MEMORANDUM

DATE: 7-18-69
A-830-BB01-HCB-41

TO: R. M. Wood, A-830

FROM: H. C. Bjornlie, A-833

SUBJECT: LIGHT/MAGNETIC FIELD INTERACTION EXPERIMENT

COPIES TO: J. M. Brown, D. B. Harmon, W. P. Wilson, Jr., A-830; File

The light/magnetic field (B/C) interaction experiment has been performed and concluded. A description of the experiment, the results and recommendations are attached to this memorandum.

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Advanced Concepts

HCB:msb
Attachment - Noted

LIGHT/MAGNETIC FIELD (B/C) INTERACTION EXPERIMENT

PURPOSE:

It is conjectured that the speed of propagation of light is modified when passing through a magnetic field. It is the purpose of this experiment to determine if such an effect exists. The experiment is to make use of existing apparatus if possible, with a minimum expenditure for the purchase of new equipment.

METHOD:

A change in light velocity is detected as a change in wave length of the affected light beam in the following manner:

One light beam of a Mach-Zender interferometer is passed through the air core of a 15 foot long solenoid, which develops a flux density of 2560 gauss. This beam is then combined with the reference beam to form interference fringes which are focussed on a multi-cell silicon-diode transducer. The electrical output of the cells, and the input current to the solenoid are simultaneously and continuously recorded.

EQUIPMENT: Light Source

University Laboratories Inc., Helium-Neon Gas Laser, Model 240, 1 Milliwatt, 6328A.

Sanborn, Model 53 battery powered 110 vdc source, provides alternate power source for laser without 60 Hz noise.

Optical System

Three front surface mirrors, approximately 1 inch x 1-1/2 inch (source and characteristics unknown).

One beam splitter, approximately 2-1/2 inch x 3 inch (Edmund Scientific - (characteristics unknown).

Collins Microflat Co., two granite surface plates with three adjustable legs, 12 inch x 18 inch x 3 inch; four granite angle plates, 3 inch x 3 inch x 4 inch, toolroom grade B.

Magnetic Field

Mag-Tran, Model SA-380 solenoid. Two concentric coils, continuously wound to produce additive flux. 15 ft. long x 2.8 inch outside dia., wound on an aluminum alloy tube of 1-11/16 inch outside dia. The wire is #3 gauge square magnet wire (.229 in) with glass filament insulation.

The solenoid is contained within a steel tube of 3 inch outside dia. x 1/4 inch wall thickness. 3/8 inch thick steel plates are bolted to welded flanges to close the ends of the tube. The tube is supported on 4 integral stands with its center line at 7-3/4 inch above the floor.

The air core of the solenoid is thermally insulated from the aluminum mandrel by two concentric PVC plastic tubes (water pipe) which provide a 1/2 inch dia. air path through the center of the solenoid.

Power is supplied by a Miller Electric Mfg. Model SR-10000IA, 50 KW at 80,160 or 320 vdc, variac controlled. The power supply is protected by a "crow-bar" circuit consisting of a IN3289 diode (GE A70B) and a 100 MFD-450 WVDC electrolytic capacitor in parallel across the solenoid terminals.

Instrumentation

Current through the solenoid is measured across a 1000 amp - 50 mv shunt.

The interference fringes are projected on a ruled line pattern of the same spacing as the fringes. The pattern is ruled with black felt tip pen on paper vellum which is cemented to a 2 inch x 3 inch microscope glass immediately above the light sensor. The sensor consists of 19 Hoffman 55C silicon cells (3/16 inch square) arranged in two rows. The cells and line patterns are arranged such that peak voltages for the two rows are phased 180° apart. Each row of cells is series wired. Output of the sensor is read as a voltage differential between the two rows of cells.

A Sanborn model 320 dual channel dc amplifier-recorder is used to record the inputs described above. When the light source is operated on ac power, a 60 Hz filter (.22 MFD - 51 KΩ) is used with the light sensor input.

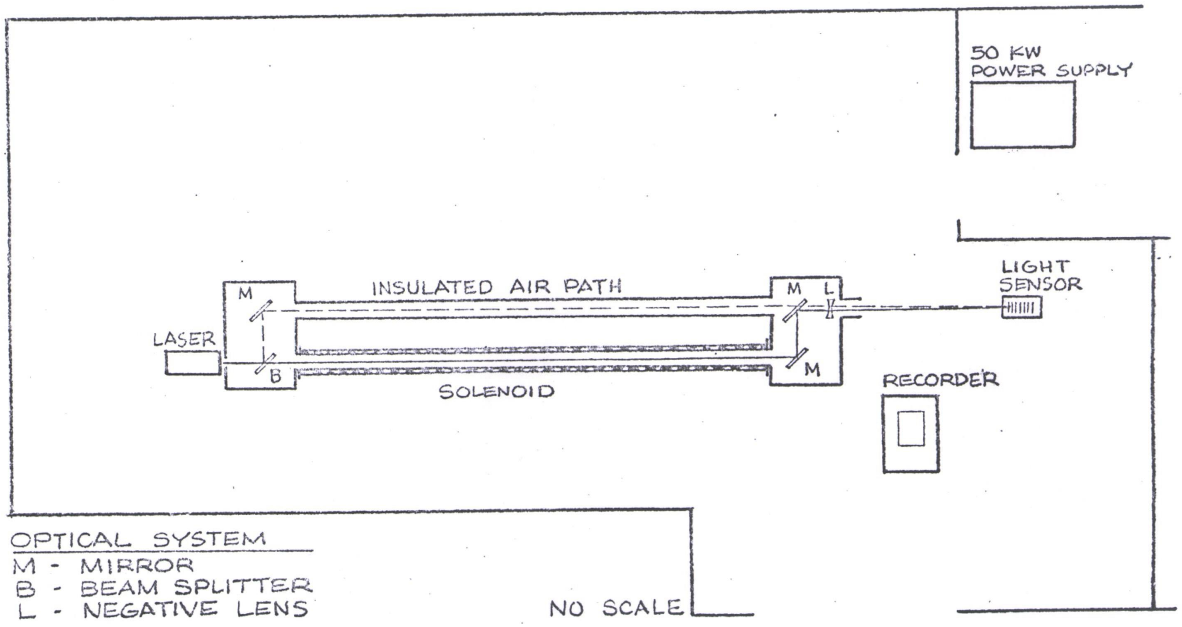
See Page 3 for schematic of equipment arrangement.

PROCEDURE:

Since the amount of anticipated fringe shift is an unknown, preliminary runs were made to visually observe fringe movement and record voltage and current readings at the solenoid. Peak power observed was 49.02 KW (570 a., 86 v.). Fringe movement was very erratic but indicated that any effect (signal) would be much less than 1λ in magnitude. To provide a quantitative picture of fringe movement, the sensor described previously was fabricated from available laboratory surplus parts. In conjunction with the chart recorder, this sensor is capable of resolving ~ 2 parts in 10^9.

The majority of the background noise was due to air temperature variations external to the solenoid. This was caused by the room air conditioning outlets immediately above the apparatus. This was cured by blocking the air outlets and constructing thermal-insulative enclosures for the light path. Additional noise was introduced via mechanical coupling with the power supply blower. This was eliminated by disconnecting the blower.

Subsequent runs using the light sensor and recorder required additional noise reduction by means of a 60 Hz RC filter and isolation of the solenoid housing from the thermal covers on the optical system.



EQUIPMENT ARRANGEMENT - UNIT 52 RM 102

PROCEDURES: (Contd)

The residual random noise was $<\lambda/50$ for most of the runs from #10 through the last one, #17. $\lambda/50$ is the distance equivalent of the previously stated resolution of ~ 2 parts in 10^9. On the chart record of runs #12 and #13 are illustrated the curve deflections which would be anticipated if the maximum field were to cause a $\lambda/40$ fringe shift. Comparing these to the actual recorded curves clearly shows an absence of signal at this field strength.

Heating of the air core of the solenoid during operation causes a predictable displacement of fringes at the average rate of 1λ/min. However, this poses no problem in signal discrimination if the field is applied and removed rapidly. The limiting cycle time for the field is approximately 4 sec. and is due to manual operation of the variac. The measured time constant of the coil (95%) is $\sim$ .01 sec.

Flux leakage at the end plate joints of the solenoid housing was checked with a Bell Gaussmeter. Readings of $\sim$ 10 gauss @ 100 a. were taken both with and without a soft-steel wire gasket between end-plate and flange.

RESULTS:

No signal of the type anticipated was observed within the limits of resolution of the existing apparatus ($\lambda/50$ or ~ 2 parts in 10^9).

RECOMMENDATIONS:

When the theory is sufficiently advanced to be able to predict the effect within a few orders of magnitude, the possibilities of experimental verification should be examined again. The following improvements to the present apparatus have been investigated.

Signal Amplification

An increase in flux density x length can be accomplished inexpensively by,

1. Addition of a second solenoid and second power supply, if available.

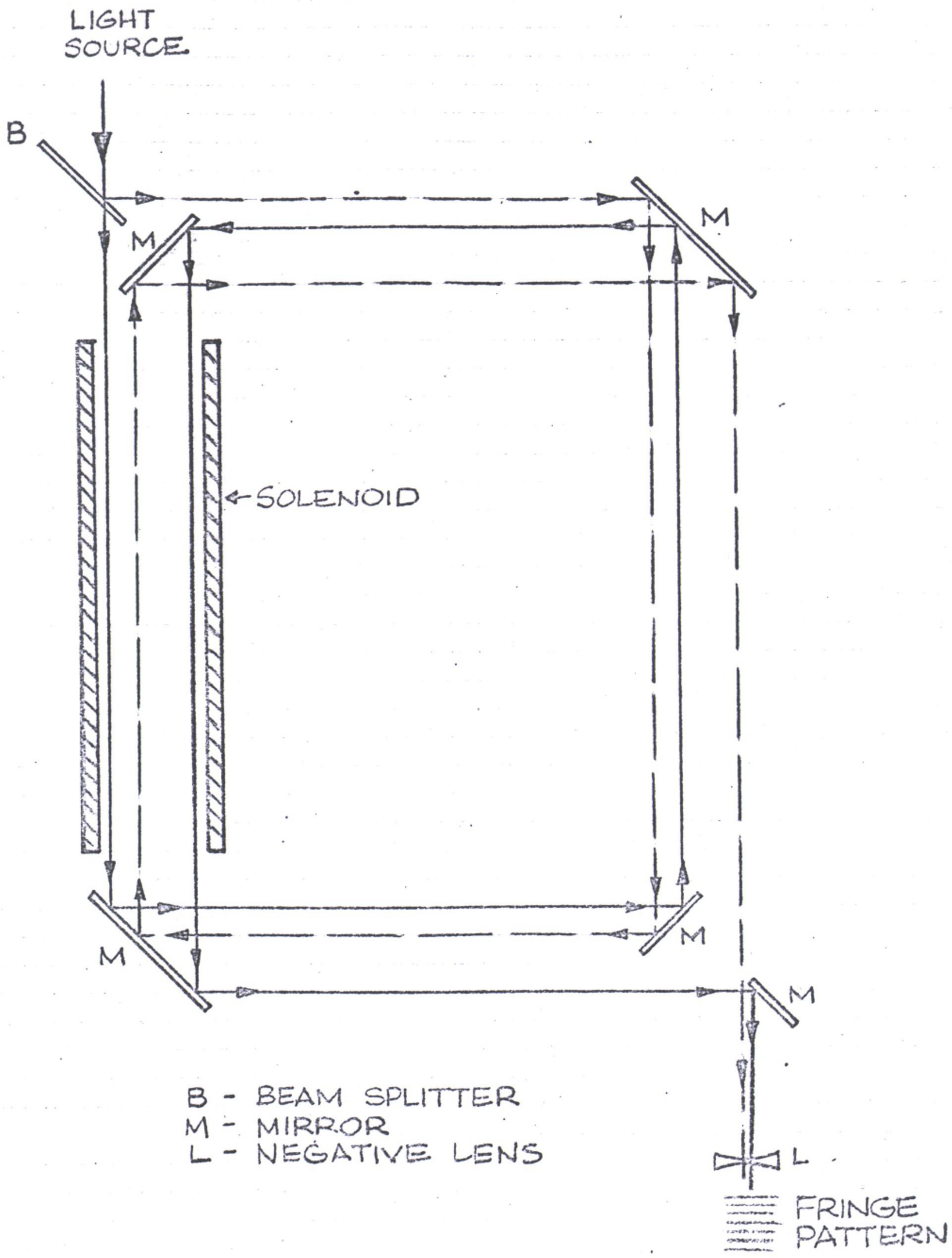
2. Recirculating the light beam through the solenoid three times.

A comparison of these techniques is shown on Page 5. The second method above was tried by modifying the existing apparatus as indicated on Page 6. To accomodate the three passes of the beam through the solenoid, the 2 PVC tubes were removed and the apertures in the end-plates were increased in size. The alignment procedure was much more difficult due to the added mirrors and path length.

COMPARISON OF PROPOSED MODIFICATIONS TO LIGHT/MAGNETIC FIELD EXPERIMENT
(Performance Is Compared To Original Experiment In Percentages)

MODIFICATION	MAG. FIELD		SIGNAL	TEMP. NOISE	RANDOM NOISE	SIGNAL /
	Gauss-Meters	Power KW	%	(N_t)%	(N_R)%	N_R
A Two Identical Solenoids on Existing Power Supply. Flux Directions Opposing Each Other.	16,550	51	144	~10	100	1.44
B Two Identical Solenoids On Separate Identical Power Supplies. Flux Directions Opposing Each Other	23,000	98	200	~10	100	2.00
C Single Solenoid On Existing Power Supply. Light Beam Recirculated to 3 Times Existing Path Length.	11,500 Act. 34,500 Eff.	49	300	100	~250	~1.2
D Modification A, Plus Light Beam Recirculated to 3 Times Existing Path Length	16,550 Act. 49,650 Eff.	51	432	~10	~250	~1.7
E Modification B, Plus Light Beam Recirculated to 3 Times Existing Path Length	23,000 Act. 69,000 Eff.	98	600	~10	~250	~2.4

SCHEMATIC OF MACH-ZENDER INTERFEROMETER WITH DOUBLE LOOP LIGHT PATHS.



RECOMMENDATIONS (Contd.)

Although this modification increases the signal threefold, random noise is also increased, fringe brightness is reduced by a factor of 9 and fringe definition is degraded. With the existing sensor, slightly modified, it was not possible to approach the resolution previously attained. This technique requires a laser of greater intensity and coherency than was used, in order to achieve the quality of fringe pattern required.

Improved Resolution

Resolution can be improved by developing a more sensitive sensing technique and using synchronous methods for isolating signal from background noise. By projecting the fringe pattern on a ⊥ screen having alternating reflective and absorbtive lines of the same spacing as the fringes, the entire cross section of the light beam can be used as a fringe shift indicator. This image of variable brightness can be focussed, by means of lenses, on a highly sensitive, fast reacting light sensor. A bridge circuit can be used to convert its change in resistance to a recordable signal.

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28 May 1969

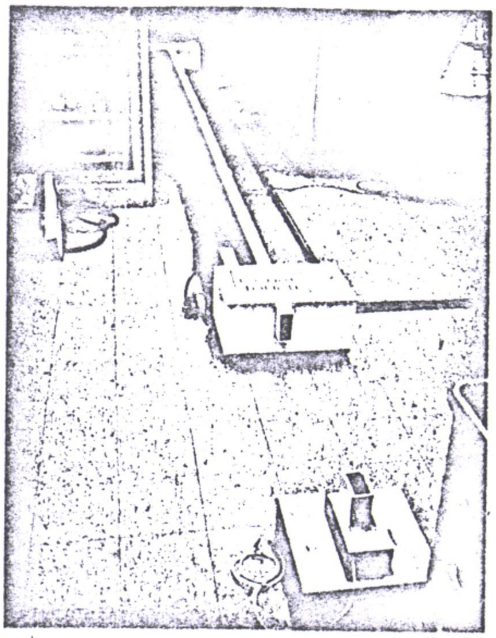

Fig. 1. General Arrangement Of Experimental Apparatus. Optical Sensor In Lower Right Corner

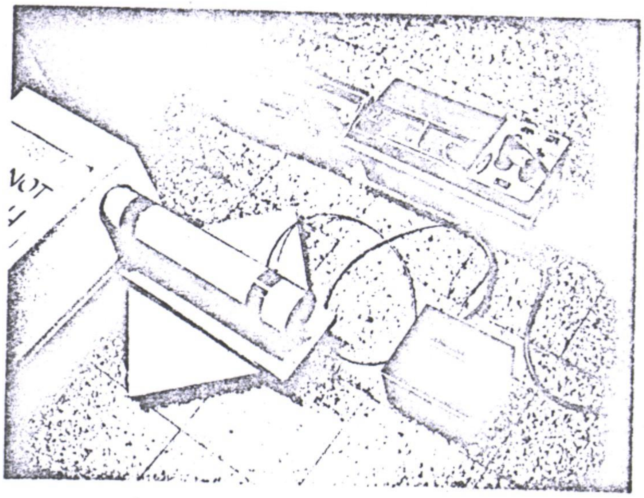

Fig. 2. Light Source He-Ne Gas Laser (6328Å) With 110 v. dc Battery Power Supply

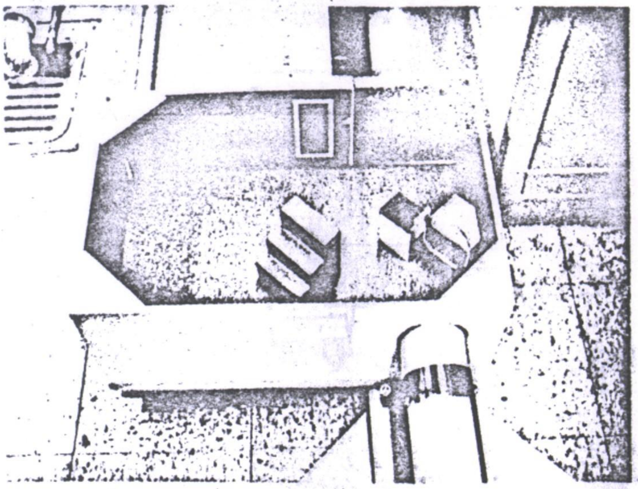

Fig. 3. Interferometer, Near End, With Cover Removed. Optical System is Arranged For Double-Loop Path. End Plate Of Solenoid Is In Upper Right, In Line With Laser Axis.

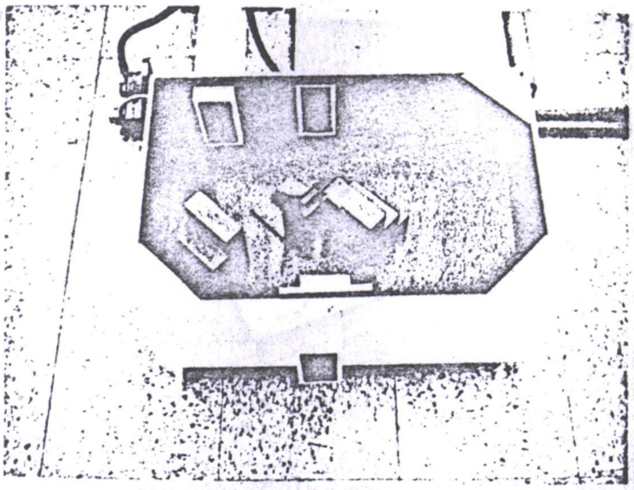

Fig. 4. Interferometer, Far End, With Cover Removed. Optical System Is Arranged For Double-Loop Path.

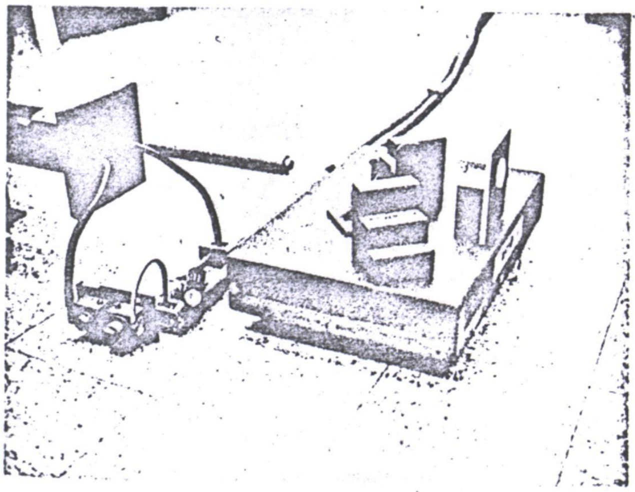

Fig. 5. Interferometer, Far End, With Complete Housing Removed. Optical Element At Right Is Negative Lens. Solenoid End Plate Is At Left. Protruding Leads Attach To "Crow-Bar" Circuit And Power Cables. Thermal Insulating Tubes Lie On Floor Behind Solenoid.

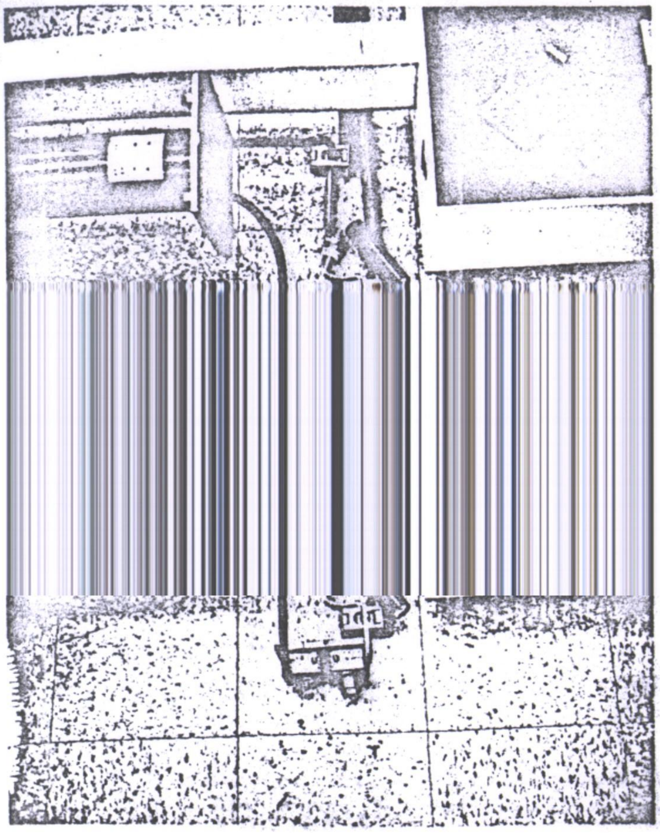

Fig. 6. Far End Of Solenoid Showing "Crow-Bar" Circuit And Power Cables.

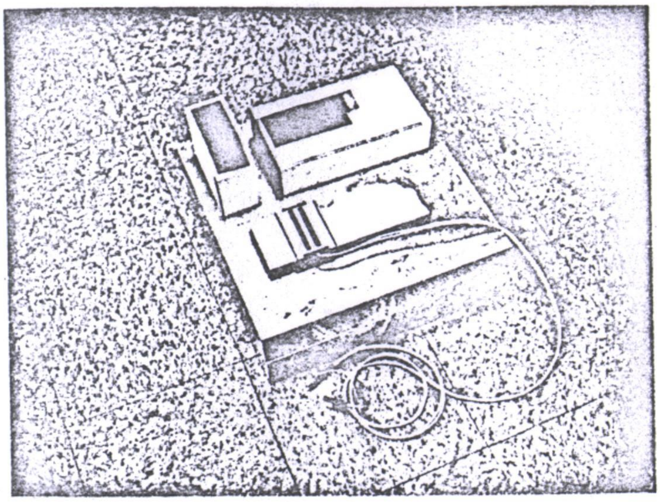

Fig. 7. Optical Sensor With Housing Removed.

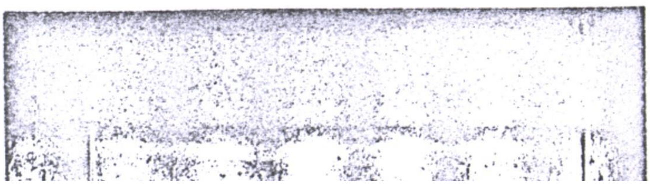

Fig. 8. Interference Fringes. Center Section Shows 5-1/4 Wave Lengths, Lower Section (Barely Visible) Shows 1-3/4 Wave Lengths