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AN OPTICAL IMAGE COMPARATOR FOR EXAMINATION OF FIELD ION MICROGRAPHS

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16. ABSTRACT

This document is a description of a device which permits direct comparison of two complex recorded images or patterns. Any small differences between the two images, normally difficult to detect by visual inspection, are distinctly illuminated and readily noticed by the observer despite the mass of complex detail common to both images.

The instrument was designed as an aid to single atom studies in the field ion microscope but may also be of application in astronomy.

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AN OPTICAL IMAGE COMPARATOR FOR EXAMINATION OF FIELD ION MICROGRAPHS

SUMMARY

An image comparator which is suitable for the detection of small differences between two almost identical complex patterns, such as those encountered in field ion microscopy and low-energy electron diffraction, has been designed and manufactured. Each image is illuminated in a different colored light, then the two are superimposed. Any small differences between the two images, normally difficult to detect by visual inspection, are distinctly illuminated and readily noticed by the observer despite the mass of complex detail common to both images.

INTRODUCTION

The device provides a method for clear and rapid visual determination of small differences between two very similar photographs or patterns. Its greatest use is with photographs that contain a vast amount of small detail which tends to obscure small differences or changes between the two, and it is particularly suited to the detection of single atom movements in field ion micrographs.

The device illuminates each of the two photographs with a different colored light. The two images are then superimposed by means of a system of mirrors and a beam-splitter. The emergent image is a mixture of the two colored lights with the small differences in the two photographs illuminated in one or other of the two primary colors. Such information cannot be obtained by superimposition of two transparencies, as this is a subtractive method like the mixing of two colored paints. The subtractive superimposition method has application where most of the spots have different positions in the two photographs, but some have the same relative positions; only the latter set of spots will be illuminated. However, such a situation is not the case with field-ion microscopy studies of atom deposition, chemisorption, surface rearrangement, migration along grain boundaries, surface diffusion and atom deposition on metal single crystal tips. In such experiments, most light spots (usually representing individual atoms), of which there are commonly 10 000 in a typical micrograph, remain in the same relative position during a chronological series of photographs, while only a few spots change their position. In practice, it is difficult and tedious to locate the spots of interest by inspection. The device described here enables one to locate such spots within a few minutes.

PRINCIPLE OF OPERATION

This instrument is shown in cut-away and sectional diagrams in Figures 1 and 2, respectively.

The two similar but not identical photographs P_1 and P_2 are mounted side by side on one inside wall of the instrument case and are illuminated by light from projectors[1] L_1 and L_2 passing through two holes in the side of the case. The light is reflected by adjustable aluminized front surface mirrors[2] M_1 and M_2 onto the photographs. A red glass filter was placed in the beam from L_1 and a green filter was used in that from L_2. Differences in intensity can be compensated by adjusting the angles of M_1 and M_2.

Reflected light from P_1 and P_2 suffers two reflections and, consequently, similar attenuation, in each case. Beam 1 (from P_1) is reflected at the front surface mirror M_5 and is subsequently 40 percent reflected into the viewing port by the beam splitter, BS[3]. Beam 2 is reflected at the front surface mirrors M_3 and M_4, then 40 percent transmitted through the beam splitter.

The photographs are adjusted in their holders until the two images coincide. The intensity of the sources is adjusted by M_1 and M_2 until the light portions of the image appear yellow, rather than red or green. Any light spot in P_1 not present in P_2 (or dark spot in P_2 not present in P_1) will appear red in the final image. Similarly, if the converse is true, a

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1. Bell and Howell 500
2. Libby-Owens-Ford Glass Co., No. 749
3. Libby-Owens-Ford Glass Co., No. 405

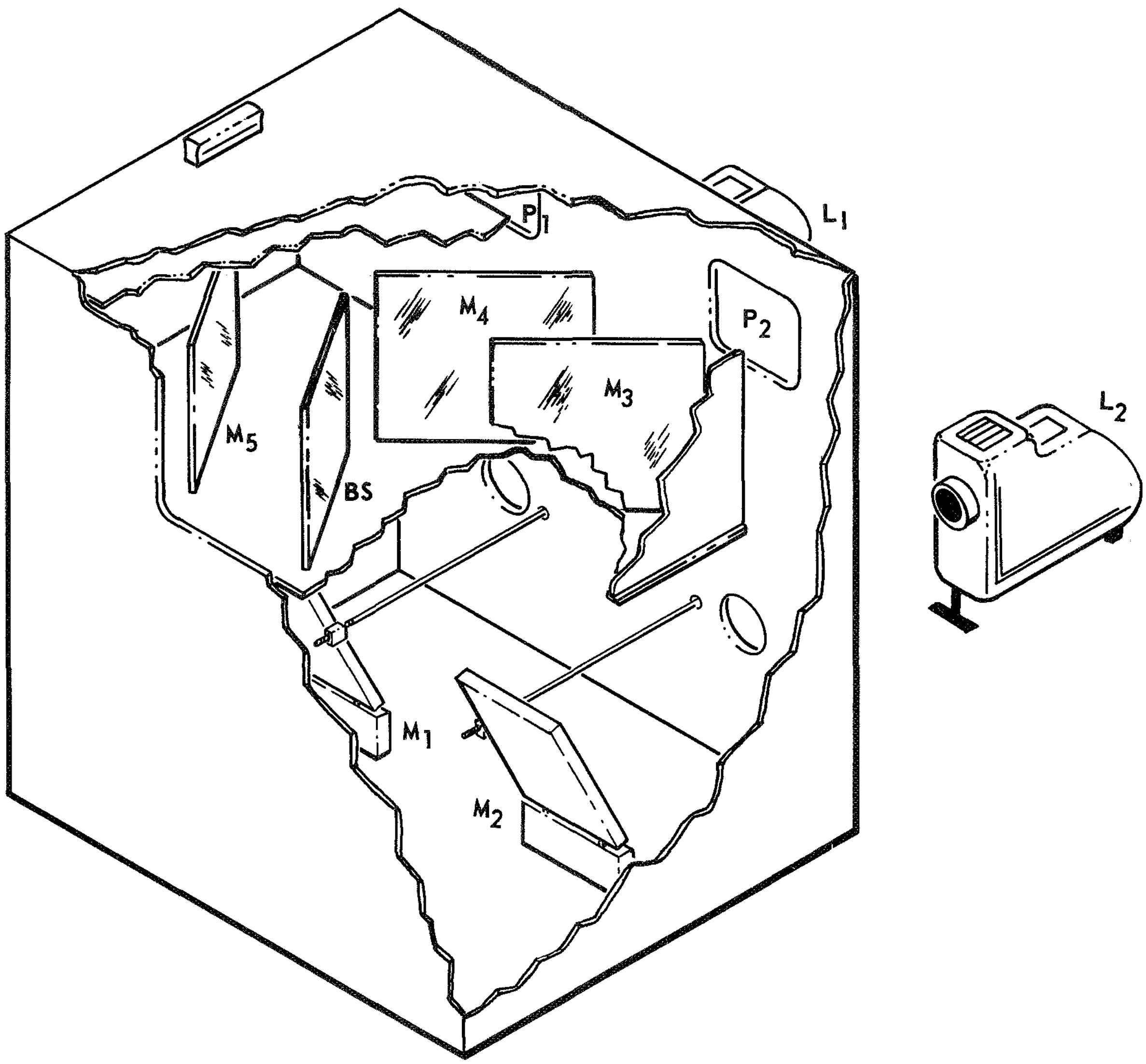

Figure 1. Cut-away isometric drawing of the image comparator, showing positions of various elements.

green spot will be visible. The following discussion is an example of the application of this optical aid in inspecting field ion micrographs, typical examples of which are shown in Figures 3 and 4. Such micrographs have a resolution of a few Angstrom units and individual atoms are clearly distinguishable. The micrographs [1] in Figures 3 and 4 are of a tantalum single crystal tip and are identical except that 20 atoms or spots of light which are present in Figure 4 are not present in Figure 3.

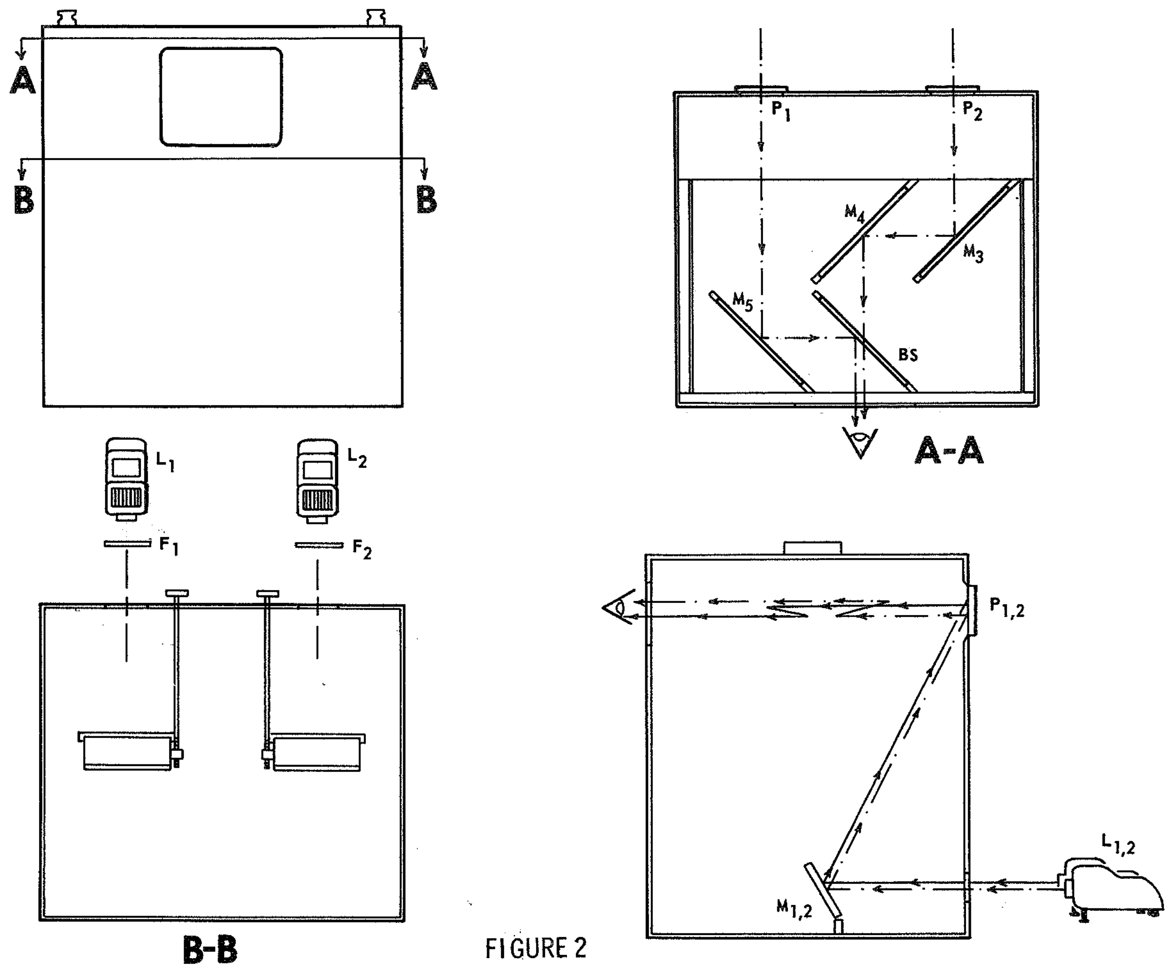

FIGURE 2

Figure 2. Front and side elevations and plan views of the instrument, showing optical paths.

In the course of an experiment on such a metal tip, atoms of a foreign gas may be deposited on the surface, or may diffuse over the surface. Similarly, atoms of the substrate itself may diffuse or be desorbed during heating under high electric fields. If the changes in the positions of atoms can be observed and recorded on a series of photographs, the use of the optical mixer makes the task of retrieving data for kinetic or other measurements a much simpler operation.

In the simulated example given here, one may imagine that the first micrograph taken was Figure 3. A small quantity of active gas was admitted to the system, and the result is shown in Figure 4. Some dispute exists in the literature [2-5] concerning the nature of the atom producing

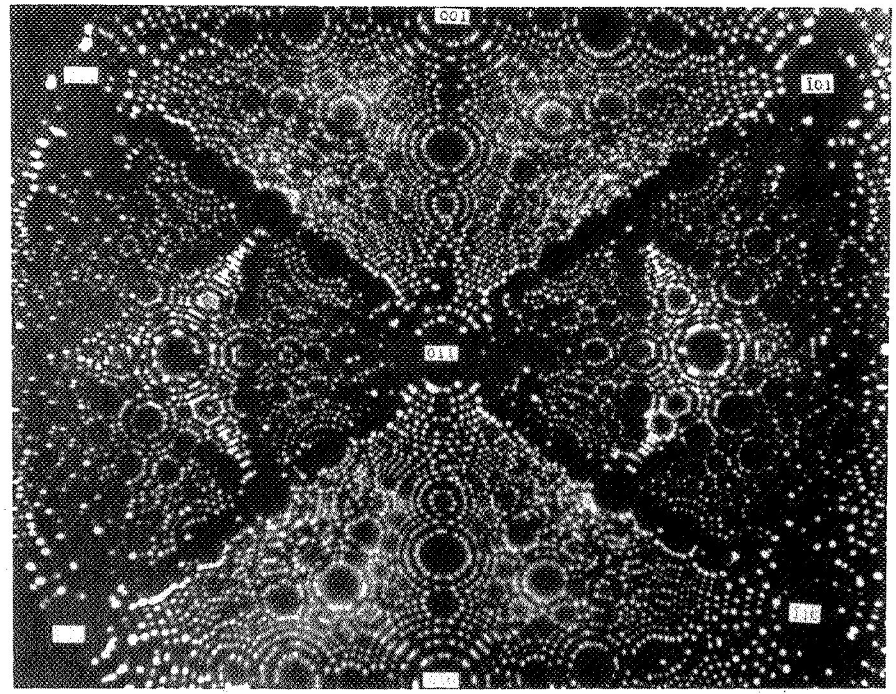

Figure 3. Field ion micrograph of a tantalum single crystal tip.

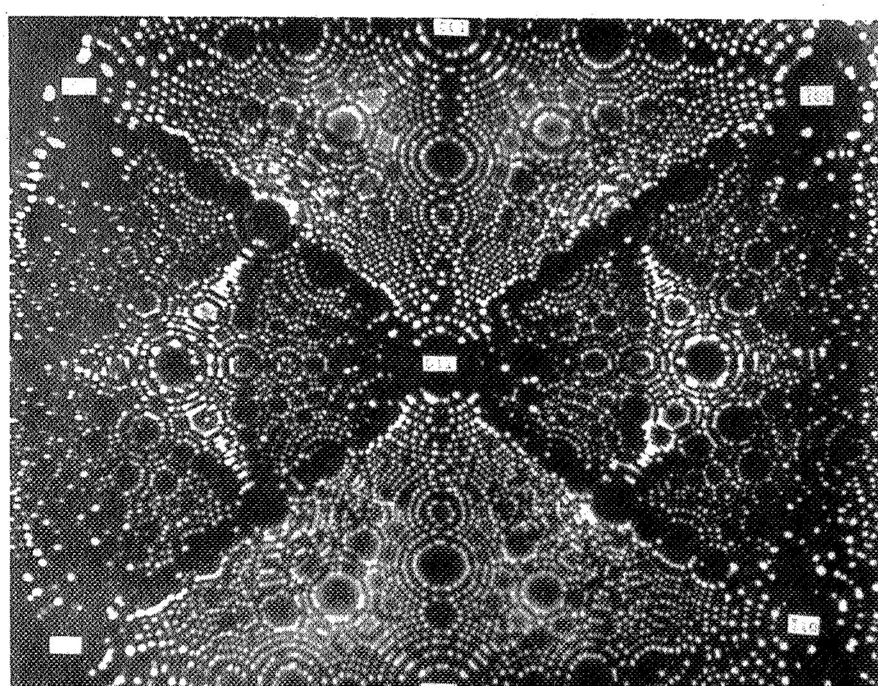

Figure 4. Field ion micrograph of the tantalum tip shown in Figure 3 with the presence of 20 additional light spots representing adsorbed atoms.

the bright spot in such instances: it may be either the adsorbed gas atom, or it may be a substrate atom forced up out of the surface during the adsorption process. The superimposed images are shown in Figure 5. It should be added that the optical resolution of photographs to be used in the instrument and, therefore, its intrinsic resolution, is considerably better than that available for the reproduction of this report. Similarly, the color contrast is much better in the instrument than that shown in Figure 5.

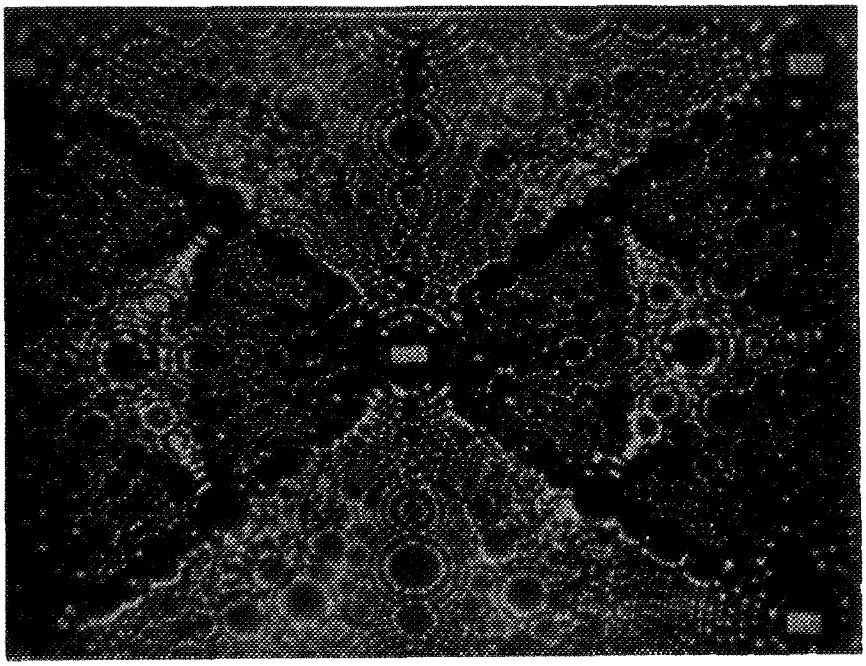

Figure 5. Image seen through the output port of the image comparator when Figures 3 and 4 were placed in the instrument and illuminated. (The 20 atoms in Figure 4 which are not present in Figure 3 are immediately evident.)

CONCLUSION

It is concluded that the simple image comparator described will greatly simplify data retrieval in field ion microscope studies of single atom movements. Also, it is tentatively suggested that the optical device be considered for possible use with night-sky photographs.

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APPROVAL

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The information in this report has been reviewed for security classification. Review of any information concerning Department of Defense or Atomic Energy Commission programs has been made by the MSFC Security Classification Officer. This report, in its entirety, has been determined to be unclassified.

This document has also been reviewed and approved for technical accuracy.

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