$$N \geqslant m\left(\lambda_{\alpha\beta} - \frac{\lambda_{\alpha\alpha}\,\lambda_{\beta\beta}}{\lambda_{\alpha\beta}}\right),$$

which reduces to

$$N \geqslant m,$$

therefore, the least value of N is $m$ and then the parameters will be $(0,\ 1,\ m-2)$.

*Sufficiency*. It follows from the inequality $m \leqslant N$ true for all PB arrays (Section 3, Rafter and Seiden[7]). Surprisingly, the greatest lower bound for N does not shift from $m$. This completes the proof.

*Theorem* 2

The necessary and sufficient condition for a SORD constructed through a PB array $(m,\ N,\ 2,\ 2)$ with $\lambda^2_{\alpha\beta} - \lambda_{\alpha\alpha}\lambda_{\beta\beta} = 0$ to have minimum number of design points is $N = m + 1$.

*Proof*

Under the given conditions of the theorem, we have the following inequality (Theorem 3.4, Rafter and Seiden[7]),

$$N \geqslant m + 1,$$

and necessity part follows immediately. Conversely, if $N = m + 1$, then we have to show that N is minimum. Since for all PB arrays $N \geqslant m$ so the only possible smaller value is $N = m$ which contradicts $N \geqslant m + 1$. Thus $m + 1$ is the minimum value of N.

Now the problem is to find the parameters of the array for a given $m$ to provide least N under the hypothesis of the theorem and can yield SORD, *i.e.*, in other words the set $(\lambda_{\alpha\alpha},\ \lambda_{\alpha\beta},\ \lambda_{\beta\beta})$ should be such as to satisfy the following:

(i) $\lambda_{\alpha\beta} > 2\lambda_{\alpha\alpha}$ or $\lambda_{\alpha\beta} > 2\lambda_{\beta\beta}$

(ii) $\lambda^2_{\alpha\beta} = \lambda_{\alpha\alpha}\lambda_{\beta\beta}$.

For this we can ascertain the parameters by taking help of two more relations, provided the solution exists,

(iii) $\lambda_{\alpha\alpha} + 2\lambda_{\alpha\beta} + \lambda_{\beta\beta} = m + 1$

and

(iv) $\lambda_{\alpha\beta} \leqslant \lambda_{\alpha\alpha} + \lambda_{\beta\beta}$.

For example when $m = 15$, the set is $\{1,\ 3,\ 9\}$.

This completes the proof.

Let us consider a 3-symbol PB array of strength two for $m$ factors in N assemblies with $\alpha$, $\beta$ and $\theta$ as symbols. Let, then, the pairwise frequencies be $\lambda_{\alpha\alpha}$, $\lambda_{\alpha\beta} = \lambda_{\beta\alpha}$, $\lambda_{\beta\theta} = \lambda_{\theta\beta}$, $\lambda_{\alpha\theta} = \lambda_{\theta\alpha}$, $\lambda_{\beta\beta}$ and $\lambda_{\theta\theta}$.

Here is a result for SORD with 5 levels.

*Theorem* 3

A three symbol $(\alpha \neq 0,\ \beta \neq 0,\ 0)$ PB array of strength two must satisfy

$$\lambda_{\alpha\beta} + \lambda_{\alpha 0} > 2\lambda_{\alpha\alpha} \text{ or } \lambda_{\alpha\beta} + \lambda_{\beta 0} > 2\lambda_{\beta\beta}.$$

to yield a five level SORD.

The proof is straightforward.

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*April* 7, 1978.

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## TRACK-ETCHED MICRO-FILTERS

The technique which led to the development of track-etched micro-filters was discovered in 1962 by Price P. B. and Walker R. M.[1]. They observed fine holes due to fission fragments in 12 μm thick layers of synthetic mica during the course of their studies on chemical etching of charged particle tracks. The existence of these holes was demonstrated by using transmission electron microscopy. The chemical etching thus permits drilling of fine holes of adjustable size in thin sheets of cleavable solids and plastics.

The heavy charged particles passing through any of these solids produce continuous damage along their path and thus leave behind a trail of radiation damaged material. The chemical etching of these irradiated solids leads to the formation of fine hollow channels along the path of the charged particles due to preferential etching of the damage trail. These channels are usually uniform in width along their entire length and maintain the directions of the original tracks[2]. If the thickness of the detector sheet is less than the particle's range in it, the above process leads to the formation of fine holes in the irradiated detector sheet. The micro-filters thus formed have uniform holes and offer certain advantages over conventional filters made of cellulosic plastics and having irregular holes[3]. Fig. 1 is a microphotograph of a micro-filter.

*Experimental*

The uniformity of the holes is achieved by allowing a collimated beam of charged particles to strike the filter sheet. A simple way[2] of collimating the beam of particles is to separate the source from the target film and evacuate the intervening space to overcome degradation in energy of charged particles. The larger the separation and smaller the source area, the more complete will be the source alignment.

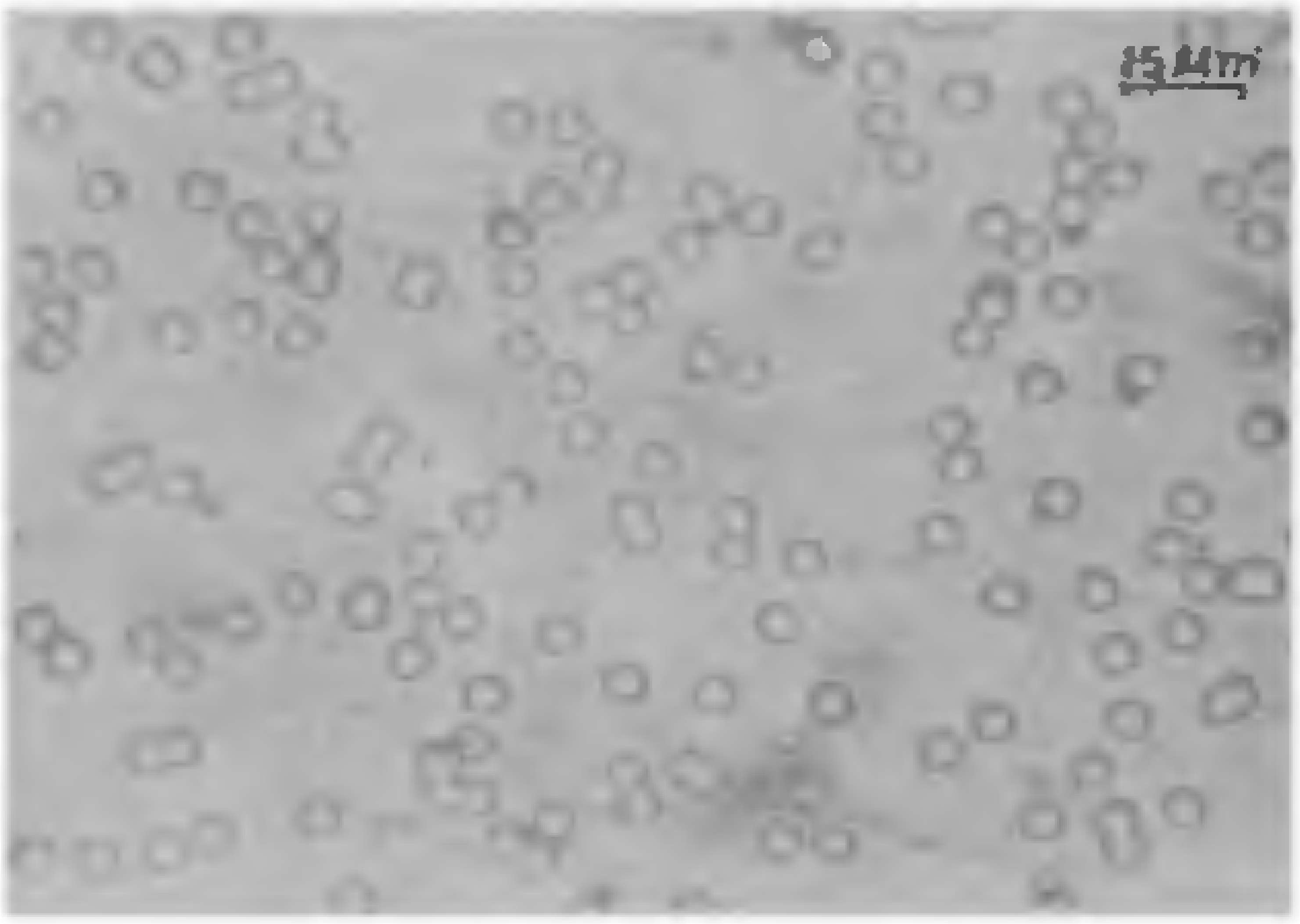

FIG. 1. Microphotograph of a microfilter.

An electrodeposited californium–252 source (10 mm diameter) was used as a source of fission fragments. The distance between the source and the filter was 12 cm. Since the diameter of the irradiated circular film portions was 2·5 cm, the angle of incidence of fission fragments remained within 12° of the normal to the filter sheet. Makrofol sheets of 10, 12 and 16 μm thickness were employed in these investigations. All the etchings were carried out at 60° C in 6N NaOH. A one-to-one correspondence exists between fission fragment tracks and the etched holes under conditions approximating to normal incidence.

The hole diameters at different etching times revealed that the diameter increased linearly with the etching time. The largest hole size that could be obtained depended on the film thickness. Thus the holes of 9·6, 10·6 and 14·2 μm diameter were obtained in films of 10, 12 and 16 μm thickness respectively. In these large hole size regions, however, the films became very thin and posed handling problems. The smallest hole size that could be conveniently obtained was ≈ 1 μm.

The hole densities depend directly on the particle flux. But randomness in positions of holes must be considered as a limiting factor. This leads to formation of large sized holes due to overlap, which impair the usefulness of the filter. The maximum hole density obtainable is actually governed by the acceptable probability of overlap and the hole size. In any work involving the use of these filters, it is extremely unlikely that filters with overlap probabilities exceeding 10% could be used. Since the percentage area occupied by these holes is only slightly greater than the percentage probability of overlap (irrespective of hole size) the strength of the filter sheet will not change significantly due to porosity of this order.

### *Applications*

The above microfilters were tested and found useful in the following applications—

(A) *Biomedical applications*

(i) Separation of lymphocytes from tumor cell suspensions prepared from solid tumor. Fig. 2 is a microphotograph of Murine Fibrosarcoma Tumor Cells separated by using a filter with hole diameter = 2·86 μm.

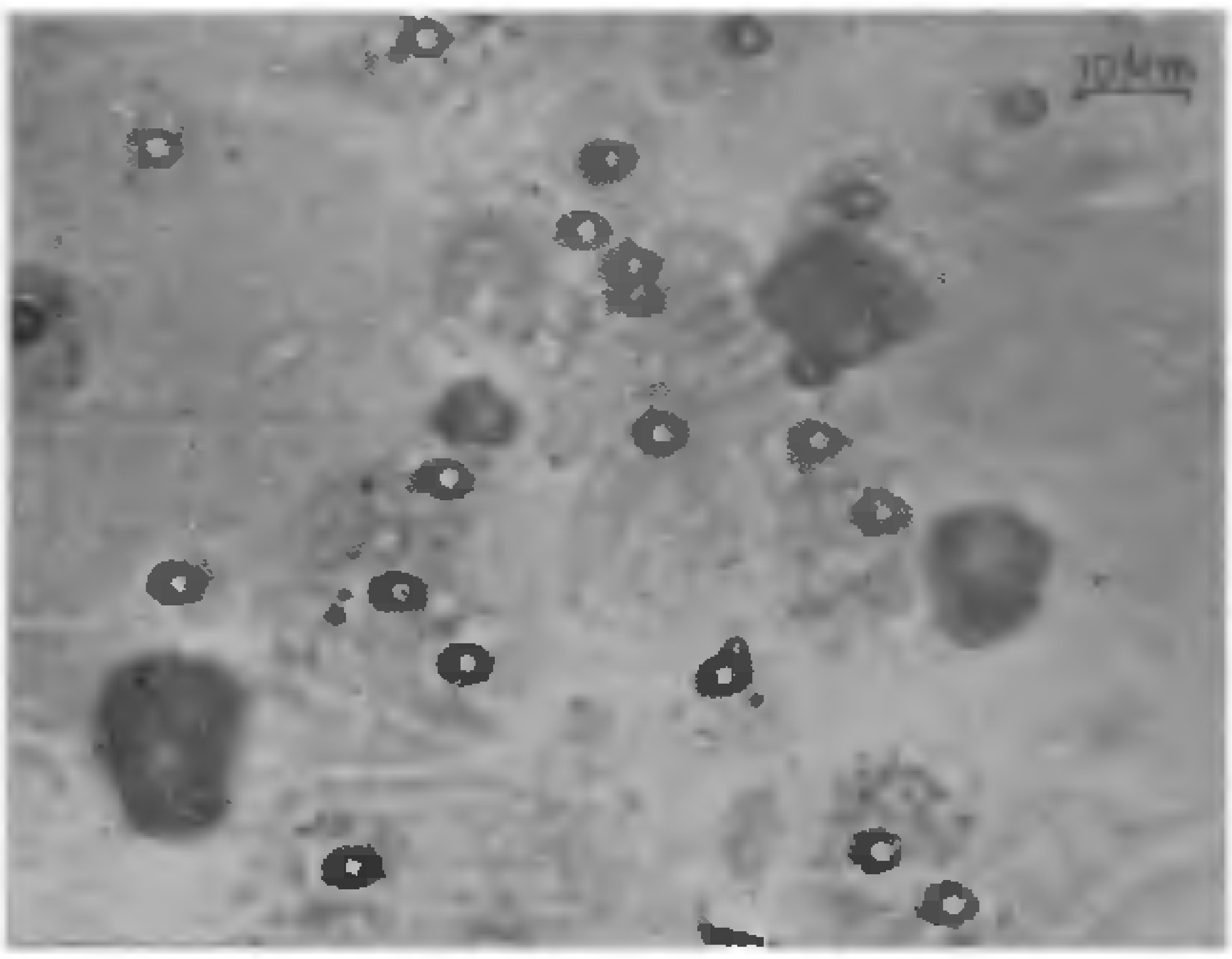

FIG. 2. Microphotograph of Murine Fibrosarcoma Tumor Cells separated by the use of microfilter with hole diameter 2·86 μm.

(ii) Separation of bacteria from Tumor cell suspension.

(B) *Environmental studies of particulates*

With about 10% porosity, these microfilters are capable of sampling upto 40 litres of air per minute using " Rotovac TR-7 " type of air sampling pumps.

Applications of these filters in other fields have also been reported, *e.g.*, cleaning of gases, clarification of liquids, filtration of drugs, virus and bacteria counter, biological membranes, in immunology and in the study of phenomenon of superfluidity and superconductivity.

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