21
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MHSMP-77-50

Dist. Category UC-37

MARCO IMAGE CONVERTER CAMERA

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DEVELOPMENT DIVISION

JULY - SEPTEMBER 1977

MASTER

Process Development
Endeavor No. 105

Mason & Hanger-Silas Mason Co., Inc.
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AMARILLO, TEXAS 79177
806-335-1581

operated for the
ENERGY RESEARCH AND DEVELOPMENT ADMINISTRATION
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U. S. GOVERNMENT Contract EY-76-C-04-0487

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Printed in the United States of America
Available from
National Technical Information Service
U. S. Department of Commerce
5285 Port Royal Road
Springfield, VA 22161
Price: Printed Copy $4.00; Microfiche $3.00

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ABSTRACT

The cause of the poor optical performance of the Marco Image Converter Camera was determined and successful corrective measures were taken.

Future efforts involve the evaluation of the exposure and delay circuits to determine if the camera possesses useful capabilities.

INTRODUCTION

The Marco Model M4 Camera System was purchased several years ago as a high-speed image converter framing camera capable of taking as many as four consecutive pictures of an event with exposures of 5 to 50 ns and interframe times of 5 ns to 10 ms. Although the design was probably based upon other cameras Marco had built, this model was essentially a prototype and the instruction manual provided is extremely sketchy, providing only limited (and in some instances, inaccurate) information. It was therefore necessary to determine most of the operating characteristics of the device. It was quickly determined that the optical performance was unacceptably poor. Efforts to obtain a modified optical system from the manufacturer were unsuccessful. The purpose of this project is to reevaluate the camera and determine whether or not it is capable of providing useful service to Pantex or whether it should simply be discarded.

DISCUSSION

The Marco M4 Camera consists basically of four independent image converter tubes (coupled with ordinary optical cameras) and associated control circuitry. When an event is to be recorded, the mechanical shutter of the optical camera is opened but exposure of the film does not begin until a high voltage pulse causes the phosphor of the image converter tube to become illuminated. The control circuitry determines both the time of initiation and the duration of the high voltage pulse. Each head is independently controlled, allowing different delays and exposures for each head. There is also a "focus" mode in which the tubes are on continuously (at low illumination) and exposure is controlled by the mechanical shutters. This mode is used while setting up the experiment and to provide pre-test still pictures.

Although the heads can be located independently to provide different views of an event, the most generally useful application involves mounting them in the camera main frame which permits all four heads to view the event along the same line of sight. Fig. 1 illustrates how this is accomplished.

In the original investigation, it was found that when utilized in the focus mode and independent of the mainframe, each head was capable of providing an acceptable image of a resolution chart but not when placed in the mainframe. The conclusion was that the beam splitters were responsible for the optical problems and verbal agreement to replace them (never fulfilled) was obtained from Marco. When the present project was started, the same behavior was observed and the same conclusion was reached. Since the beam splitters appeared to be the principal source of the problem, it was reasonable to expect that the image quality should diminish sequentially with head number, as the light reaching each succeeding head passes through and/or reflects from an additional beam splitter. To test this hypothesis, a sequence of photographs was made. At Head 4 the shutter release cable was found to be defective, requiring the shutter to be tripped manually. Fully expecting this picture to be the poorest of the series, we were astonished to find its quality to be essentially indistinguishable from that obtained without the mainframe. This implicated the automatic shutter release mechanism as the source of trouble, probably due to vibrations.

Following this line of investigation it was found that when the other heads were used with manual shutter releases, good pictures resulted. To complete the sequence of pictures, Head 3 was placed in position 4 and the shutter released automatically. The picture, expected to be poor, was as good as the best resulting from manual shuttering.

It was already known that shutter vibration was not a problem with heads outside the mainframe, so any troublesome vibrations must have been in the mainframe assembly itself. This eliminated everything but the beam splitters (Fig. 1), which are made of thin plastic film. A test showed that these films vibrated appreciably when the shutters were tripped automatically. This explained why the images at positions 1, 2 and 3 were affected by vibrations but it was

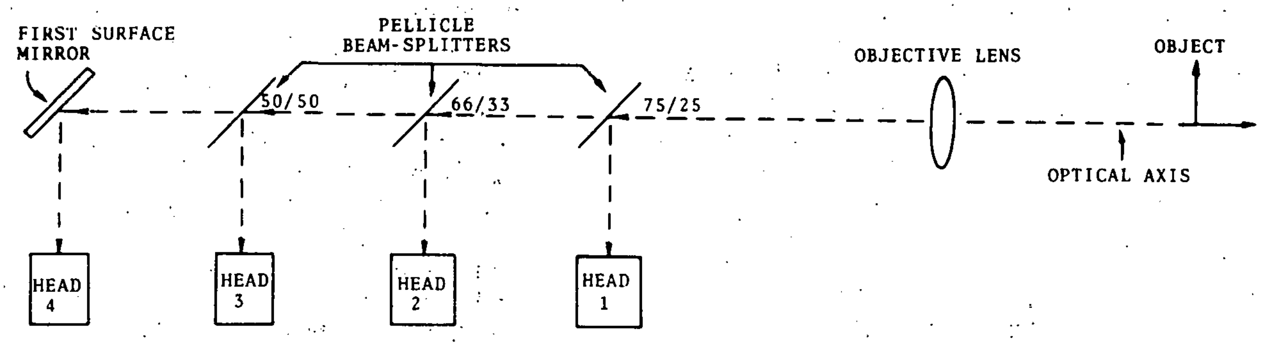

Fig. 1. Optical Arrangement of Marco M4 Camera

not immediately obvious why this was not the case at position 4. Fig. 1 shows that each head receives its light by reflection; Heads 1, 2 and 3 from the beam splitters and Head 4 from a rigid mirror. Thus, the vibrating films were behaving as moving mirrors for Heads 1, 2 and 3. A moving mirror can affect the image at the focal plane by two mechanisms: first, by altering the optical path length and thus causing defocusing; and second, by causing lateral motion of the image. The rigid mirror at position 4 would be free of such problems.

Although the light reaching Head 4 passes through the 3 vibrating beam splitters, it was not affected significantly because (1) the moving films did not alter the optical path length and (2) the optical power of such thin films is so slight that no defocusing results from the changes in shape caused by vibrations.

Thus it was seen that the beam splitters were indeed the cause of the optical problems, but only because of vibrations caused by the shutter release systems which consist of standard cable releases actuated by solenoids. The solenoids employed are simple and reliable but very rough in their action. The solenoid for each head was mounted directly on the metal base of the head. One solenoid was remounted on a thin aluminum plate which was isolated from its head base by 4 neoprene spacers about 13 mm thick. This arrangement allowed almost all of the excess energy of the solenoid to be dissipated by the spacers, so that almost no vibration was transmitted through the mainframe to the beam splitters. A test showed that complete removal of the solenoid from the head offered no improvement because almost all residual vibration resulted from shock transmission through the cable release into the shutter assembly. When the four heads were modified in this manner and the four shutters actuated simultaneously only the image at position 2 was poorer than that for a free-standing head, and it was only marginally so.

Since the focus mode is far more susceptible to vibrational problems than the pulse mode (test-fire mode) it is felt that the optical and mechanical problems have been overcome, there is no need to replace the beam splitters, and the resolution of the camera is now limited by the image converter tubes, as it should be.

CONCLUSIONS; FUTURE WORK

With the modifications described above, it is felt that the performance of the camera is acceptable in the static mode. Items remaining to be evaluated are the dynamic optical quality and the performance of the delay and exposure circuits.

One question that must be considered is whether this camera provides sufficient light amplification to permit utilization of its short exposure capabilities for anything other than self-luminous events.

Investigation of these areas will be delayed until two problems can be corrected. One of the image converter tubes does not function in the pulse mode, and the spark gaps in the pulse circuit leak so badly that a cylinder of nitrogen lasts only about two days.

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