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Abstract*

A device, the Moving Aperture Microscope, is described which allows many kinds of radiation to be used in forming the microscope image. The use of the device as a proton microscope, x-ray microscope, etc. is discussed and the advantages of the increased information content of the images formed by this device are mentioned.

There are two basic considerations involved in the assessment of any microscope system. The first is how small a volume can be analyzed by the system and is generally described in terms of resolving power. The second consideration involves the kinds of information about this volume that is transferred to the image [1]. While resolving power has been investigated with great vigor the information content of the image has not received as much attention. As a result, very high resolution instruments such as the transmission electron microscope are available but the information contained in the image of such a microscope is quite limited.

Over the last several years we have attempted to concentrate our research on the information aspect of the image [2,3,4] rather than on ultra high resolution and the development of the Moving Aperture Microscope represents another step in this direction.

Principles of Operation of the Moving Aperture Microscope.

The information content of a microscope image depends on the interaction of a particular kind of radiation with the specimen. If the image is formed by focusing the radiation through a lens system as is the case with the light microscope and the standard transmission electron microscope, there are several restrictions placed on the types of radiation available and therefore on the information content of the image. First, in such a focused system the two basic functions mentioned above, localization and information transfer, are carried out by the same radiation and are therefore linked together. For example, the high information content of the light microscope image is linked to the low resolution dictated by light optics. The standard electron microscope, on the other hand, has high resolving power but this high resolution is linked to the low information content of the electron specimen interaction which basically depends only on the atomic properties (z, ρ) and gives no information with regard to the chemical nature of the specimen.

A second limitation imposed by the focused-lens system is that such a system must use only those radiations which are focusable and there are several interesting types of radiation that do not fall into this category.

In order to increase the number of types of radiation that can be used, the lens system of image formation was replaced by a time sequence of points in the Moving Aperture Microscope, much like the system used in the formation of a television image. Such a system relies on two synchronous beams one sweeping over the specimen and one on the face of the cathode ray tube. For every point on the specimen there is a corresponding point on the C.R.T. and the brightness of the C.R.T. point is modulated by the signal picked up by a detector near the specimen.

In the Moving Aperture Microscope, the beam sweeping the specimen is formed by a small aperture which is moved in synchrony with the C.R.T. beam by means of an electro-mechanical transducer. The aperture and the C.R.T. beam are driven by the same scan generator thus producing the synchronous rasters. The size of the raster of the specimen beam is very much smaller than the raster on the face of the C.R.T. and the ratio of the two sizes is the magnification of the system.

A schematic diagram of the Moving Aperture Microscope is shown in Fig. 1.

Discussion

A similar method of non-focused image formation is used in the scanning electron microscope (SEM)[1,5]. The SEM utilizes a scanning beam of electrons to sweep the specimen and can use a variety of radiations induced by these electrons as the video signal. The tiny electron beam is formed by focusing the electrons using magnetic lenses. The Moving Aperture Microscope is a further step in radiation versatility in that all forms of radiation, not just electrons, may be used as the incident exciting radiation as well as using the variety of radiation for the video signal. Thus, a proton microscope, an x-ray microscope or a high energy β-ray microscope could all be developed by using the Moving Aperture Microscope with the appropriate radiation source. The video signal in each of these modes could be the same or a different type of radiation.

Developments in rapid, accurate positioning by the use of electro-mechanical transducers and improved sensitivity of radiation detection have made this system technically feasible. The size of the beam produced by the aperture is limited by diffraction effects which in turn are a function of the wavelength of the radiation used. Since we are free of the requirement of focusing many very short wavelength radiations, both electro-magnetic and particulate are available to us.

It would seem that the Moving Aperture Microscope by using a variety of kinds of radiation could add considerably to the information content of microscopic images. As an alternative mode of operation in cases where a very thick aperture is required, it would be possible to move the specimen with the electro-mechanical transducer while the aperture remained stationary.

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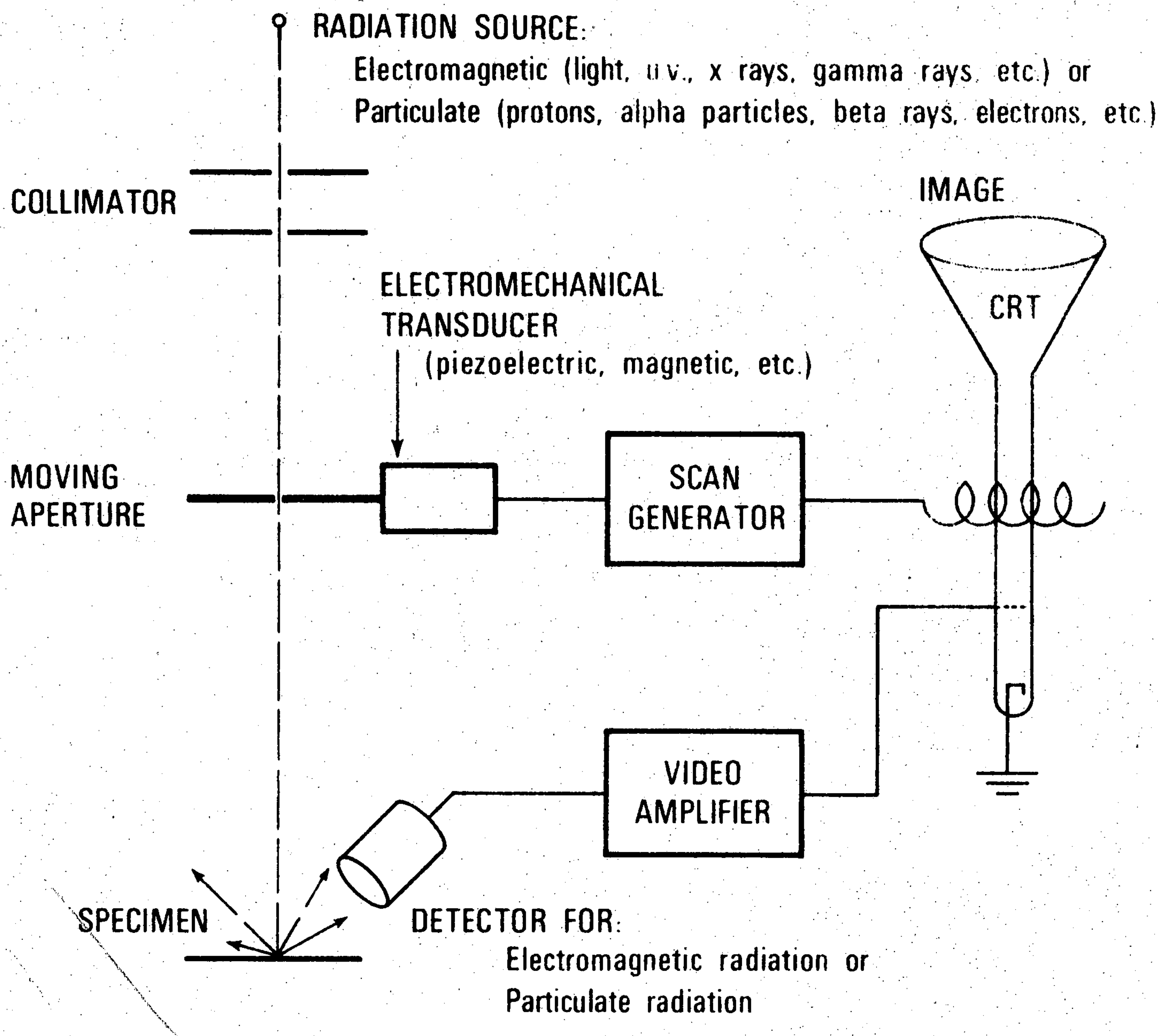

MOVING APERTURE MICROSCOPE SCHEMATIC DIAGRAM

DBL 682-4587

Fig. 1