

Why Filter the Cardiopulmonary Circuit Pre-bypass?

G. D. Kemna, C.P., C.C.P. and J. P. Docherty, C.C.P.

Perfusion Services
Royal Jubilee Hospital
Victoria, British Columbia, Canada

INTRODUCTION

In the early days of cardiopulmonary bypass the perfusionist was aware of the high number of complications which could arise from particulate matter introduced into the cardiopulmonary circuit, during cleaning, siliconizing and setting up of the cardiopulmonary equipment. Each perfusionist employed his own technique to eliminate particulate matter⁽¹⁾ from the circuit (flushing with isotonical solution or millipore filtration).

Today, using the most recent disposable oxygenator and precision manufactured medical grade tubing it's easy to adopt the attitude "why filter the cardiopulmonary circuit pre-bypass?" This study of the Harvey H600 5 micron filter will demonstrate to you the reason for filtration of the cardiopulmonary circuit pre-bypass.

MATERIALS

Oxygenators

- 1) Bentley Bos-10
- 2) Harvey H-1000
- 3) Optiflow II
- 4) Polystan V.T. 7000
- 5) Shiley S-100
- 6) Tmo Travenol (membrane)

Solutions

- 1) DH₂O—hospital CSR
- 2) 5% D.H.S.

Tubing—Packs

- 1) Bentley Laboratories
- 2) Gies Pharmaceuticals
- 3) Polystan—Surgical
- 4) Travenol Laboratories

Filter

Harvey H600—William Harvey

METHOD

Utilizing our routine cardiopulmonary set-up⁽²⁾ we joined the Harvey H600 bypass filter, arterial and venous lines into a loop; primed the loop and circulated the pump at 4L/min for two minutes; then removed the filter from the circuit, protectively capped and numbered it. A second filter and disposable oxygenator was then introduced into the circuit; the remainder of the priming solution (Lactate Ringer's with 5% Dextrose) was added to the oxygenator and circulated at a rate of 4L/min for two minutes. The second filter was then removed from the circuit, treated the same as the first, and both were then sent to the Biology Department at the University of Victoria. Two random 1 cm square samples were removed from each individual filter and prepared in a dust free environment for electron microscopic scanning. Photographs of each sample were taken at magnifications of 600 times and 1500 times.

1) *Area of Debris*—to determine the area of debris, multiply the dimensions of debris on the negative by 2.1; this gives the actual dimension at a specific magnification (600 times). Then divide by the 600 magnification, giving the actual size of the debris particle.

Example—measurement of a red blood cell was 1.5 mm on the negative.

$$\frac{\pi r^2 \times 2.1}{600} = \text{_____ microns}$$

$$\frac{.75 \times .75 \times 3.14 \times 2.1}{600} = 6 \text{ microns}$$

2) *Amount of the Debris*—Area of the total filter over the area of the optical field, times the number of foreign bodies found on the optical field equals the number of debris.

$$\frac{7200 \text{ mm}^2}{8.75 \text{ mm}^2} \times \text{FB} =$$

3) *Size comparison*—Foreign body size in microns over red blood cells in microns equals number.

$$\frac{\text{FB size}}{\text{RBC size}} = \times \text{greater}$$

Filter	RESULTS		
	Amt of debris	Size of debris	× larger than RBC
<i>Control</i>			
1) filter only	none	—	—
2) filter \bar{c} 5% D.H.S.	none	—	—
3) filter \bar{c} human RBC	308,625	6u	—

Filter	RESULTS		
	Amt of debris	Size of debris	× larger than RBC
<i>Tubing</i>			
1) Polystan	823	335u	59×
2) Tmo	1,646	196u	33×
3) Bentley	9,053	165u	28×
4) Gics	none	—	—
<i>Oxygenators</i>			
1) Shiley S-100	823	271u	45×
2) Bentley Bos-10	823	427u	72×
3) Optiflow II	5,761	515u	86×
4) Tmo (membrane)	2,469	2,690u	448×
5) Harvey H-1000	6,584	1,328u	221×
6) Polystan V.T. 7000	1,646	212u	35×

DISCUSSION

All products with the exception of Gics Pharmaceuticals tubing pack demonstrated a certain degree of debris matter. By first filtering the tubing and then the tubing and oxygenator we were able to determine the origin of the particulate matter. The first filter contained the debris matter from the tubing pack, the second filter contained the debris matter from the oxygenator. The control for this study consisted of two filters, the first being a new unused filter which demonstrated a clear optical field with no debris. The second filter was washed in Lactate Ringer's with 5% Dextrose and showed no sign of particulate matter. In this study we were concerned with debris matter larger than a R.B.C.

Blood normally circulates through the smallest of blood vessels unobstructed. If microdebris is introduced there is a potential possibility of temporary or permanent occlusion. This occlusion could lead to an infarct of a vital organ (brain, kidney, heart). Therefore we found the Harvey H600 filter excellent for our use of 5 microns, just below that of a R.B.C. To determine quantitatively the actual size of the debris and to make these results comprehensible we needed to deal with a known factor. The one known factor that we could depend on was the red blood cell, which is approximately 6 microns in size. Therefore we contacted the staff members of the Biology Department at the University

of Victoria, who agreed to prepare red blood cells on a filter using an acceptable technique⁽³⁾, then scanning the filter with an electron microscope they photographed red blood cells at 600 times magnification and 1500 times magnification. Taking measurements from photographs at 600 and 1500 times magnification we were able to make an accurate comparison of all our photographed debris matter. The accuracy of this study can be realized when you calculate the size of a red blood cell by applying the formula used to determine the size of debris matter. To arrive at the amount of debris trapped by each filter we simply counted the number of debris particles found in the optical field, multiplied by the factor 823 (this is determined by dividing the filter area by the area of the optical field). We feel that the amount of debris calculated in each filter was a valid measurement because of the method in which the samples were selected. All filters were numbered by ourselves and the two random samples were extracted from each filter by a technician at the University of Victoria who had no knowledge of our studies.

CONCLUSION

Filtration of cardiopulmonary perfusate with the Harvey H600 5 micron filter pre-bypass will eliminate particulate matter introduced by disposable medical products.

ACKNOWLEDGEMENTS

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Dr. C. L. Singla, Mr. H. F. Dietrich, Mrs. B. Hall for their expertise in cutting and mounting specimens, scanning with the J.S.M.-35 Scanning electron microscope and the photography.

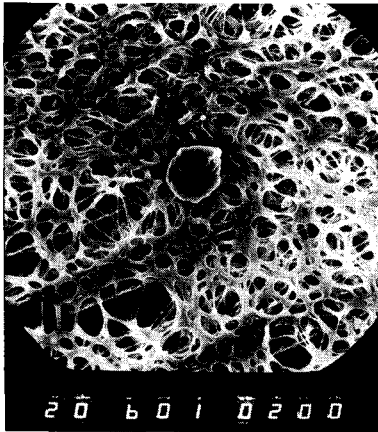
Mr. D. R. Johnston, University of Alberta, Edmonton for kindly supplying the Travenol membrane used in this study.

REFERENCES

1. Reed, Charles C., Clark, Diane K., "Particulate Contamination in Bubble Oxygenators" *Amsect Proceedings II*, 1974.
2. Kemna, G. D., Docherty, J. P., "A Unique Combination for High Flow Perfusion Techniques," *Amsect Proceedings V*, 1977.
3. Bessis, Marcel, "Living Blood Cells and Their Ultrastructure" (Discocyte-Echinocyte Transformation). Translated by Robert I. Weed, Springer-Verlag, New York-Heidelberg-Berlin 1973.

RESULTS

X600

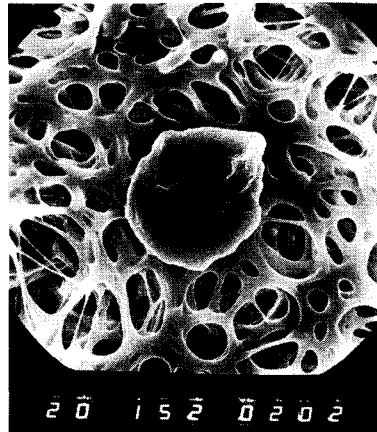


0200

POLYSTAN VT-7000

RESULTS

X1500

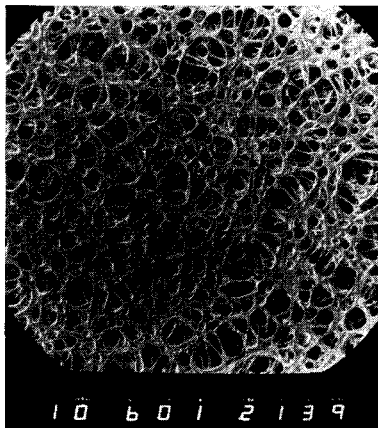


0202

POLYSTAN VT-7000

RESULTS

X600

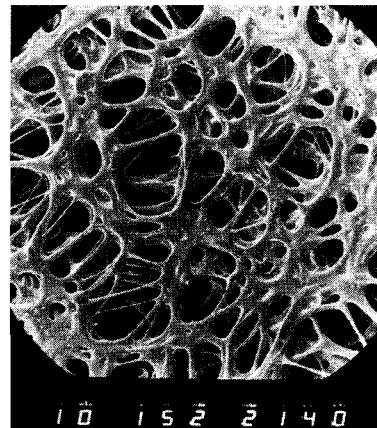


2139

CONTROL CLEAN FILTER

RESULTS

X1500

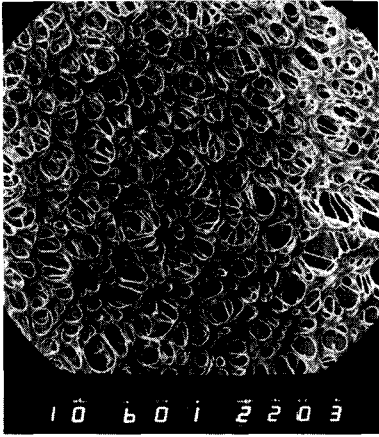


2140

CONTROL CLEAN FILTER

RESULTS

X600

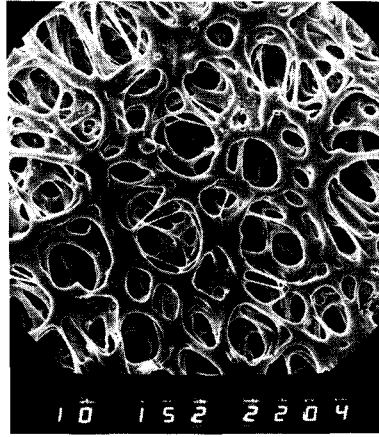


2203

CONTROL FILTER WITH 5% DHS

RESULTS

X1500

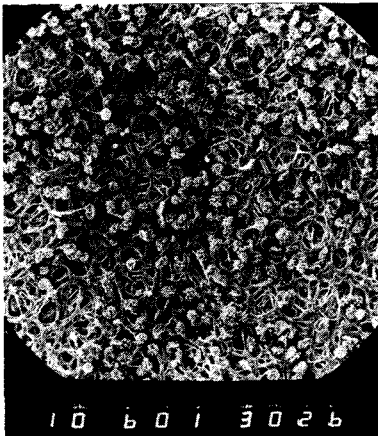


2204

CONTROL FILTER WITH 5% DHS

RESULTS

X600

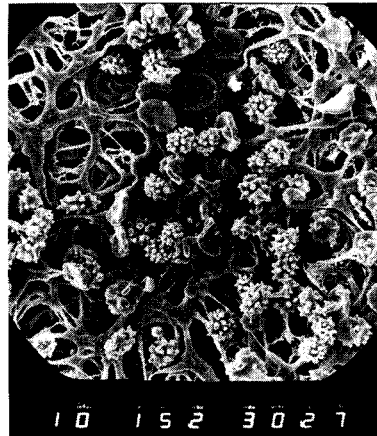


3026

CONTROL FILTER WITH RBC

RESULTS

X1500

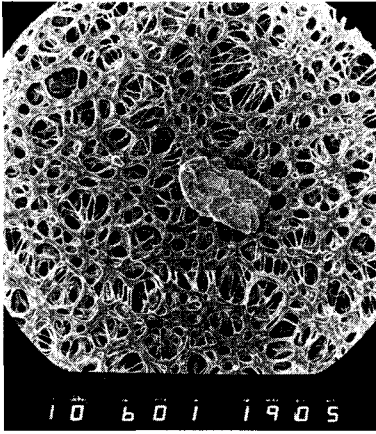


3027

CONTROL FILTER WITH RBC

RESULTS

×600

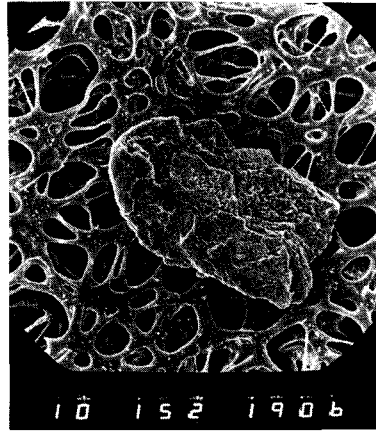


1905

POLYSTAN TUBING

RESULTS

×1500

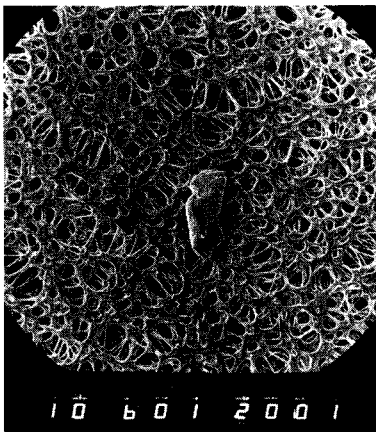


1906

POLYSTAN TUBING

RESULTS

×600

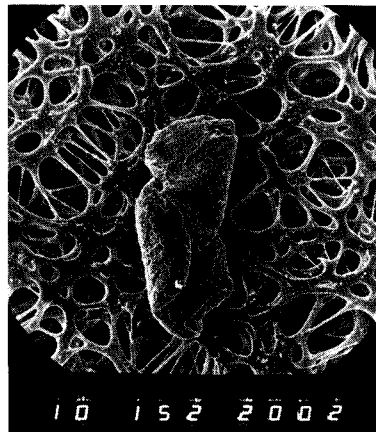


2001

TRAVENOL TUBING

RESULTS

×1500

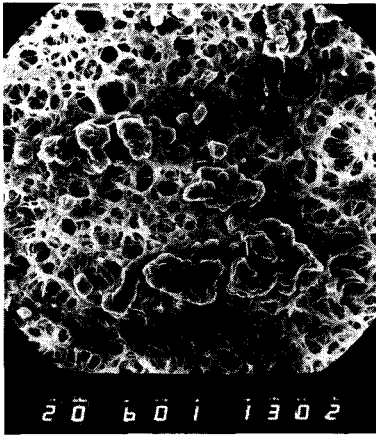


2002

TRAVENOL TUBING

RESULTS

X600

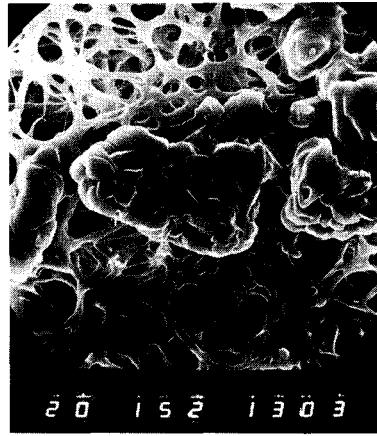


1302

BENTLEY TUBING

RESULTS

X1500

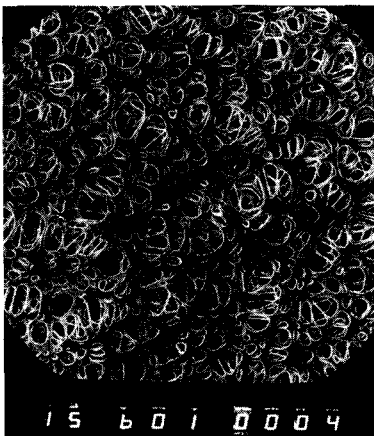


1303

BENTLEY TUBING

RESULTS

X600

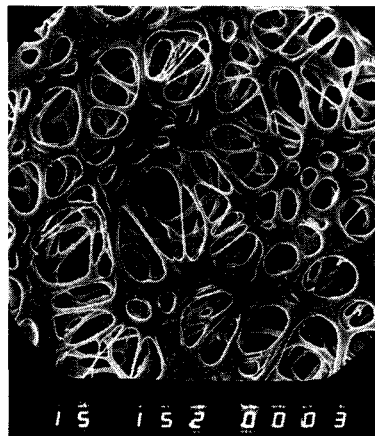


0004

GICS TUBING

RESULTS

X1500

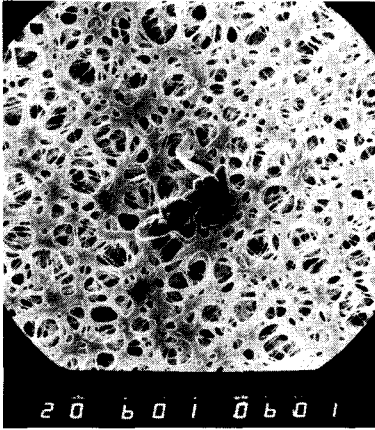


0003

GICS TUBING

RESULTS

X600

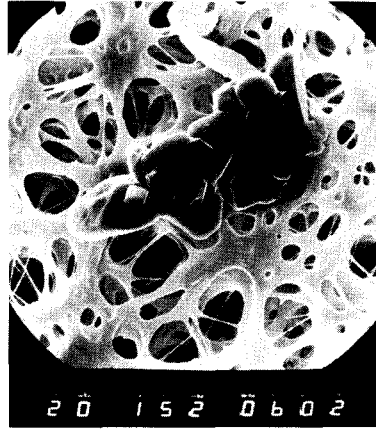


0601

SHILEY S-100

RESULTS

X1500

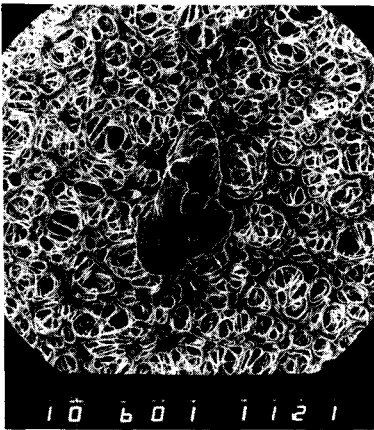


0602

SHILEY S-100

RESULTS

X600

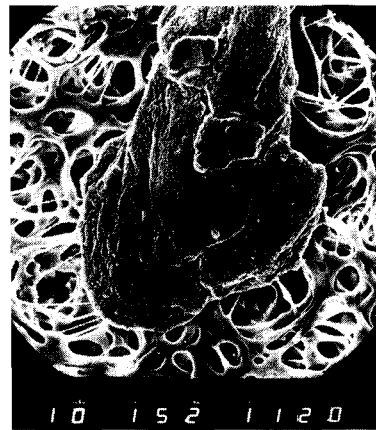


1121

BENTLEY BOS-10

RESULTS

X1500

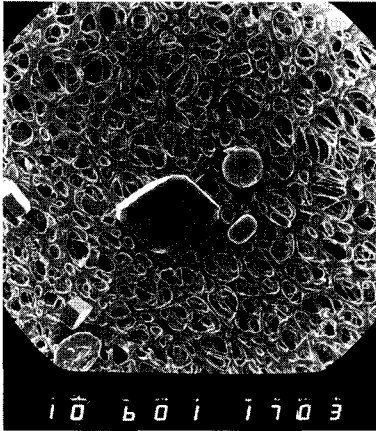


1120

BENTLEY BOS-10

RESULTS

X600

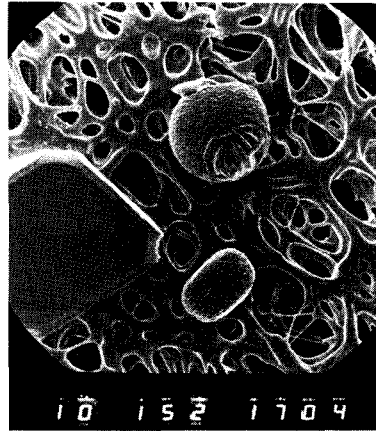


1703

OPTIFLOW II

RESULTS

X1500

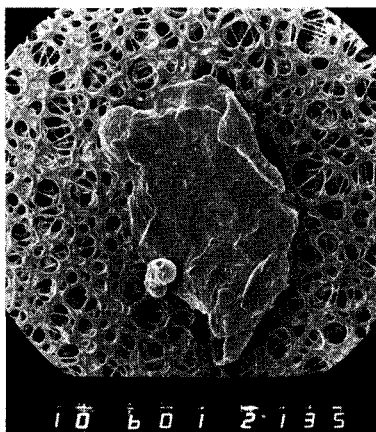


1704

OPTIFLOW II

RESULTS

X600

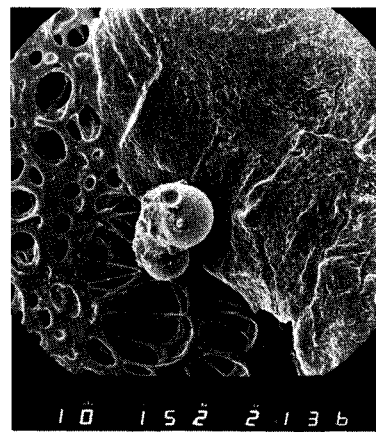


2135

TMO (MEMBRANE)

RESULTS

X1500

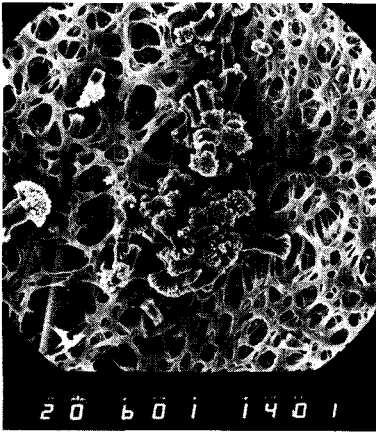


2136

TMO (MEMBRANE)

RESULTS

X600

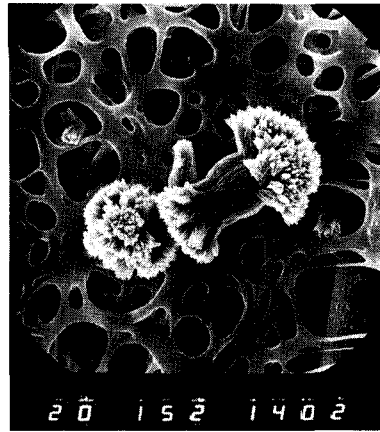


1401

HARVEY H-1000

RESULTS

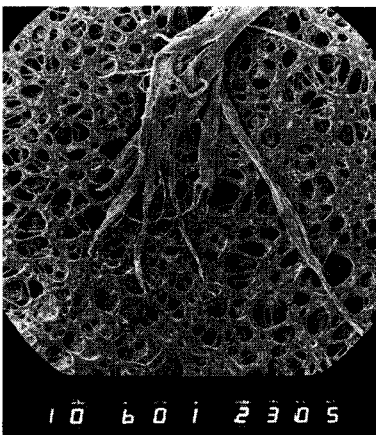
X1500



1402

HARVEY H-1000

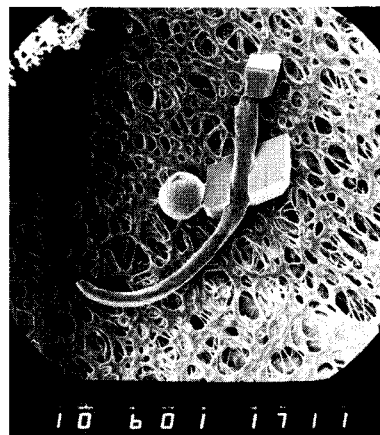
PICTURES OF INTEREST
X600



2305

DH₂O

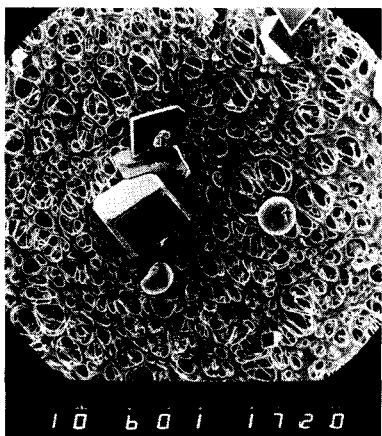
PICTURES OF INTEREST
X600



1711

OPTIFLOW II

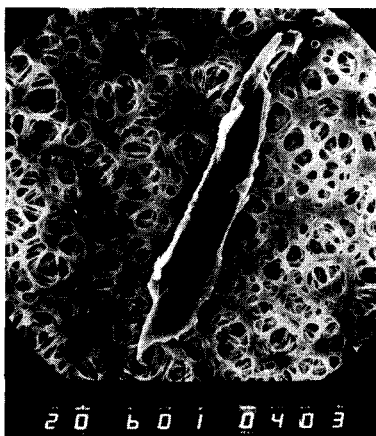
PICTURES OF INTEREST
X600



1720

TMO (MEMBRANE)

PICTURES OF INTEREST
X600



0403

SHILEY S-100