG. 13 The surface after 100 milkings of the same liner (i.e. used liner B; Fig. 12) investigated at the central (top) and distal third (bottom) of liner wall

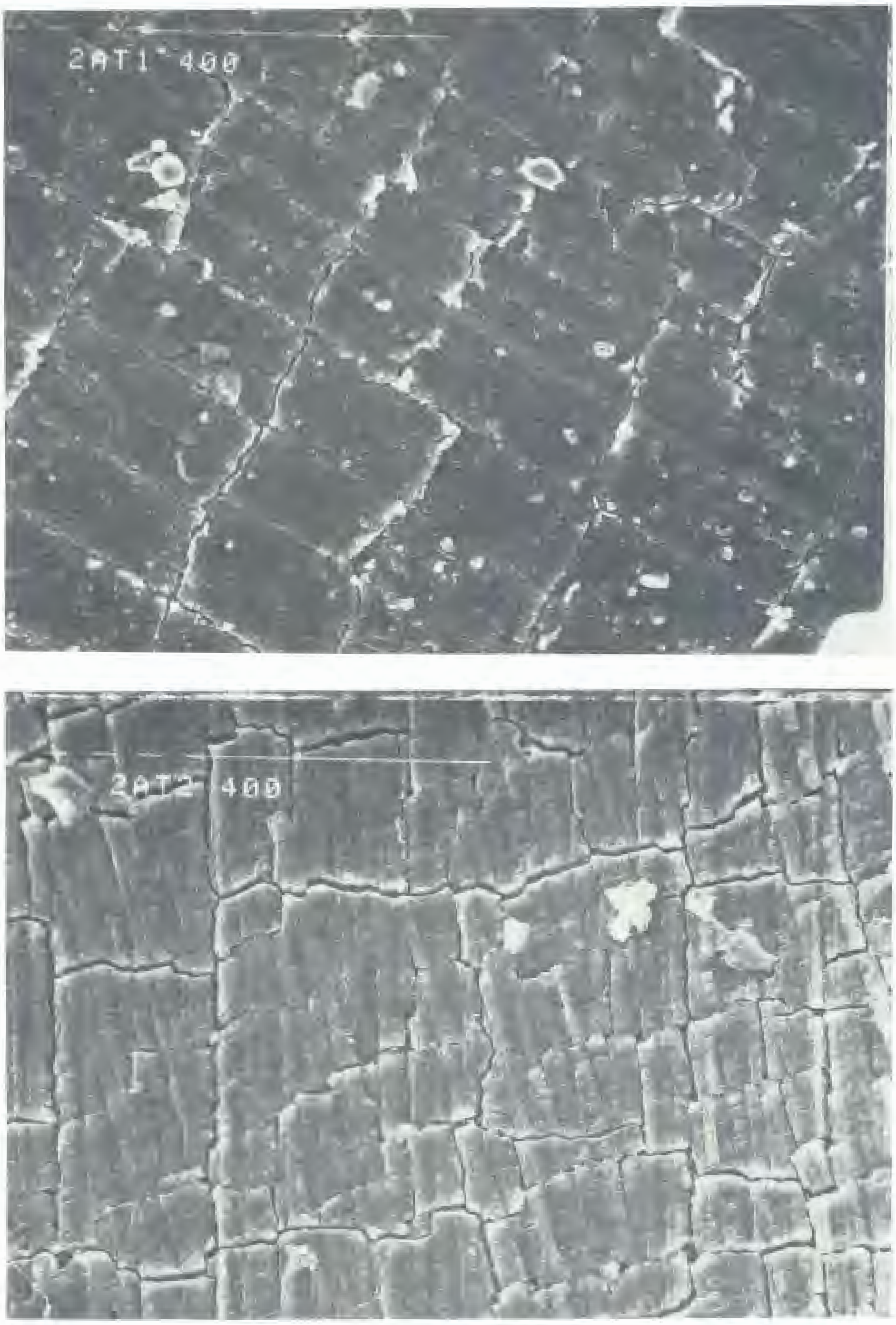

FIG. 14 The surface after 100 milkings of the same liner (i.e. used liner 2A) investigated at the orifice (top) and proximal third (bottom) of liner wall

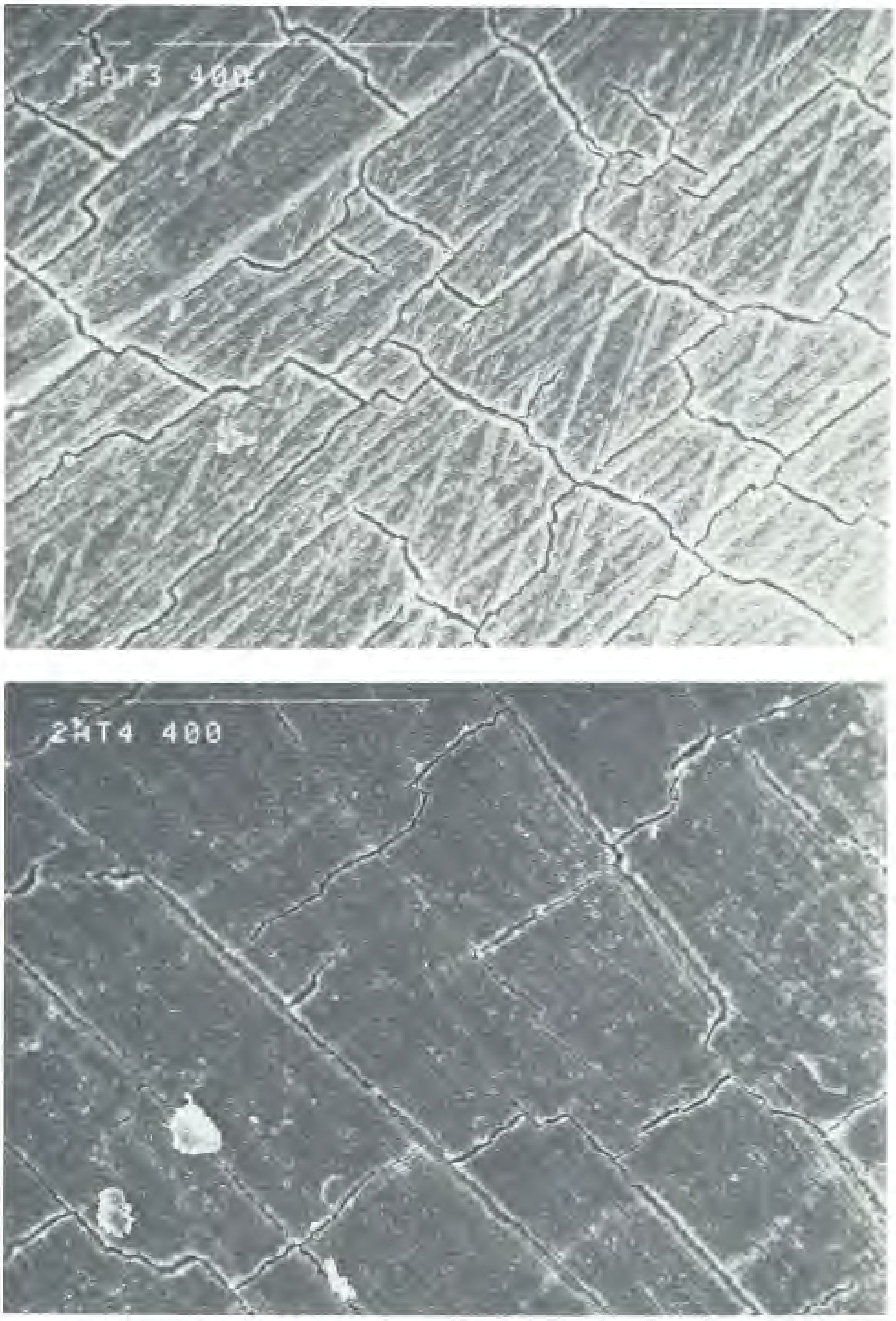

FIG. 15 The surface after 100 milkings of the same liner (i.e. used liner 2A; Fig. 14) investigated at the central (top) and distal third (bottom) of liner wall

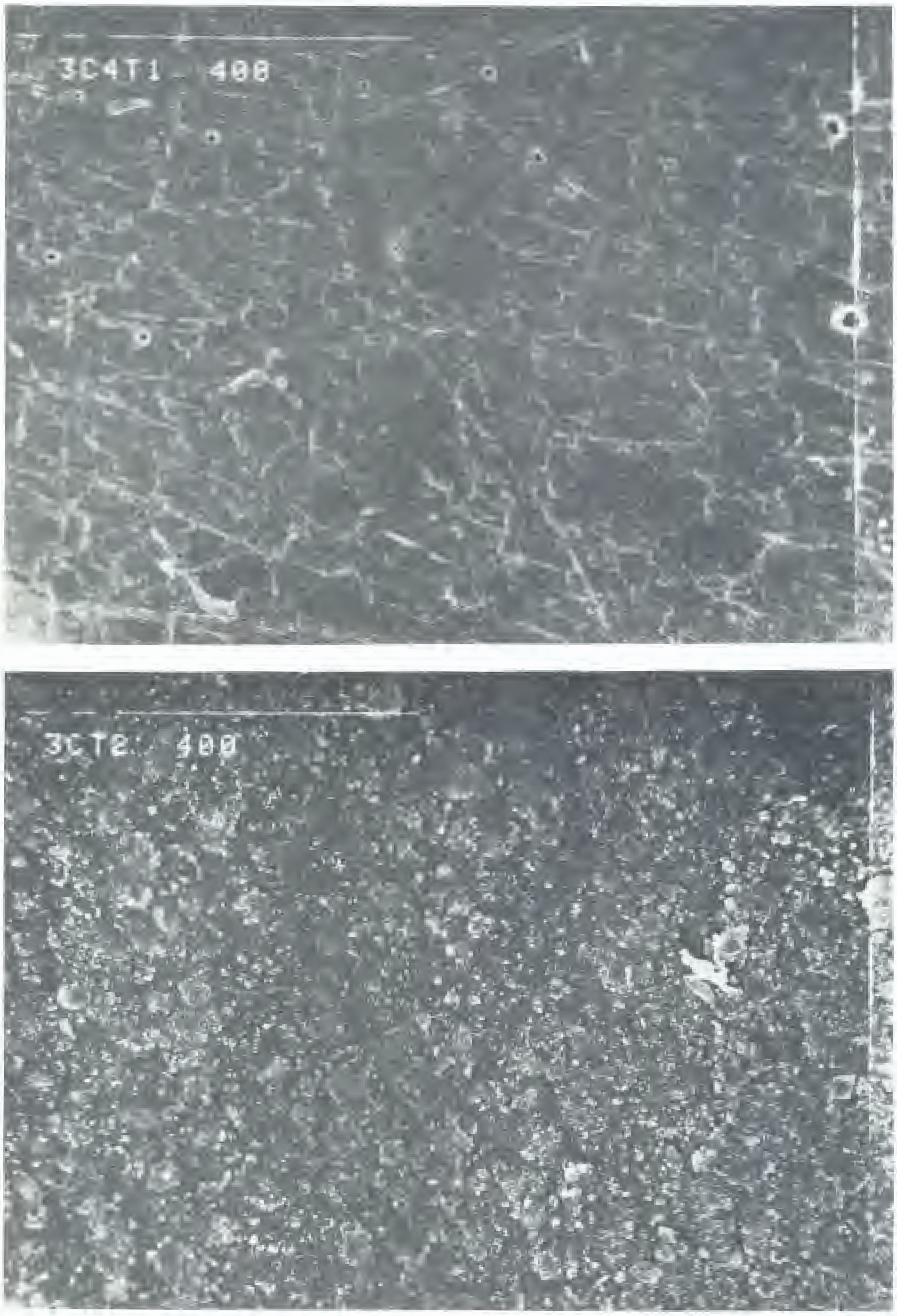

FIG. 16 The surface after 500 milkings of the same liner (i.e. used liner 3C) evaluated at the orifice (top) and proximal third (bottom) of liner wall

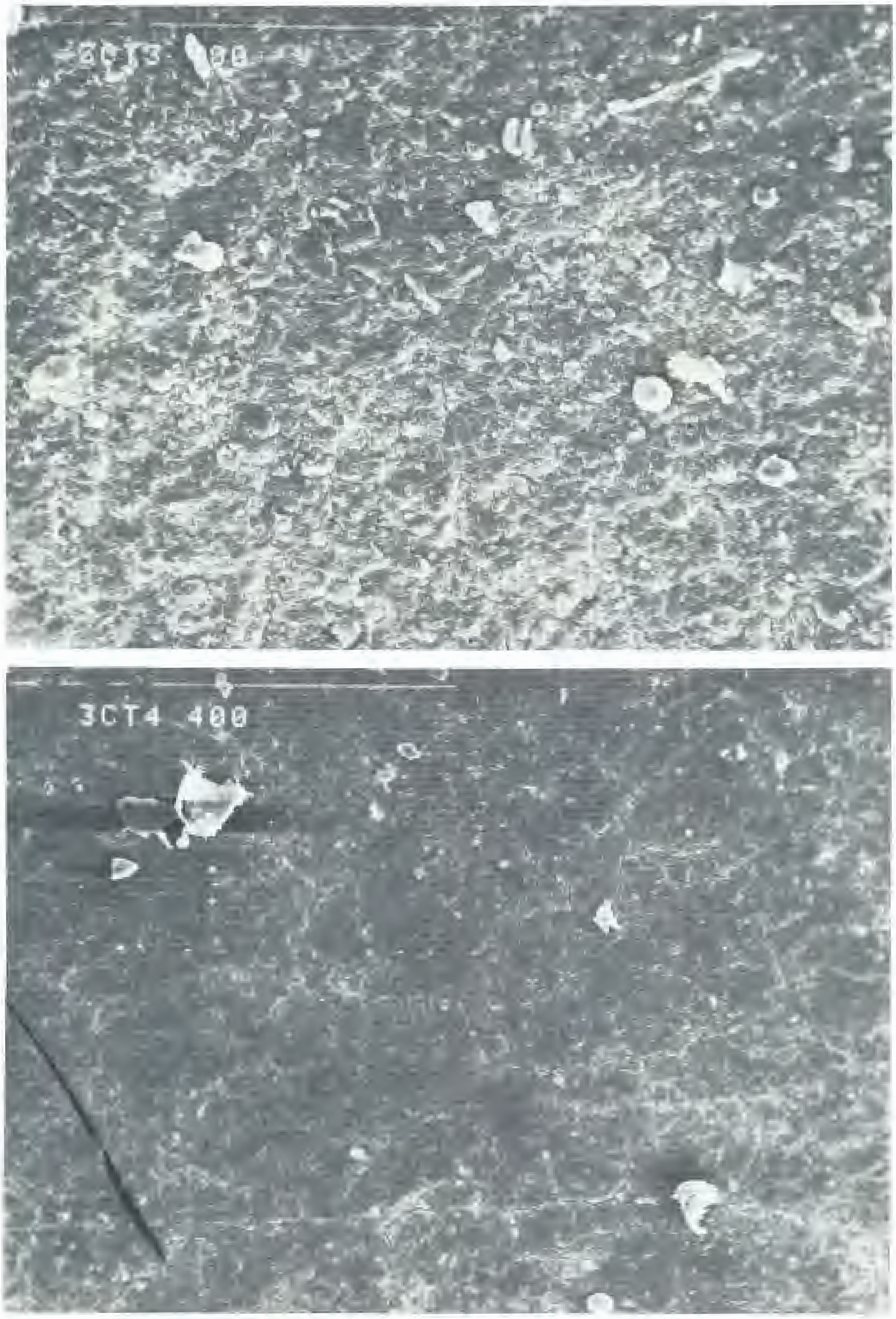

FIG. 17 The surface after 500 milkings of the same liner (i.e. used liner 3C; Fig. 16) assessed at the central (top) and distal third (bottom) of liner wall (*N.B.*—Black line at left bottom of 3CT4 a fault on negative)

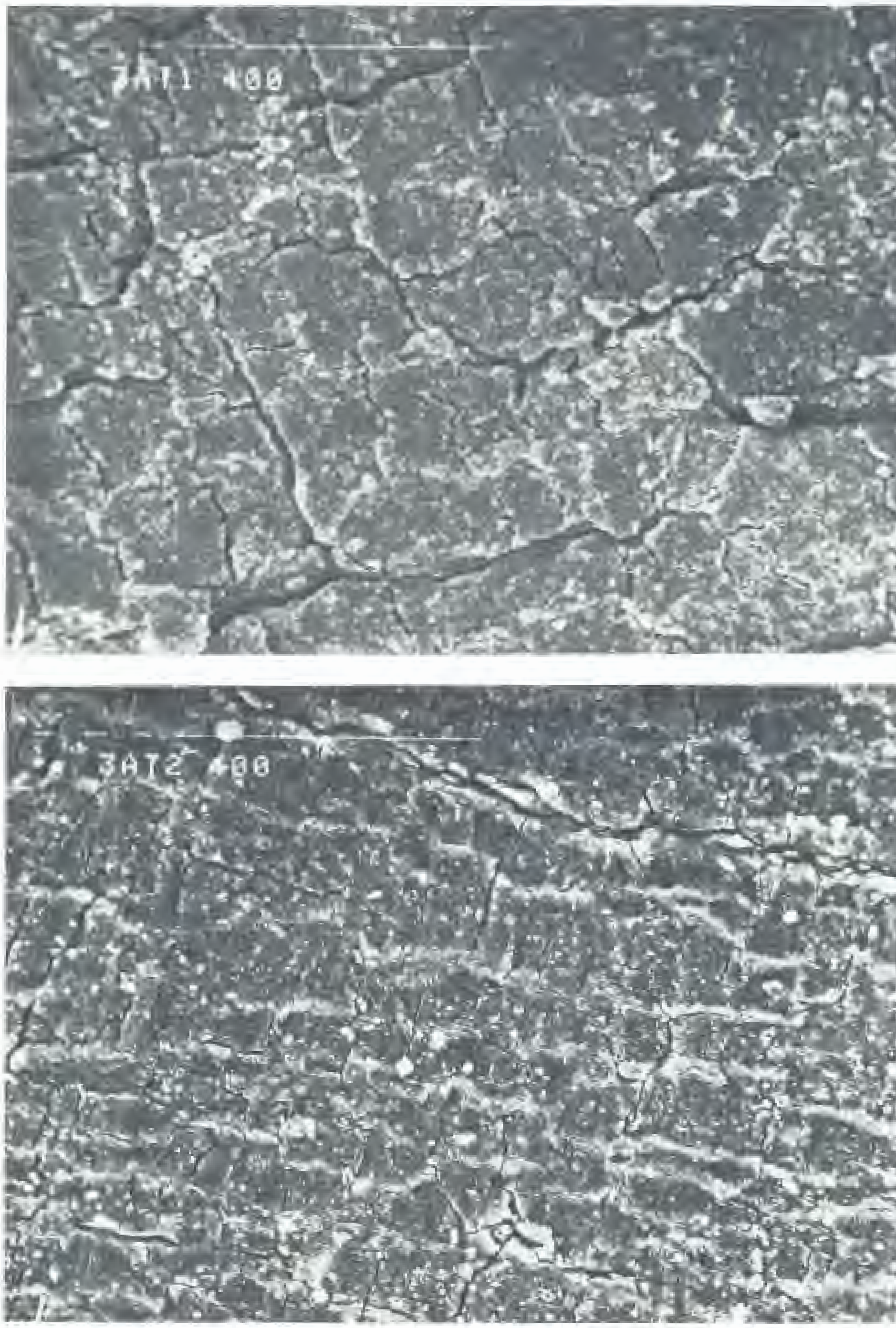

FIG. 18 The surface after 500 milkings of the same liner (i.e. used liner 3A) investigated at the orifice (top) and proximal third (bottom) of liner wall

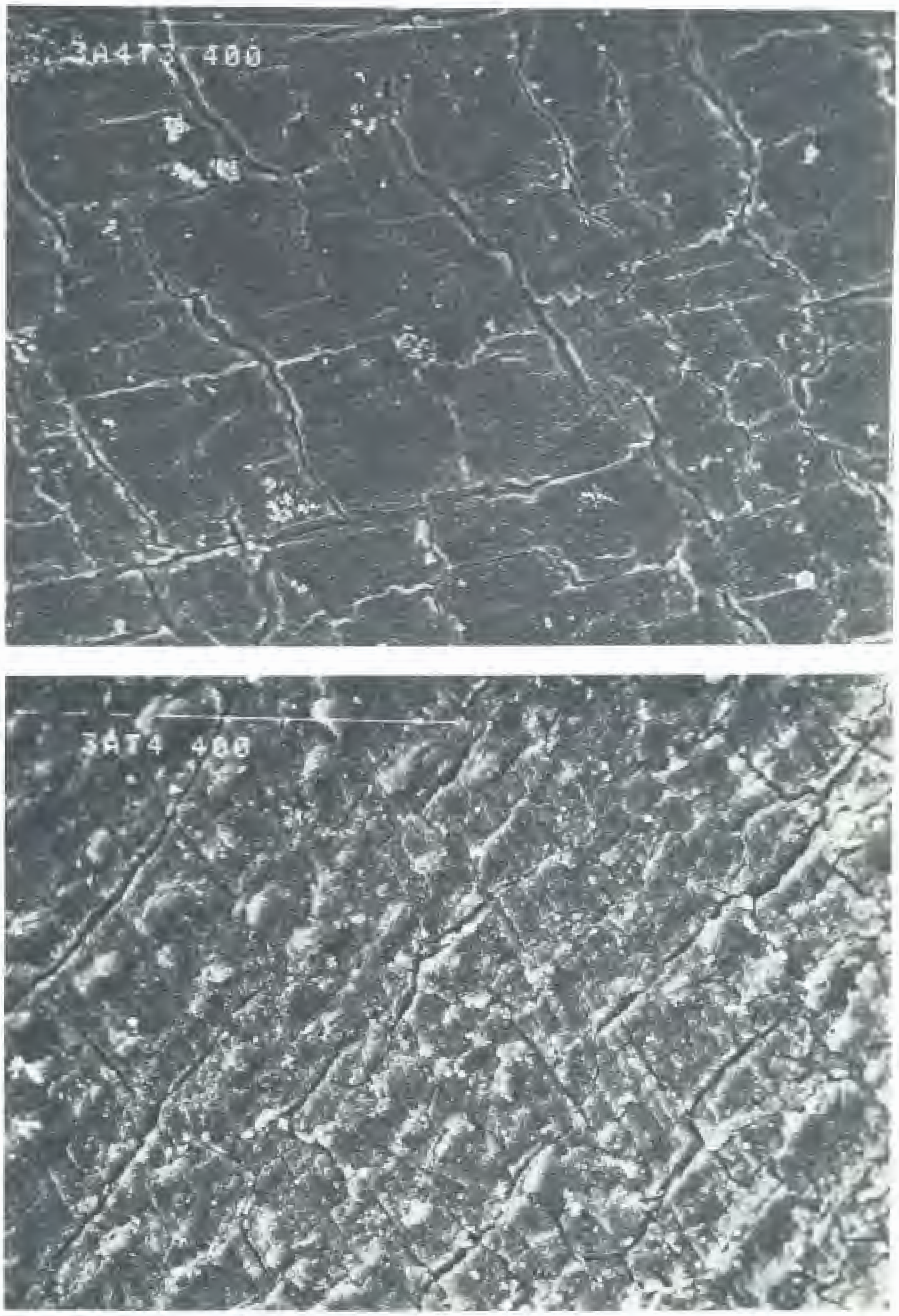

FIG. 19 The surface after 500 milkings of the same liner (i.e. used liner 3A; Fig. 18) assessed at the central (top) and distal third (bottom) of liner wall

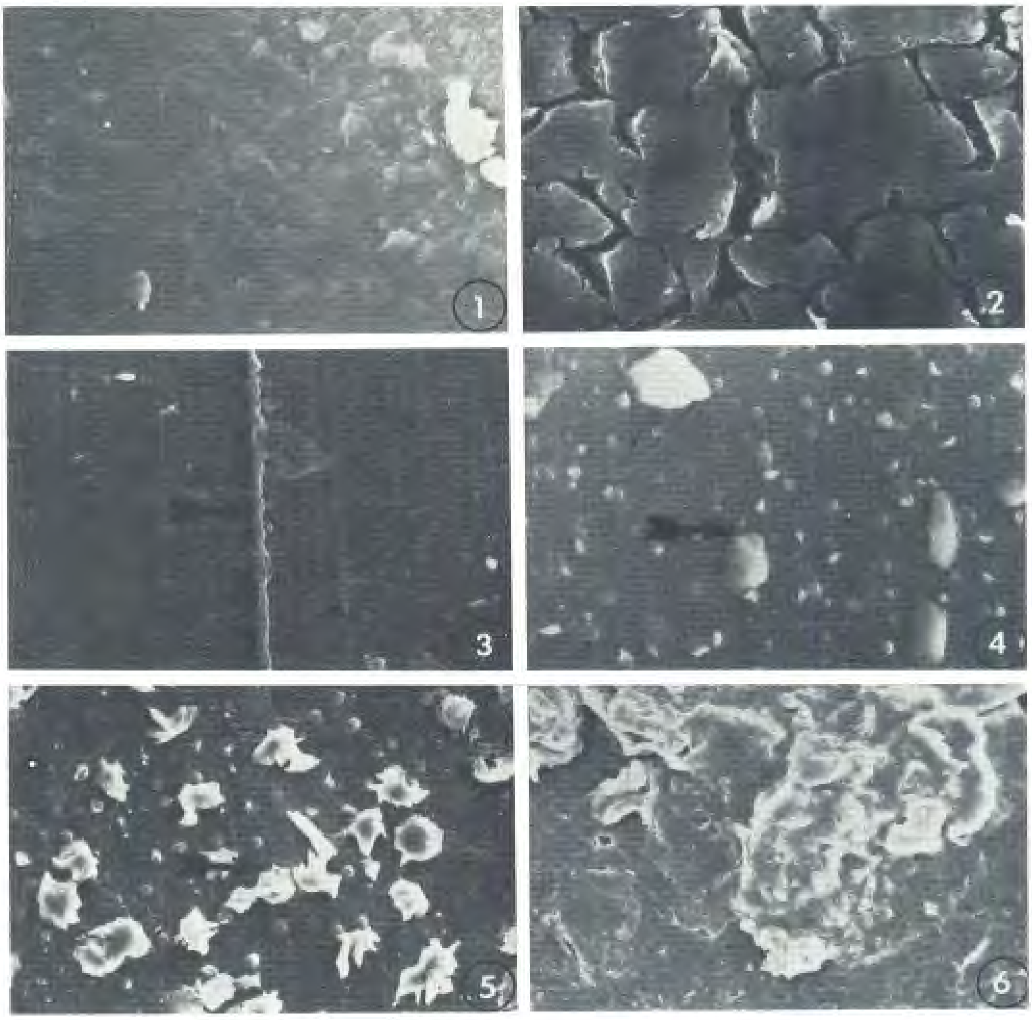

FIG. 20a Faults of the luminal surface of teat cup liners further described in Table 3

6, 7, 14–19), and it seems questionable, therefore, whether such liners should be distributed at all. Claims that certain liners are good for 1 500–2 000 milkings also seem questionable.

In the course of this investigation, only a few results, interesting from a practical point of view and established on only a few liners (Table 1), have been discussed. However, on the evidence from all the makes and models of teat cup liners examined and the importance of such liners to bovine udder health, production, quality and cost of milk, it is evident that—

1. teat cup liners should be specially packed for protection against damaging factors, e.g. light, oxidation, distortion;
2. such packaging should be properly labelled with respect to type, model, manufacturing batch number of liner; date of manufacture; expected life of liner under normal conditions; conditions of storing, cleaning, disinfecting; and
3. teat cup liners should conform to certain standards of quality.

It seems conceivable that major problems, experience under present conditions, may be solved by the close cooperation of Organized Dairy Farming, manufacturers and distributors of teat cup liners.

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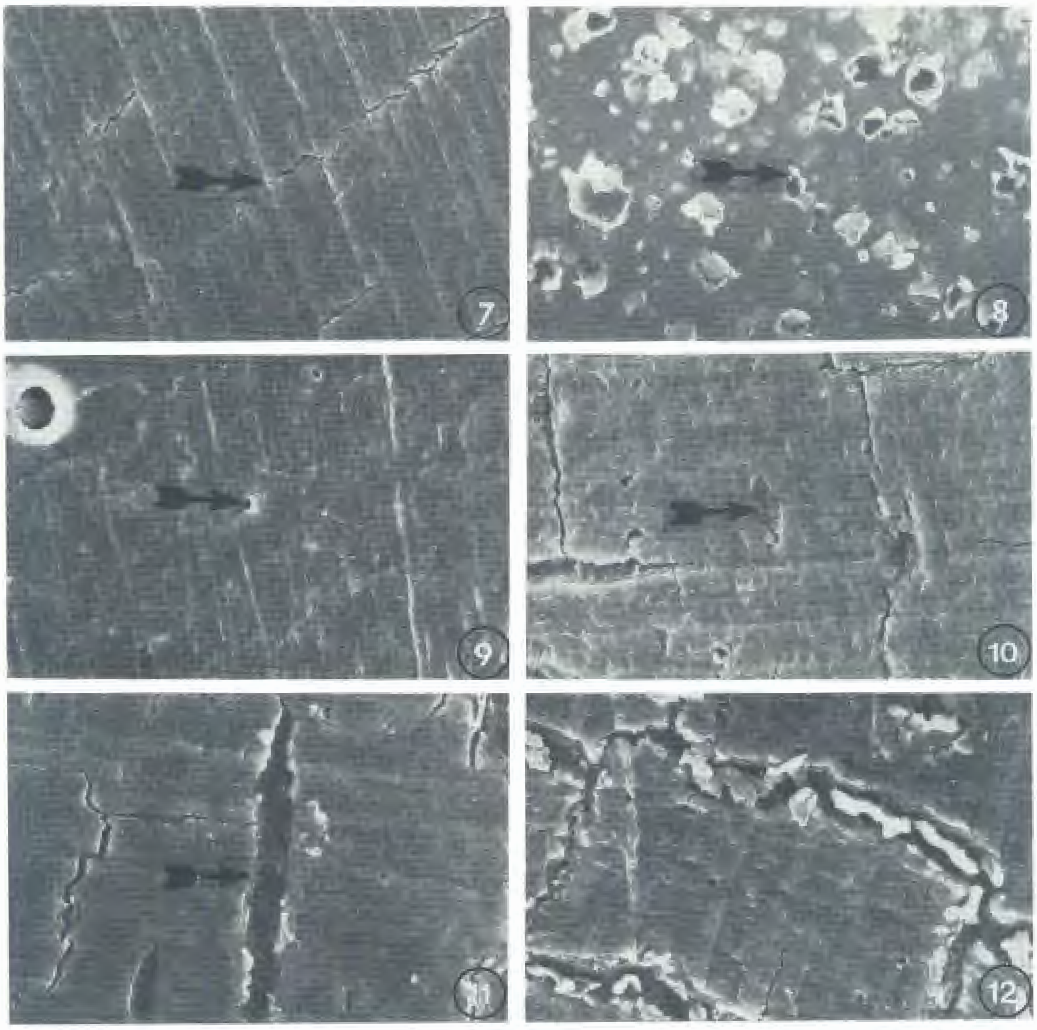

FIG. 20b Faults of the luminal surface of teat cup liners further described in Table 3

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