Range Commanders Council

TECHNICAL REPORT

HIGH-SPEED CAMERA TIMING REPORT

NOVEMBER 1973

WHITE SANDS MISSILE RANGE
KWAJALEIN MISSILE RANGE
YUMA PROVING GROUND
DUGWAY PROVING GROUND
ELECTRONIC PROVING GROUND
COMBAT SYSTEMS TEST ACTIVITY

ATLANTIC FLEET WEAPONS TRAINING FACILITY
NAVAL AIR WARFARE CENTER WEAPONS DIVISION
NAVAL AIR WARFARE CENTER AIRCRAFT DIVISION
NAVAL UNDERSEA WARFARE CENTER DIVISION NEWPORT

30TH SPACE WING
45TH SPACE WING
AIR FORCE FLIGHT TEST CENTER
AIR FORCE DEVELOPMENT TEST CENTER
AIR FORCE WEAPONS AND TACTICS CENTER
SPACE AND MISSILE SYSTEMS CENTER,
SPACE TEST AND EXPERIMENTATION PROGRAM OFFICE

TECHNICAL REPORT

HIGH-SPEED CAMERA TIMING REPORT

Prepared by

Telecommunications Group
Range Commanders Council

November 1973

Published by

Secretariat
Range Commanders Council
White Sands Missile Range
New Mexico 88002

ABSTRACT

This technical report contains the results of tests conducted on Light Emitting Diodes (LEDS) for use as replacements for neon lamps. Neon lamps have been used to imprint data on the continuous running photographic films used in various types of instrumentation camera systems. All test results indicate that LEDS produce superior timing marks, improve field operation, reduce maintenance costs, and significantly increase timing reliability. Included in the appendices to this report are purchase descriptions of new Timing Terminal Units (TTU) and related equipment.

CONTENTS

PAGE

CHAPTER 1

INTRODUCTION

Background

In May 1969, the Telecommunications Group (TCG) of the Range Commanders Council (RCC) was concerned with methods and procedures for obtaining reliable timing on film in high speed instrumentation cameras. A task entitled "High Speed Camera Timing Report" was approved by the Inter-Range Instrumentation Group (IRIG) Executive Committee of the RCC. An ad hoc committee consisting of Milton R. Bradley, Holloman AFB, Chairman; Jack Giacomo, Jr., White Sands Missile Range; Jack E. Norbeck, White Sands Missile Range; Quinnie Flint, White Sands Missile Range; and C. W. Davidson, White Sands Missile Range, was formed to compile this report.

The committee petitioned IRIG members and associated organizations for literature describing their efforts to improve timing marks on film in high-speed cameras. The body of literature collected from these sources is the primary basis for the material presented and the conclusions reached in this report.

Neon Lamp Use

Photo optical recording, of timing signals on the edge of motion picture film, is a regular requirement for the measurement event data on many instrumentation camera systems used in various range tests. These timing signals are recorded on film by projecting light from neon lamps through slits or dot-like mechanical apertures on one or both edges of the film. The use of neon lamps to record timing on film has always presented operational problems, some of which are:

1. Due to darkening of the neon lamp envelope, the light intensity of the neon decreases with use. As a result, the timing marks on the film are degraded to such a point that data are lost or extremely difficult to reduce.[1]

2. Since the neon lamp output varies with use, the operator has no assurance that the neon lamps will last throughout the mission.[2]

3. "Neon light output is relatively low and the optical transfer characteristics are generally insufficient in most neon lamp marking systems. For these reasons, the neon lamp must invariably run at operating levels far above its rating. This operating requirement often leads to premature burnout or erratic performance."[3]

4. Premature burnout of neon lamps in a camera system presents maintenance, cost, and supply problems.

5. Neon lamps require high voltage to operate, thus a continuous keep-alive current is needed to maintain the lamps at threshold.

ACKNOWLEDGEMENTS

1. Bradley, M. R., AFMDC, 20th Meeting TCWG, November 1962.

2. Bramlett, William L., Jr., Track Directorate, Report of Neon Bulb Testing, 24 February 1965.

3. Beal, C. H.; Dearing, Leroy M.; Hillier E., Film Data Recording Using Electroluminescent Diodes: Design Considerations, Journal of the Society of Motion Picture and Television Engineers, Volume 78, No. 11, November 1969.

CHAPTER 2

HOLLOMAN AIR FORCE BASE (HAFB) TESTS CONDUCTED ON LEDS IN OPTICAL INSTRUMENTATION CAMERAS

Tests and Results

In 1968 the Holloman AFB Test Track contracted with L. M. Dearing Associates for the purchase of a LED Driver, model 12CCU, and the modification of one camera timing indicator block, series 2500. The indicator block was installed in a photosonics 10A camera. The camera control unit (CCU) referred to in the instruction manual is unique to the Holloman Test Track; therefore, results of those tests are not discussed in this report. Several tests under controlled laboratory conditions were conducted. The timing signals used were IRIG formats A003, B003, and E003.

In conducting the tests, various current settings were used to determine optimum timing marks for the type of film and frame rate. In this report, optimum timing marks are those that produce good to excellent timing to the film reader.

Field Tests

Field Test Setup

All tests were performed using the standard L. M. Dearing model 12CCU. Test data are contained in Table I.

Results of serrated formats A003 and B003 timing tests were also excellent.

A special test locating the camera 2000 feet from the diode driver was also performed. Standard field wire was used to connect the output of the diode driver to the camera. Timing marks for this test were rated fair.

Conclusions

Timing marks from LEDS were far superior to neon lamps. The Holloman Test Track initiated procurement that would eventually result in a complete changeover of instrumentation cameras to LEDS.

Future Considerations

On-Camera Numeric Timing System

The Holloman Test Track has under procurement 10 each On-Camera Numeric Timing Systems for the Photo-Sonic 70mm 10A camera.

TABLE I

TESTS RESULTS

Camera — Photosonics 10A with L. M. Dearing Associates Model 2412-2 L. E. Diode Timing Block.

Film — LSB — 50132

Frame Rate — 20 fps

Timing Marks — 250 microsecond pulse width, coded decimal binary.

Test	Current Setting (ma)	Remarks
1.	15	Poor. Timing marks extremely light.
2.	20	Poor. Light timing marks.
3.	25	Poor. Light timing marks.
4.	30	Fair. Light timing marks.
5.	35	Fair. Light timing marks.
6.	40	Fair. Light timing marks.
7.	45	Fair. Light timing marks.
8.	50	Fair. Light timing marks.
9.	55	Fair.
10.	60	Good.
11.	80	Good.
12.	100	Good.
13.	120	Excellent.
14.	140	Good. Timing marks bleeding together.
15.	160	Good. Timing marks bleeding together.
16.	180	Poor. Bleeding, timing marks dark.
17.	200	Poor. Bleeding, timing marks dark.
18.	220	Poor. Bleeding, timing marks dark.
19.	240	Poor. Bleeding, timing marks dark.

The system will be attached to the Photo-Sonics 10A camera door and contains:

IRIG A & B Translators
BCD Time Code Generator with Internal Oscillator.
Decoder/Drivers
9-Digit LED Optical Numeric Data Recorder.

Nine digits of time to 23 hours, 59 minutes, 59.999 seconds are recorded from 7-segment LEDS in the upper corner of the 70mm film camera aperture coherent with the pictures.

Event time reading for data reduction will be simplified with this system.

Conclusions

1. The light output of the LED remains constant for the life of the diode.

2. The LED life is indefinite if the driving current is kept within diode limits.

3. Timing marks up to 100 KHz can be easily obtained.

4. The use of LEDS to mark film results in an overall improvement in field operation, reduced maintenance costs, and reduction of film data.

NOTE

Additional information can be found in Appendices A through H.

BIBLIOGRAPHY

1. Herr, Maxwell A., Miniature Light Sources for Timing Signal Recording, Draft of Paper for Oral Presentation at 102nd Technical Conference of Society of Motion Picture and Television Engineers.

2. L. M. Dearing Associates, Inc., Pulselight Photometer, Model 1200A, L. M. Dearing Associates, Inc., Product Bulletin.

3. Mudge, John K., Electronic Index and Fiducial System for Benson-Lehner 70mm Camera, Measurements Division, Integrated Range Mission, White Sands Missile Range, New Mexico, July 1961.

4. L. M. Dearing Associates, Inc., Solid State Camera Timing System, L. M. Dearing Associates, Inc., Product Bulletin.

5. Strowe, R. J., Study of Time Tag Photographic Data, Prepared for National Aeronautics and Space Administration, Contract NASIO-5922, VL-1025-4-0, John F. Kennedy Space Center, Kennedy Space Center, Florida 32899.

CHAPTER 3

WSMR TESTS CONDUCTED ON LEDS IN OPTICAL INSTRUMENTATION CAMERAS

Test Setup

Laboratory tests were conducted using LEDS to mark timing on various types of optical instrumentation cameras. The timing output signal to drive the LEDS in the cameras was a serrated (i.e., dc level shift reconstruction of the mark carrier cycles) IRIG A or B time code with a pulse width adjustable from 10 to 100 microseconds. The output current to drive the LEDS was variable from 10 milliamperes to 2 amperes. The equipment used to furnish the serrated timing signal to drive the LEDS was a Datum Inc., Model 9610 TTU with the appropriate plug-in modules. This equipment is discussed in detail under the headings "Timing Terminal Unit System" and "High Current Amplifier System" in Appendix I.

The LEDS used for film annotation were Monsanto MV10B3 with a peak emission at 6,800 angstroms. In conducting the test, various current and pulse width settings were tried in order to arrive at an optimum current and pulse width setting for the types of film, frame rates, and types of IRIG timing used. For purposes of this report, we define optimum current and pulse width as those settings that will produce good to excellent timing for various types of film over the widest range of frame rates possible.

Discussion and Results

Table II gives the optimum current and pulse width settings for various types of cameras, film, frame rates, and types of timing. The results which are contained in the remarks column show that at slow frame rates there is slight overexposure. One significant benefit of the LEDS is that when the timing is overexposed, no detraction from an accurate reading of the timing is apparent. Conversely, if neon lamps were used, the timing marks would be smeared so that it would be impossible to read the timing. It was noted that at high frame rates there is some unevenness in the exposure, but this presents no problem in reading the timing.

For Table II, the ideal current and pulse width settings would be those that produce the best possible timing on film for each type of film at the required frame rate.

Conclusions

Using optimum current and pulse width settings for various types of film and range of frame rates instead of ideal current and pulse width settings for each type of film and frame rate minimizes setup time in the field while providing reliable timing for film reading.

TABLE II

OPTIMUM CURRENT AND PULSE WIDTH SETTINGS

Type of Camera	Type of Film	Frame Rate	Type of Timing	Current Setting	Pulse Width Setting	Remarks
10A Photo-Sonic	LSB (2476)	20 to 80	B	80 ma	100μs	Slight overexposure on slow frame rates.
	MS (color) (2256)	20 to 80	B	80 ma	100μs	
10B Photo-Sonic	LSB (2476)	90-180-360	A	100 ma	20μs	
	LSB (2476)		B	80 ma	100μs	
	MS (2256)		A	100 ma	20μs	
	MS (2256)		B	80 ma	100μs	
4C Photo-Sonic	LSB (2476)	250 2,500	A	110 ma	20μs	Uneven exposure at high frame rate.
	MS (2256)		A	110 ma	20μs	
4E Photo-Sonic	LSB (2476)	18 to 360	A or B	100 ma	20μs	Slight Overexposure at slow frame rates.
	MS (2256)			100 ma	20μs	
Continuous Frame Camera (CFC) Photo-Sonic	LSB (2476) 2484	50-10K inches per minute	B and H	10-50 ma	280μs	Slow film speeds require a different current setting for each selected speed to avoid overexposure.

TABLE II (Cont'd)

Type of Camera	Type of Film	Frame Rate	Type of Timing	Current Setting	Pulse Width Setting	Remarks
705A Flight Research	LSB (2476) MS (2256)	30 to 300	A or B	70 ma	28μs (A) 280μs (B)	These pulse widths will be narrower with new camera timing amplifier (3.3.3).
B-L Benson-Lehner	LSB (2476) MS (2256)	7½ to 80	B	70 ma	280μs	Same as above.
Hy-Cam Red Lakes Lab	LSB (2476) MS (2256)	5,000 to 11,000	A	400 ma	10μs	High current amp required. Current measured at the camera.
Nova Waddell	LSB (2476) MS (2256)	5,000 to 11,000	A	400 ma	10μs	Same as above.
Contraves Mod F	LSB (2476) MS (2256)	5, 10, 20, 30	B	100 ma	20μs	At 5 per sec, a 10μs pulse width is automatically selected.
Askania 20 per High Speed	LSB (2476) MS (2256)	5, 10, 20	B	100 ma	20μs	Same as above.

APPENDIX A

METHOD TO PROVIDE RELIABLE TIMING ON HIGH-SPEED CAMERAS

Mr. Milton Bradley, AFMDC

At the present time, neon lamps (NE51, etc.) are used to provide timing to instrumentation cameras. Several tests were made at AFMDC to determine a method for providing timing to high-speed cameras.

When using neon lamps, as the film advance speed is increased, the neon lamp brilliance must be increased. The current necessary for this increase in brilliance causes an internal breakdown of the lamp within minutes.

In the case of the NE51, two results are noticeable:

a. The ignition voltage increases (in some cases from 65 to 130 volts). The exact amount varies between lamps.

b. The glass envelope is internally blackened, reducing the amount of emitted light.

In order to obtain satisfactory timing under these abnormal conditions, the neon lamp must be replaced immediately prior to use and the amount of "pre-fire" checkout reduced to an absolute minimum.

The neon lamp also suffers another important disadvantage. Using symmetrical square waves, the neon fails to extinguish at 5 kc, producing an unbroken black line.

In order to obtain higher timing resolution of high-speed cameras, IRIG Format A, 10 kc modulated, will be required.

There are two methods that appear to be the better approach for producing reliable timing:

a. A strip of magnetic tape along the edge of the film.

b. A high voltage capable of producing a spark across the two electrodes in air.

The first method is probably the most desirable since it would be capable of reproducing any one of the IRIG formats, either modulated or unmodulated. However, there are several disadvantages:

a. A record head and associated electronics are required.

b. Operators would require more extensive training.

c. If it is possible to develop the film without destroying or altering the timing information, reproduce heads would be necessary, making manual reduction complicated and time consuming.

d. Film and system costs would be high.

The second method, although not the ultimate, requires the least amount of internal camera modification. However, this method would not be able to reproduce the unmodulated formats.

In order to make spark gap tests, a circuit was breadboarded. High frequency, high voltage coils for this use were not readily obtainable. The best coil for this test was found to be a model airplane ignition coil. Several film tests were made and the highest spark frequency was 5 kc.

Also available at Holloman was a Fastex camera with a commercially built spark gap system. The maximum spark frequency with this system was 2 kc. In the film samples (Figure 12, page D-15), the spark produced by the breadboard model is not as distinct as the commercial model. This is believed to be from an incorrect setting of the spark gap electrodes.

AFMDC has fifteen camera pad amplifiers out for bid. These amplifiers will produce a high voltage, high frequency spark.

APPENDIX B

INSTRUCTION MANUAL

SST-III LIGHT EMITTING DIODE DRIVER CAMERA CONTROL UNIT - MODEL 12CCU

FOR

DEPARTMENT OF THE AIR FORCE

Headquarters Air Force Missile Development Center - (AFSC)

Holloman Air Force Base, New Mexico

Contract F29651-70C-0276

By

L. M. DEARING ASSOCIATES, INC.

12324 Ventura Blvd.

Studio City, California, 91604

March, 1971

1.0 GENERAL

The L. M. Dearing Associates, Inc. SST-III Light Emitting Diode Driver and Camera Control Unit Model 12CCU is designed to receive positive or negative going pulses from a balanced line input between three and twenty volts DC level shift. These signals generated at the control center are programmed to be inverted for a camera run function, as well as providing a timing signal for the cameras in use.

Three separate component boards are used to process the signals as generated by the master time code generator.

A signal duty cycle sensing amplifier board. This circuit board provides the programming for camera turn-on and turn-off function based on the polarity of the incoming signal. The logic of the circuit is based on duty cycle response of the G or GX code and responds to a relative duty cycle of 60% negative (or more) and 40% positive (or less). Should the incoming signal be positive going, the average weight of duty cycle is considered to be 40% and, therefore, will close a relay on the panel which in turn will close the camera drive relay. Should the timing signal drop out, the camera will remain in the on condition until such time as a negative going signal appears across the input leads of the circuit, at which time the relay will be driven to an open position, thus stopping the camera.

A voltage regulator board is supplied to provide the appropriate voltage for the sensing amplifier card.

A LE diode driving board is a DC amplifier/switch which contains two separate amplifiers, one for each LE diode in the camera. This board receives the gated output of the programming amplifier board to provide current drive to each individual LE diode in the timing block of the camera. The output of this board is adequate to provide 300 ma to Channel A and 600 ma to Channel B.

2.0 POWER SUPPLY

The power supply of this unit consists of a 117 VAC 60 Hz. transformer which supplies charging current to the battery supply of the unit which is on a float condition and provides supplemental power to the main diode driving amplifier. There are multiple taps on the input of the 117 VAC windings, plus a variable dropping resistor, to enable adjustment of the charging rate for the batteries, should it be required. The output of the transformer is rectified and switched into the battery system.

In this way the unit is at all times operating on battery power in a float charge state, being constantly charged by the AC supply. Should, at any time, the AC power input fail, the batteries will automatically take over and run the unit for a minimum of three hours of full level operation. Should battery failure occur, the unit will function on AC power.

2.1 Battery Charge Procedures

It is suggested that on receipt the units be plugged into the AC lines and the pre-charge switch energized for between four and six hours for firm battery charging to the initial charge. The batteries as shipped in the units have been pre-charged and tested. However, for initial field testing it would be advisable to give a final charge to bring them to level. Subsequent pre-charging should be unnecessary except under those conditions where extended periods of battery run have been necessary.

The batteries at full charge should provide 4 to 6 hours of normal "ON" operation, (i.e., signal coming in - but camera and LE diodes at rest) and still function on command of the reversed signal. The full charge rate range for this battery pack of 16 Nickel Cadium cells is considered to be at 22 volts. This should be measured at charging rate. The voltage under full load is between 18 and 20 volts, measured at battery test points.

2.2 Use of Unit on AC Power Only Without Batteries Installed

Should it become necessary or desirable to use this unit with the batteries removed, a filter capacitor should be installed in place of the battery to provide adequate filtering and adequate power delivery for full level operation. While the unit will operate without a filter capacitor in place of the battery, maximum levels of signal output may not always be achieved and some AC ripple component may be observed in the output signal. A filter capacitor with a 25 to 30 volt working voltage rating and of between 3000 and 5000 microfarads capacity is recommended. There is adequate room for this unit to be installed in the space now occupied by the battery.

3.0 CONNECTORS

All connectors on this unit appear on the rear section of the driving box. From left to right, as they appear on this section of the box, the J3A (Channel A) and J3B (Channel B) connectors have positive pulses at Pin A of J3A and Pin B of J3B and common ground at Pin C.

The 14S-5S J4 connector is used for camera control output. Pins A and B are relay closure contacts. The 14-7P connector is for signal input Pins A and B, as well as binder terminals which are paralleled. Pin C is for ground when available. The 16-10P connector is used for power input 117 VAC, and A and C are the input pins. A mating connector and cord is provided for this unit. Pin B is for 3rd wire safety ground.

4.0 CAMERA CONTROL UNIT TIMING SIGNAL INPUT

The unit input is designed to present 600 to 800 ohms impedance load to the timing line. This input is connected to a line transformer to present a constant impedance to the line. The output of the transformer is 600 ohms and is delivered to a comparator circuit to allow sensing of the signal polarity. This signal is then routed to a flip-flop which in turn provides the signal to a relay driver for the camera closure relay. At the same time, gated timing is provided for driving the main diode driver board. An additional relay closure is provided for driving a tally light for indicating the polarity condition of the input signal.

5.0 FRONT PANEL

Front panel controls from the left hand side of the panel are as follows: A "pre-charge" switch which allows the unit batteries to be charged while the remainder of the system is inoperative - this is a separate switch for battery charging purposes only. Battery test points are located below this switch.

Meter Select switch allows metering and adjustment of output Channel A to 300 ma and Channel B to 600 ma to provide the output levels required for different instrumentation films and/or camera speeds, or for each side of timing block.

Polarity Reversal switch for the purpose of changing polarity is available, should input connectors be reversed or should the twisted pair be reversed.

Camera Test and Relay Run Switch and Pilot Lamp. The amber pilot lamp L3 is immediately above this switch. When the switch is on "test" and lamp is off, it means that reverse polarity (negative going timing pulses) are being received. When the switch is on test and positive going timing pulses are being received, this pilot will be on, the timing LE diodes will be operating but the remote camera relay will not be energized and the camera will not run.

With the switch in Camera Relay Run position and pulses are reversed, the camera control sensing unit and 12CCU relay will energize the remote camera relay to start the camera. Note: The polarity reversal switch can provide a time to frame reference signal with the LE diodes in the camera. The switch in camera test position prevents camera run when making these time to frame reference marks.

A Timing Signal Indicator Lamp (yellow) (L-5) to the right of the meter indicates whether timing is on the line regardless of polarity when master switch is "on".

Master-On-Off Switch - This is the main power switch which breaks all circuits in the "off" position except the precharge.

Test Points - TP Scope to the right of the master on-off switch are switched with the output meter and sample the signal going to the LE diode.

Output Indicator Lamps (Red) for Channel A and Channel B (L-1 and L-2) provide some indication at the higher output level of the brightness of the LE diodes in timing blocks. Lamp brightness follows the LE diode current for all conditions except a short.

Controls - The output lamps are shunted to provide the following output ranges as measured on the meter:

Channel A - 0 to 300 ma
Channel B - 0 to 600 ma

The higher output levels should be used only briefly in testing (1 or 2 minutes) unless the Series 2500 LE diodes are well heat sinked. Outputs of 300 to 600 ma are required only at the higher film travel rates of 150 to 600 feet per second which require that the Series 2500 LE diodes operate for only brief periods which is entirely safe.

CAUTION: Reverse polarity can destroy light emitting diodes that are not protected against reverse polarity.

At all times the controls for the individual camera output channels should be in a counter-clockwise position (which attenuates the output signal to zero) when installing cameras. As the knobs are advanced clockwise, output is increased as will be indicated by the meter readings. Normally, depending on the speed at which the camera is being operated and the degree of sensitivity of the film, readings of 40 milliamperes are used for slower camera speeds, and up to 600 milliamperes at

At the higher camera exposure rates. Bear in mind that these readings are continuous current readings and the individual peak currents appearing at the diodes on peak pulses will exceed this by a factor directly proportionate to the percentage duty cycle of the code being transmitted.

CAUTION: The Model 1200U delivers high power to drive the L.M. Dearing Series 2500 LE diode timing cartridges and block. It will burn out the Series 1400 and Series 1500 LE diodes if used at driving currents above 60 ma.

NOTE: It is often helpful on initial setup to use 12 volt 40-60 MA indicator lamps as "dummy loads" for testing purposes instead of light emitting diodes.

Once it is determined that an adequate signal is available and being delivered to the LE diode outputs, each camera output level should be adjusted by selecting the proper metering point on the meter switch selector.

A suggested 100 ma of diode exposure current is a nominal "continuous" or "average" current reading for the Series 2500 LE diodes. Exact current levels should be determined by test and/or light output metering with the Model 1200A Pulselight Photometer to provide optimum exposure under specific operating conditions.

6.0 SETTING UP, TESTING AND OPERATION AT CAMERA SITES

6.1 BATTERY AND OUTPUT LEVELS

Before use at camera sites the checks listed below in Section 6.1.1 and 6.1.2 should be made.

6.1.1 Batteries - as tested with pre-charge (ON) should be at 20-22 volts (nominal - 21.5).

6.1.2 Timing Output Levels - Timing exposure is directly proportional to the metered current in milliamperes. These levels should be selected to suit the film type and cameras used. The suggested levels for Dearing Series 2500 LE diode timing cartridges given in 6.1.3 to 6.1.7 below are for Holloman GX 2000 time code at top camera speeds. For 1/2 this camera speed reduce these levels by 1/2, etc.

L. M. DEARING ASSOCIATES, INC.
12345 VENTURA BLVD. / SUITE R / STUDIO CITY, CALIF. 91604 / (213) 769-2521

6.1.3

Camera/Film Type	Speed	Current in ma
16mm Cameras, Hycam Nova, Fastax	10,000 frames/sec. or 250 feet/sec.	
MS Ektachrome		300 ma
LSB		200 ma
2484		600 ma Channel B 300 ma Channel A

6.1.4

35mm 4B Photosonic	2500 frames/sec.	
LSB		250 ma
MS Ektachrome		300 ma

6.1.5

70mm 10B Photosonics	360 frames/sec.	
MS Ektachrome		250 ma
LSB		200 ma

6.1.6

70mm Photosonics CFA	150 foot/sec.	
LSB		250 ma
MS Ektachrome		300 ma

6.1.7

70mm 10A Photosonics	80 frames/sec.	
LSB		100 ma
MS Ektachrome		200 ma

6.2 TESTING AT CAMERA SITE

6.2.1 Important - for testing always put switch #4 left in "Test Camera" position to prevent accidental camera run.

6.2.2 Plug in 117 VAC, timing input to Model 12CCU, connect remote camera control and output Channels A and/or B to the camera control and cameras respectively.

6.2.3 Turn master switch "ON" - the yellow timing signal light - to right of meter - should light if timing signal is at adequate level - if not call console for signal check.

6.2.4 Put polarity reversal switch in the position which lights output level indicator lamps and LE diodes in camera.

6.2.5 Adjust level controls of Channels A & B and monitor each with meter to give recommended levels (see 6.1.2 to 6.1.7).

6.2.6 Reverse position of polarity reversal switch. Unit remains in Master "ON" test condition.

6.3 CAMERA RUN OPERATION

Put switch #4 from left in "Camera Relay Run" position. Check that only yellow timing signal lamp is on before closing cover. Unit is now in "ON" standby "RUN" condition. Reversal of signal at console will start camera and timing. Return of signal to original polarity will stop camera and timing.

7.0 VOLTAGE REGULATOR AND DUTY CYCLE SENSING AMPLIFIER BOARD

7.1 Need for Matched Pairs of Voltage Regulator and Duty Cycle Sensing Amplifier Boards

Each camera control unit is equipped with a voltage regulator board (VRB CCU-12) especially designed to supply the 3,6,9,12 & 15 volts necessary for the adjacent duty cycle signal sensing amplifier board (SRB CCU-12) and the buffer amplifier board. Since moderate variations occur in the regulation circuit because of individual zener diode tolerance differences, each voltage regulator board and sensing amplifier board for a given serial numbered unit are adjusted and matched at the factory and marked with the same serial number. To avoid re-adjustment, these boards should not be interchanged with other units. Each camera control unit has the appropriate voltages adjusted during manufacture and these should not change through the life of the unit.

7.2 - Adjustment of Trigger Sensing Level

While the voltage variations from the regulator board are small, the sensing amplifier board selectivity depends upon the correct voltage levels being delivered to it. Since sensing is balanced in the amplifier, the trigger voltages need to be accurately adjusted for maximum efficiency and noise rejection. Should component values change or should components fail and require replacement, the sensing voltages can be re-adjusted to desired levels on the duty cycle sensing amplifier board. This is simply achieved by making measurements from the two test points on the mid-point of the trim pots, R13 & R14 on the amplifier board, with reference to the 6 volt level of the voltage regulator board. For average operation with the Holloman GX 2000 timing code, voltages should be adjusted to: +2.5 volts reference the 6 volt level on the left hand trimming potentiometer (R-14) as viewed from the screw turn side, and to -2.5 volts on the right hand trimming potentiometer center point (R-13) also as viewed from the screw turn side, i.e., the rear of the sensing amplifier board.

A second method of measurement of these voltages can be made with reference to ground level voltage where the left hand trim potentiometer (R-14) should be adjusted for a level of 8.5 volts, and the right hand trim potentiometer (R-13) adjusted to a level of approximately 3.5 volts.

The voltage levels for both the above methods of voltage adjustment provide trigger sensing at signal duty cycle of approximately 45% (and lower). This provides a good margin above that required by the Holloman GX timing code signal.

Other than the above noted adjustments, no further adjustments should be necessary on the camera control unit.

It may be found in practice that in cases where extreme noise levels on the timing signal line interfere that slight adjustment of these triggering voltages to provide a lower duty cycle triggering level will reduce the possibility of transients being sensed. Such spikes could be misinterpreted as real signals and result in false camera starts.

8.0 WARRANTY, MAINTENANCE & AVAILABILITY OF PARTS AND SERVICE

8.1 Warranty - All parts are guaranteed against defects in materials and workmanship for a period of 90 days from the date of the original purchase. During this period any such defects will be remedied at the factory without charge (except for transportation).

8.2 Maintenance and availability of parts and service. - Normally this unit will not require maintenance unless it is subjected to severe physical or electrical shock. Should either of these hazards be encountered it is recommended that the unit be returned to L. M. Dearing Associates, Inc. laboratory for servicing.

On any equipment damaged by mishandling or accident, or worn from normal use, L. M. Dearing Associates, Inc. will inspect and make appropriate repairs, adjustments, or corrections as required at standard repair rates.

Replacement or spare parts are available from L. M. Dearing Associates, Inc. as shown on the parts list (Section 9). It is recommended that spare or replacement parts by ordered by LMDA stock number.

L. M. DEARING ASSOCIATES, INC.
12345 VENTURA BLVD. / SUITE R / STUDIO CITY, CALIF. 91604 / (213) 769-2521

PARTS LIST - SST-111 LIGHT EMITTING DIODE DRIVER CAMERA CONTROL UNIT - MODEL 12CCU

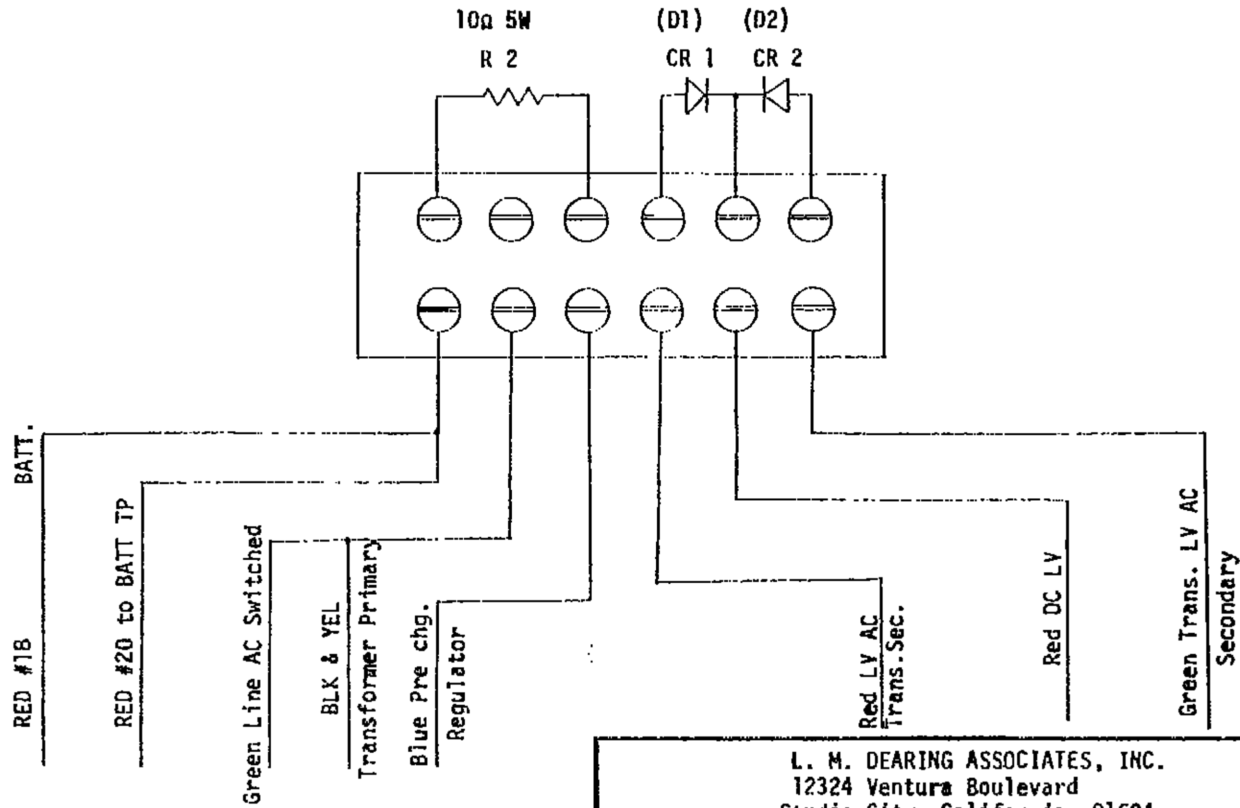
Designation	Part	Value	Manufacturer Name	Manufacturer Part No.	LMDA Stock Part No.
	Lamps				
L 4	Pre charge		Chicago Miniature	CM 20-1	20001
L 5	Timing Input		Eldema	CF03 YCS 2187	20002
L 3	Camera Relay Run		Eldema	CF03 ACS 2187	20003
L 1, L 2	L E Diode Output Indicator		Eldema	CF03 RCS 2181	20004
	(Note: Do not substitute other lamps for above.)				
	Switches				
SW 1	Pre charge		J B T	JMT 223	20005
SW 2	Meter Select		J B T	JMT 223	20005
SW 3	Polarity Reversal		J B T	JMT 223	20005
SW 4	Camera Test		J B T	JMT 123	20006
SW 5	Master		Electronic Controls	803-4C	20007
M 1	Meter	0-3 mA movement 0-6 Scale	Modutec--L.M.Dearing Associates. (Special)	M1 CCU-12	20008
R	Control Potentiometer	5000 ohm	Centralab	5000 ohm WN502	20009
B 1	Battery Pack	20 volt 1.9 AH	Gulton--L.M.Dearing Assoc. (Special)	16-R-190	20010
	P C Boards				
PCB 1	Voltage Regulator Board		L.M.Dearing Assoc.	VRB CCU 12	20011
PCB 2	Sensing Amp "		" " " "	SAB CCU 12	20012
PCB 3	Buffer Driver "		" " " "	BDB CCU 12	20013
T 1	Transformer		Triad	F-92A	20014

PARTS LIST

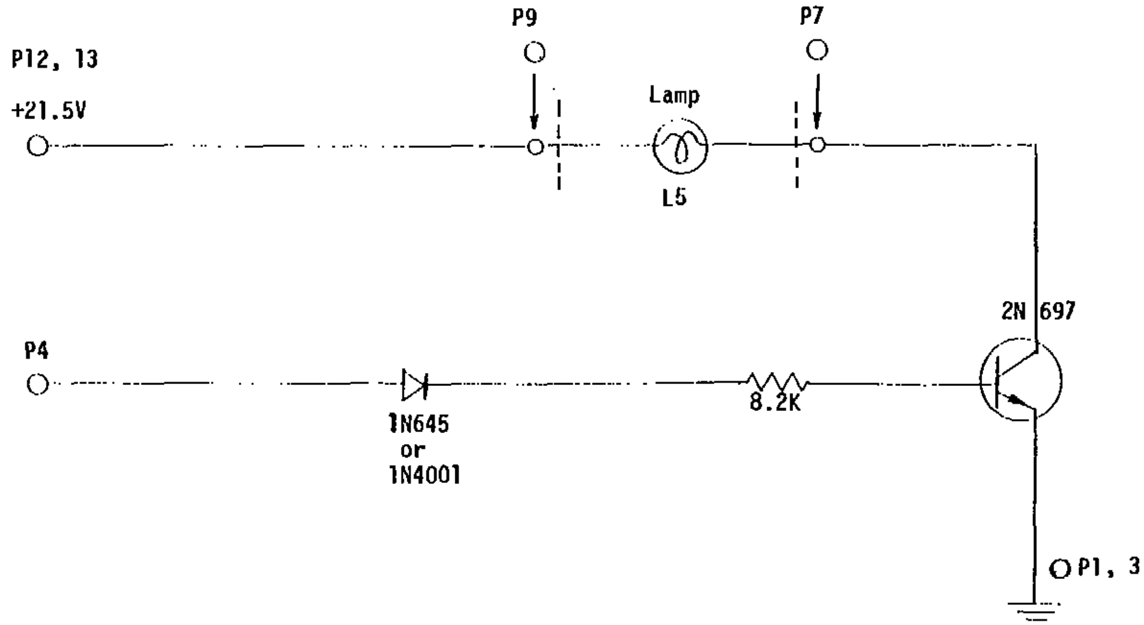
Designation	Part	Value	Manufacturer Name	Manufacturer Part No.	LMDA Stoj Part No.
Q 1 MF	Power Output Transistor		T I	TIP-33A	20015
Q 2 MF	" " "		T I	TIP-33A	20016
J 1	Connector		Amphenol	MS3102A-16-10P	20017
J 2	"		"	MS3102A-14-7P	20018
J 3 A, B	"		"	MS3102A-16-7S	20019
J 4	"		"	MS3102A-14S-5S	20020
R 1 MF	Main Frame Resistor	50 ohm-25W	Ohmite	ST-210-25	20021
R 2 MF	" " "	10 ohm-5W	"	ST-995-5B-10	20022
R 3 MF	" " "	30 ohm-5W	"	ST-995-5B-30	20023
R 4 MF	" " "	10 ohm-5W	"	ST-995-5B-10	20024
S 1, 2 MF	Shunt		L.M.Dearing Assoc.	Special Meter Shunt CCU 12	20025
CR 1, 2	Rectifier	2 A	I. Rect.	IR20A05	20026
F 1	Fuse	2 A	Littlefuse	3AG-2A	20027
C 1	Capacitor By-pass	.0068 100V	Sprague or equiv.	6PS-D68	20028

Mechanical parts, including case, mainframe, panel and hardware--available from LMDA by part name.

L. M. DEARING ASSOCIATES, INC.
12345 VENTURA BLVD. / SUITE R / STUDIO CITY, CALIF. 91604 / (213) 769-2521

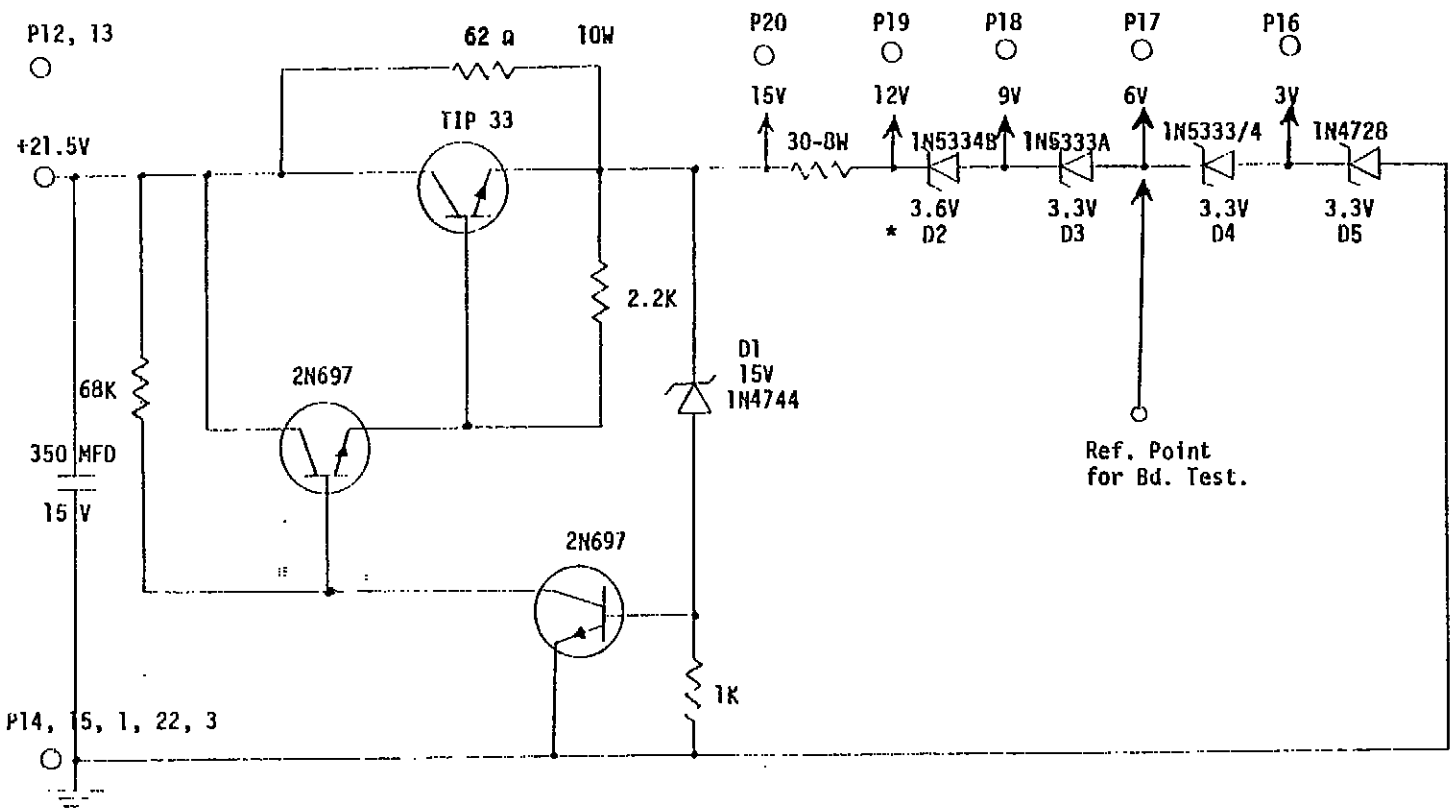


L. M. DEARING ASSOCIATES, INC. 12324 Ventura Boulevard Studio City, California 91604		
SCALE. None	APPROVED BY: AB	DRAWN BY PC
DATE. 1/11/71		REVISED
RECTIFIER & POWER TERMINAL STRIP		
L E DIODE DRIVER & CAMERA CONTROL UNIT MODEL 12 CCU		DRAWING NUMBER 1001



NOTE: Located on
Power Regulator Board

L. M. DEARING ASSOCIATES, INC. 12324 Ventura Boulevard Studio City, California 91604		
SCALE: None	APPROVED BY: AB	DRAWN BY PC
DATE: 10/27/70		REVISED
TIMING INDICATOR AMPLIFIER		
L E DIODE DRIVER & CAMERA CONTROL UNIT MODEL 12CCU		DRAWING NUMBER 1002

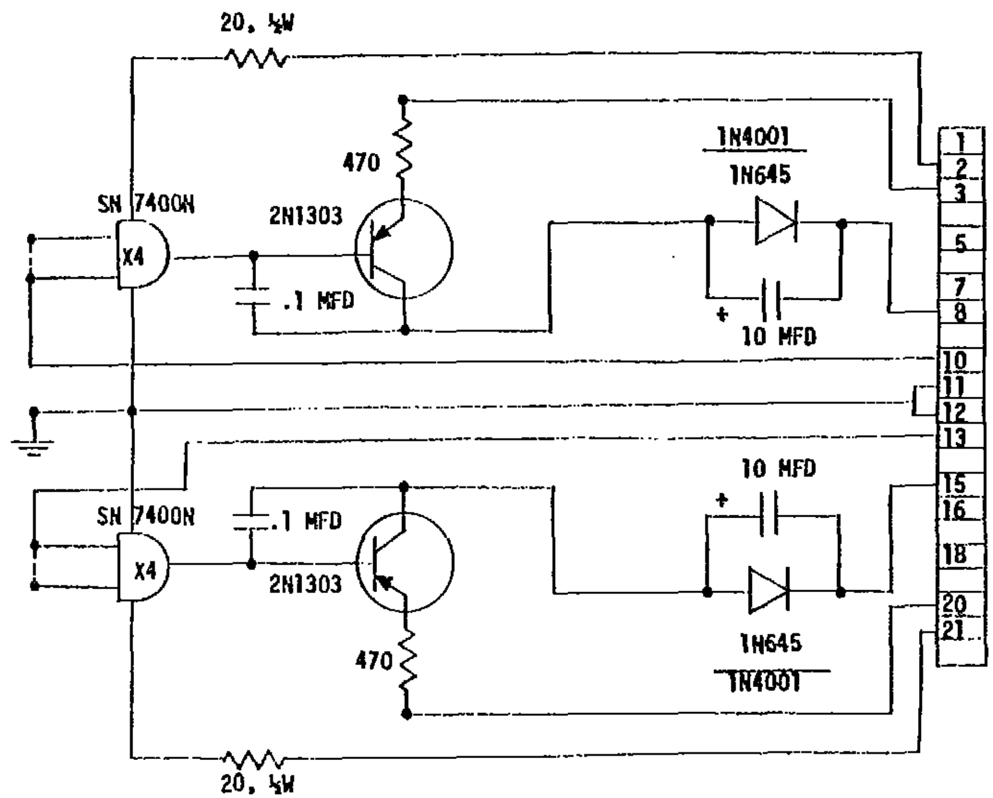


* D - 1 thru 5 Selected Components

D 2,3,4 - Either 1N5334 (B) (A)
or 1N5333 (B) (A)
Selected as to Z voltage
under Load

L. M. Dearing Associates, Inc. 12324 Ventura Boulevard Studio City, California 91604		
SCALE None DATE 10/27/70	APPROVED BY: AB	DRAWN BY PC REVISED
POWER REGULAT OR BOARD VRB CCU 12		
L E DIODE DRIVER & CAMERA CONTROL UNIT MODEL 12 CCU		DRAWING NUMBER 1008

Figure No. 1004, Duty Sensing Amplifier, has been deleted per request of the manufacturer.

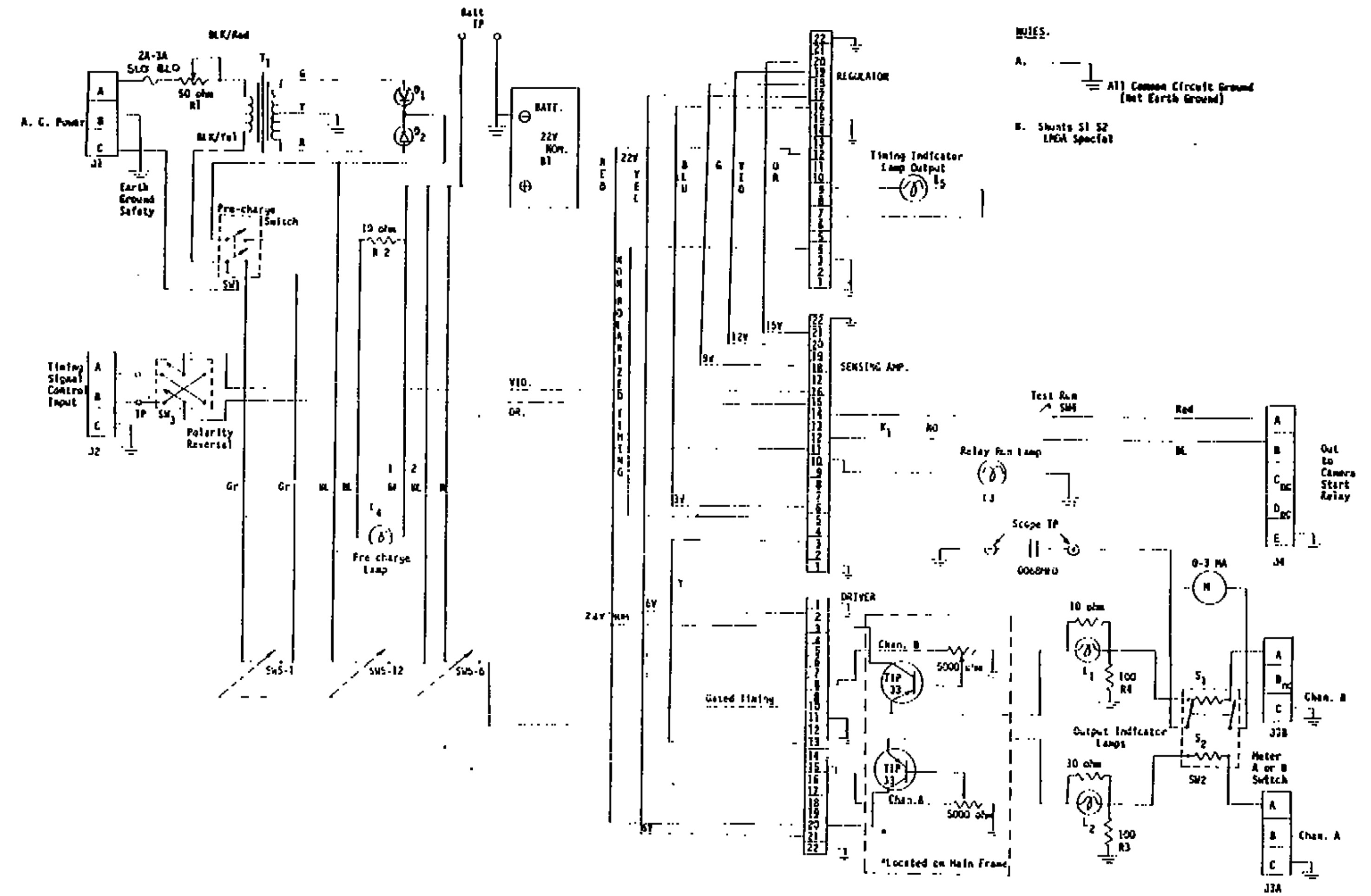


L. M. DEARING ASSOCIATES, INC.
12324 Ventura Boulevard
Studio City, California 91604

SCALE: None	APPROVED BY: AB	DRAWN BY PC
DATE: 12-4-70		REVISED

PC BOARD - BUFFER DRIVER AMPLIFIER (DUAL) BDB CCU 12

L E DIODE DRIVER & CAMERA CONTROL UNIT MODEL 12 CCU	DRAWING NUMBER 1005



NOTICE: PROPRIETARY DESIGN RIGHTS - - - This design was originated by and is the exclusive property of L. M. Dearing Associates, Inc. It is disclosed in confidence with the understanding that no reproduction or other use of the information is authorized without specific agreement in writing executed by L. M. Dearing Associates, Inc.

NOTE:
All Pin numbers Reference Designation on PC Board Receptacle.
Plating side of card towards Front Panel of Frame.

L. M. DEARING ASSOCIATES, INC.
12324 Ventura Boulevard
Studio City, California 91604

SCALE: None	APPROVED BY:	DRAWN BY: PC
DATE: 11-6-70	AB	

MAIN FRAME WIRING AND CONNECTOR PIN CODE CCU-12

L E DIODE DRIVER & CAMERA CONTROL UNIT MODEL 12 CCU — 1006

APPENDIX C

INSTALLATION RECOMMENDATIONS for L. M. DEARING ASSOCIATES, INC. SERIES 2500 TIMING BLOCKS AND LIGHT EMITTING DIODE CARTRIDGES

For

HOLLOMAN AIR FORCE BASE
New Mexico

Contract F29651-70C-0276

By

L. M. DEARING ASSOCIATES, INC.
12324 Ventura Blvd.
Studio City, California, 91604

March 1971

L. M. DEARING ASSOCIATES, INC.

SERIES 2500 TIMING BLOCKS & LIGHT EMITTING DIODE CARTRIDG.

The L. M. Dearing Associates, Inc. Series 2500 light emitting diode timing blocks and cartridges utilize an extremely powerful light emitting diode emitting in the red at 6500A°. The surface brightness at full power is 2500 ft. lamberts which is approximately three times the brightness of the LMDA 1400 series light emitting diode timing block cartridges. Hence, the 2500s are particularly useful for high speed instrumentation cameras. Each L. E. diode is protected against incorrect polarity with a protective diode on the positive lead.

All Dearing Series 2500 L. E. diode conversions and cartridges are calibrated and selected for brightness vs. the current in milliamps required by the top frame rate of the camera. They are equipped with brass or aluminum heat sinks to allow reliable operation at 300 to 600 ma of continuous current.

PHOTOSONICS 10-A CAMERA TIMING BLOCK AND CONVERSION

L. M. Dearing Associates Model 2514-2 L.E. diode camera timing block for the Photosonics 10A camera is a new replacement block of Delrin. The # 2514-2 is the same outside dimension as the neon timing block it replaces. It is installed in the camera on a direct plug-in basis, utilizing the same pin connections as originally designed for the neon inputs. Pin B is positive for the inboard side and Pin H is negative for the inboard side. Pin E is positive and Pin F is negative for outboard side.

Protective diodes and aluminum heat sink for both of these light emitting diodes are installed within the block. In this camera the rotational position of the connector varies with different cameras. In the timing block the connector is mounted in a sleeve which, by loosening a set screw, can be rotated to matching position with the mating receptacle in the camera. Care should be used on making this adjustment the smallest amount in either clockwise or counter-clockwise direction.

PHOTOSONICS CFA, 10B, 4B, 4C CAMERAS TIMING BLOCK CONVERSION

The Photosonics Model CFA, 10B, 4B, 4C cameras have used the neon NE17 lamp in their timing blocks. For convenient camera timing block conversion to light emitting diodes for these cameras, L. M. Dearing Associates, Inc. has developed the 2517 light emitting diode cartridge with the same diameter and approximate length as the NE17 neon lamps. Each 2517 cartridge carries an anodized aluminum heat sink and protective diode installed on the positive lead inside the cartridge. This protective diode is a 1N645 or 1N4001 with high reverse voltage characteristics for protective purposes. The contact and register pins are in the same position as those on the NE17 neon lamps. The positive contact is marked with a "dimple" (red side) on each 2517 cartridge.

Two lengths are provided - 2517 (1.35" long) for the 4B, 4C and 10B cameras, and 2517-A (1.6" long) for the CFA cameras.

Conversion is accomplished by inserting the 2517 or 2517-A in the neon compartment, making certain that polarity is maintained.

L. M. DEARING ASSOCIATES, INC.
12324 VENTURA BLVD. / STUDIO CITY, CALIF. 91604 / (213) 769-2321

HYCAM CAMERA TIMING BLOCK (LATCH BLOCK) CONVERSION

The latch block supplied with each Hycam camera should be used only with that camera and should be so identified. It can then be sent to L. M. Dearing Associates for drilling and installation of lens and cartridge.

The Dearing L.E. diode conversion, Model #2518-2, for the Hycam camera requires two #2518 super bright L.E. diode Hycam cartridges, each with lens system #1482. The L.E. diode cartridges replace the NE2J neon lamp holders in the Hycam latch and timing block. Each L.E. diode cartridge is wired with a red (positive) lead and a black (negative) lead. Each 2518 cartridge carries brass and aluminum heat sinks to allow high current operation.

For re-installation of the latch block in the Hycam camera, the red and black lead wires are carried through to the terminal board on the inside of the shutter housing. Each of these leads should be input connections to the camera and checked for true continuity on both the inboard and outboard L.E.D. cartridges. The protective diodes supplied for prevention of reverse polarity are mounted on the terminal strip within the camera shutter housing. These protective diodes are the IN645 or IN4001 with high reverse voltage characteristics for protective purposes. It is recommended that these be located in the positive red leads on the terminal block. The end of the protective diode bearing the band marking should connect to the red wire going to the light emitting diode.

LENS SYSTEM

The #1482 lens system provides a mark perpendicular to the direction of film travel and from the edge of the film to the inside of the perforations. The lens assembly is held in position by a #2-56 socket head set screw through the side of the latch block. The front face of the lens assembly should be positioned so as to just clear the film sprockets - (.010 inch clearance is satisfactory). If adjustments of position are made be sure that the rotational position of the front cylindrical lens is perpendicular to the direction of film travel.

NOVA CAMERA TIMING BLOCK CONVERSION

L. M. Dearing Associates, Inc. timing block conversion #2511-2, with lens system #1482 is made to be installed in the Nova camera as follows:

The timing block has been pre-wired for direct plug-in to existing camera connector in such fashion that each red lead in the camera timing block represents the positive connection and each black lead represents a negative connection. The #1 pin, which is the top pin of the four connector configuration, will be positive for the outboard side of the camera. #2 pin will be black and will be the ground return lead for the outboard side. #3 pin will be red and positive for the inboard side of the camera, and #4 pin will be black for the inboard side ground return.

The protective diodes supplied for prevention of reverse polarity are to be inserted in the leads to the timer input connector on the back of the camera. All resistors should first be removed from these leads. These protective diodes are the 1N645 or 1N4001 with high reverse voltage characteristic for protective purposes. They should be connected to the leads to pins A and C with the end of the diode having the band marking connected toward the light emitting diode in the timing block.

It may be necessary to adjust the lens system of this block conversion for sharpest focus at the film plane of the camera on the sprocket wheel. This adjustment can be made by loosening a set screw in the side of the block on each lens and sliding the lens fore or aft for sharpest focus of the slit image. Best results will be obtained with a clearance of 0.010" between the front surfaces of lens barrel and the sprocket teeth.

3 December 1964

APPENDIX D

CAMERA TIMING INDICATORS
TEST REPORT ON PROTOTYPES
Contract No. AF 29(600)-4727

L. M. Dearing Associates, Inc.
12345 Ventura Blvd., Suite R
Studio City, California 91604

SECTION I

INTRODUCTION AND SUMMARY

This is in accordance with Item 2 of the referenced contract. This report describes the test results and features of the prototype Camera Timing Indicators which have been fabricated and installed in the Wollensak 16mm WF-3 and the Waddell 16mm Model 16-1 cameras.

Prototype Camera Timing Indicators have been constructed and installed in the Wollensak WF-3 and the Waddell 16-1 furnished by Holloman AFB. A simple, reliable block construction was used with the specified design dimensions and positioning of the timing marks from the spark and the neon sources.

These blocks have been tested both in the camera and on the optical bench, using the 30-second bursts with short cooling off time. In these tests both the spark and the neon sources were demonstrated to have practical, useful lifes in tests extending up to sixty 30-second bursts.

In camera tests, the prototypes have been shown to meet fully the specifications in Exhibit A dated 11 June 1964 and the engineering change A dated 2 September 1964. The prototype units consist of a Lamp Holder Block containing a spark source of press fitted elements and a neon lamp source (NE2J or BA1C option) plus 4mm cylindrical lens mounted in a lens barrel and focused on a slit and diffusing screen positioned closely to the lamp envelope.

Highly efficient illuminating and slit imaging systems for the neon sources were separately investigated and developed. They can be provided as accessory items. These utilize specially ground and polished, efficient spherical condenser lenses to collect the light from the bright electrode and either a cylindrical or spherical fast (effective aperture is f1.3) copy lenses to image on the film the slit which is positioned on top of the condenser. The light gain from these remarkable systems is of the order of 5 to 20 times, resulting in some extremely bright and easily visible timing marks.

The replacement of the neon bulb is easily made from the front without disturbing the block. The spark source can be readily removed and exchanged after removal of the block.

Simple, reliable connectors are utilized rather than the spring pin connectors and locking system suggested in the design study and evaluation.

Much additional study has been made relative to the problem of installing and wiring these lamp blocks in the camera. As a result, the installation of these prototypes is much simpler than was anticipated last September.

The basic block is offered with a spark source and 4mm cylindrical lens system including optional use of the NE2J or BA1C lamp. Two interchangeable accessory, highly efficient lens systems are offered which are completely interchangeable with the 4mm cylindrical lens in all blocks. Their use is especially attractive in that light increases of more than an order of magnitude are delivered to the film.

Sample film tests showing the results obtained with this spark source and various neon lamp and lens options on black and white (negative-reversal) and color films are attached. Photographs of the various lamp blocks and lamp and spark source elements are also included in the report.

SECTION II

FEATURES OF THE DESIGN

Ease of Adaptation to the Waddell and Nova 16mm and the Wollensak 16mm and 35mm High-Speed Cameras.

This contract requires a Camera Timing Indicator block which is easily adapted to the cameras specified in Exhibit A. These include:

16 each	–	Fastex, 16mm, Model WF-3, manufactured by Wollensak Camera Company
13 each	–	Fastex, 35mm, Model WF-5, manufactured by Wollensak Camera Company
11 total	–	Waddell and Nova, 16mm, Models 16-1, 2, 3, manufactured by James Ipollito Company

Extensive examination of these cameras showed the advisability of positioning the neon timing marker image on the front edge of the film as related to the camera door, and the spark image to the rear. Otherwise it would be necessary on the 35mm Wollensak Fastex camera to insert the neon lamps through a long tube to reach the rear position. With the neon lamp in the front, maximum accessibility for the changing of lamps is thus maintained.

Lamp Holder Blocks

In our September evaluation and design, AFMDC technical personnel expressed concern about providing a means for locking the spring bronze contacting points for both the high voltage and low voltage leads between the yoke and the Lamp Holder Block of the earlier design. This proved to be a difficult problem which has been solved by utilizing conventional standard Microdot connectors for the neon and spark in the Waddell-Nova, and a long lead screw connector for the spark voltage on the Wollensak. A slightly larger lamp block is now accurately positioned in the camera with one or two screws, easily removable for adjustment of the spark gap. The neon bulb can be changed or replaced from the front by removing a simple screw cap without disturbing the Lamp Holder Block in any way. We believe this Lamp Holder Block for the Camera Timing Indicator will be extremely reliable and has the added advantage of simplicity.

For the 16 and 35mm Fastex cameras, the block will be similar in all dimensions except for a longer depth and spacing between the spark and neon gap sources to accomodate the extra width of the 35mm film. (See Figures 1 through 5.)

Due to severe space constraints in the Waddell camera, a trapezoidal shaped Lamp Holder Block with different outside dimensions is utilized. (See Figures 6 and 7.) This allows the

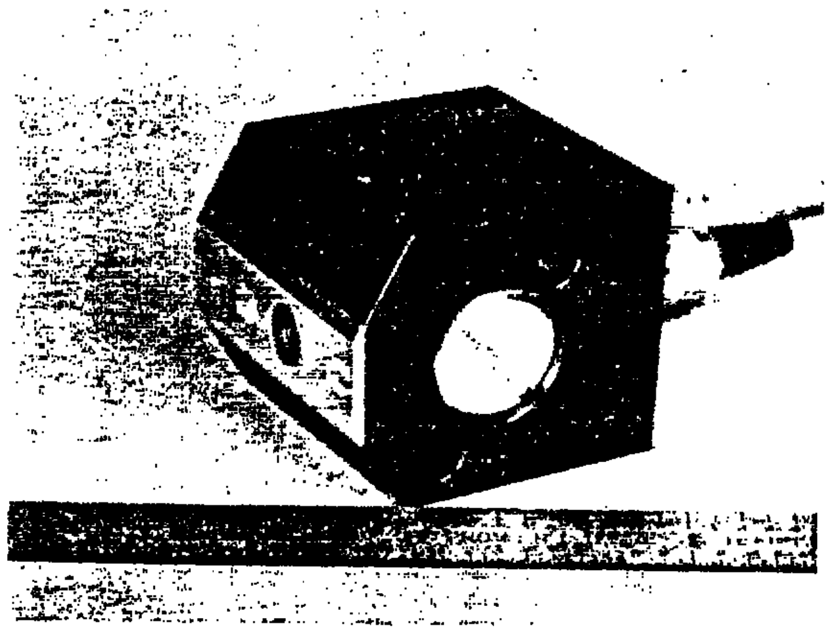


Figure 1 - Camera Timing Indicator for Wollensak WF-3 (Front and Top View).

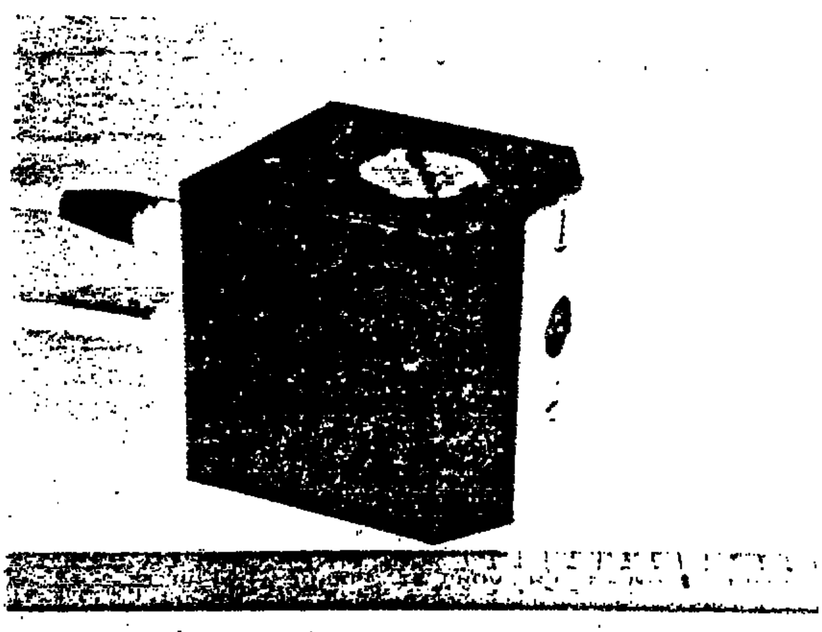


Figure 2 - Camera Timing Indicator for Wollensak WF-3 (Side View).

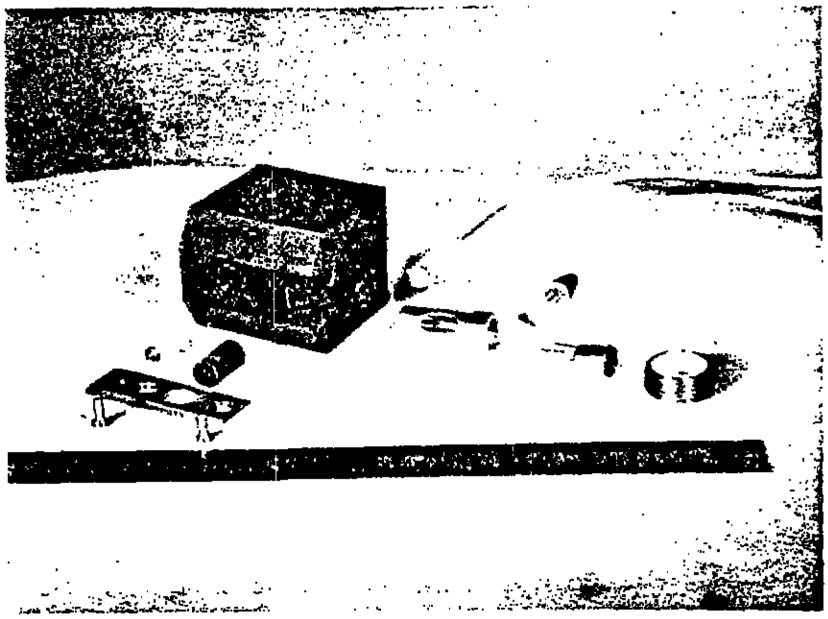


Figure 3 - Camera Timing Indicator for Wollensak WF-3 (Exploded View).

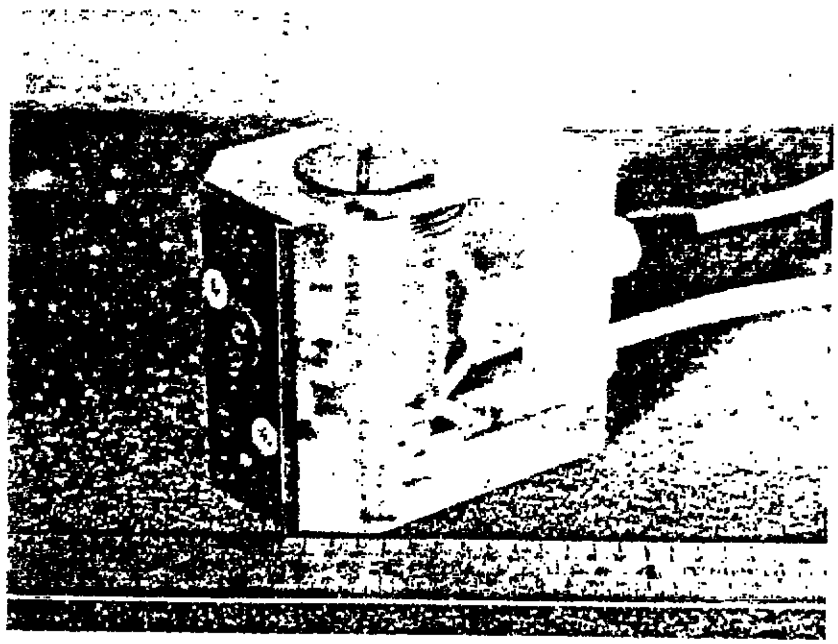


Figure 4 - Lucite Block for Wollensak WF-3 - Camera Timing Indicator (Top and Side View).

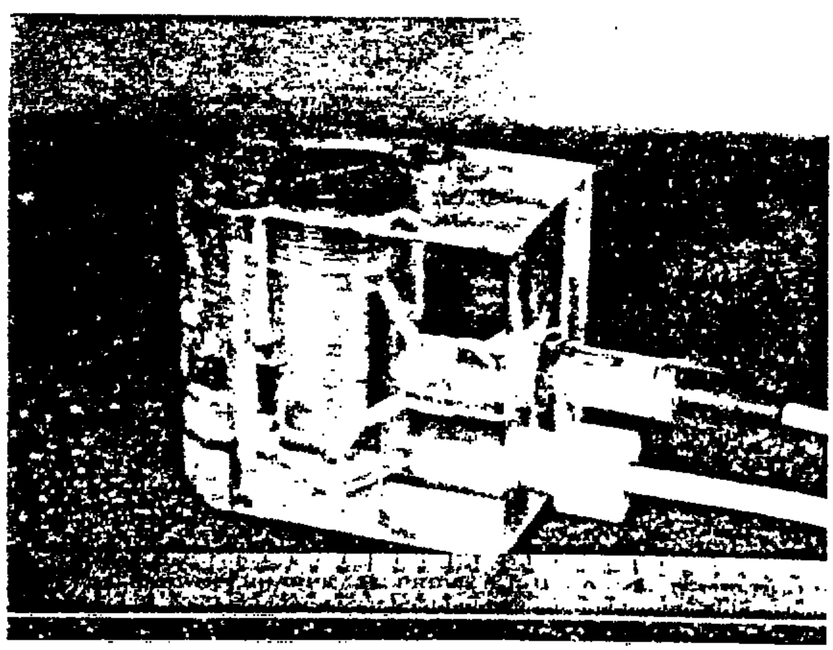


Figure 5 - Lucite Block for Wollensak WF-3 - Camera Timing Indicator (Bottom and Side View).

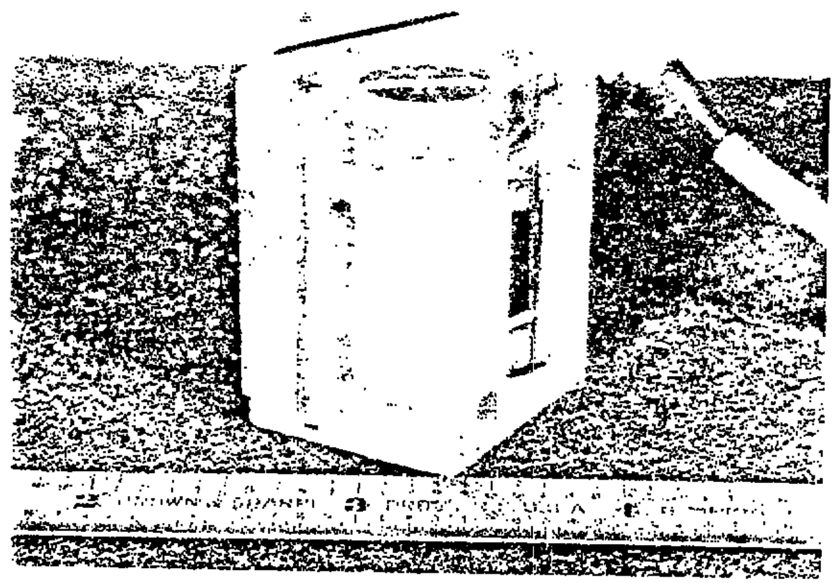


Figure 6 - Lucite Block for Waddell and Nova 16mm Models - Camera Timing Indicator (Bottom View).

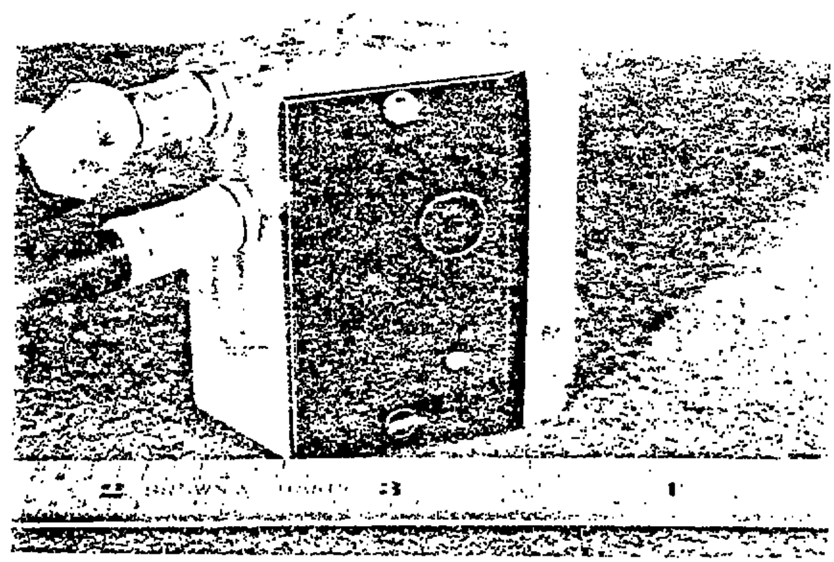


Figure 7 - Lucite Block for Waddell and Nova 16mm Models - Camera Timing Indicator (Top View).

block to be readily inserted and removed from the front while the camera is on the tripod. The spacing of the spark and light sources is identical with the Wollensak block. Spark and neon subassemblies and lens barrels are interchangeable in the blocks of all the cameras.

Installation and Wiring

Much additional study was given to the problems of installation and connecting electrical leads to these light sources for both the Wollensak and the Waddell and Nova cameras.

The Wollensak presents the lesser problem and as shown in the photographs of Figures 8 and 9, the leads follow the outside wall of the camera and can be readily disconnected without removal of the block. The block is mounted to the back plate of the camera by two screws. Preparation of the camera for mounting requires only the drilling and threading of two screw holes in the motor back plate of the camera. The high voltage connectors for the spark source and the connector for the neon source will be positioned in the outer case of the camera in areas close to the present connectors. It is expected that the sixteen 16mm Fastex Model WF-3 and the thirteen 35mm Fastex Model WF-5 cameras at the AFMDC will show considerable variation in location of existing connectors. It is anticipated that the additional high voltage connector will be finally located to suit the requirements of each camera and sufficiently long leads will be provided to take care of all conceivable arrangements.

The Waddell and Nova cameras presented a greater problem. It was originally planned to drill a hole through the back plate of the camera underneath the sprocket drive gear to accomodate spring pin leads into the lamp block for both the high voltage spark and the low voltage neon pulses.

Our prototype block allows us two more favorable options. One, the present neon leads might be retained. Two, the high voltage leads can come either through the bottom of the back plate below the sprocket drive gear or they can come through the existing hole alongside the present neon leads. This allows for a simple installation. The Lamp Holder Block itself is mounted and positioned in the Waddell and Nova cameras by one screw and one locating pin and hole.

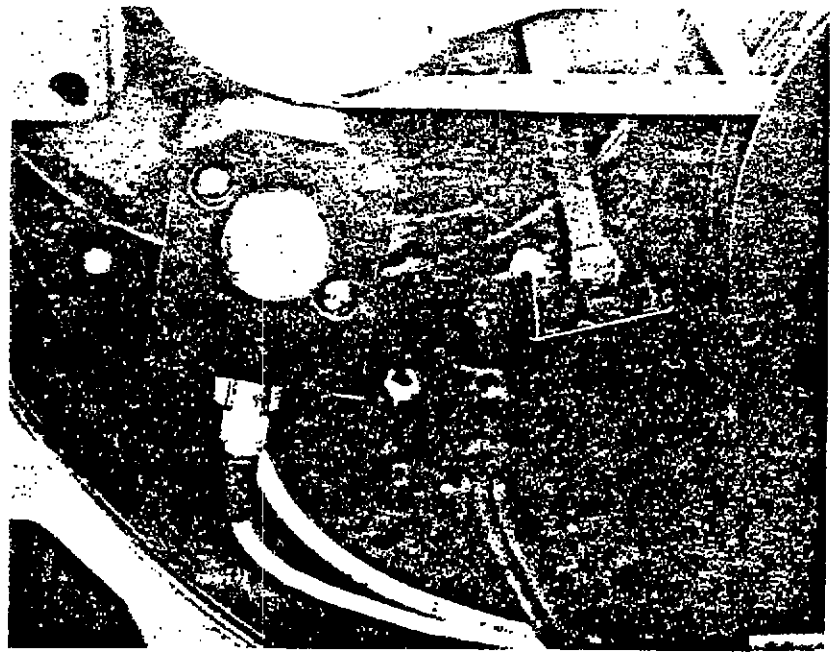


Figure 8 – Delrin Block Installed in Wollensak 16mm **WF-3 - Camera** Timing Indicator.

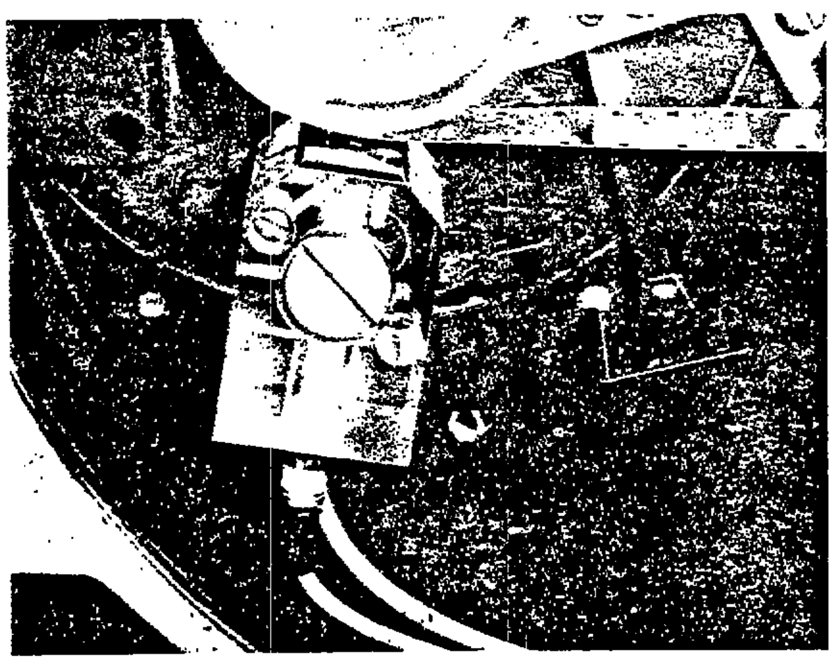


Figure 9 – Lucite Block Installed in Wollensak 16mm WF-3 - Camera Timing Indicator.

SECTION III

DESCRIPTION OF PROTOTYPES

Lamp Holder Blocks for the Wollensak Cameras

The prototype Wollensak Lamp Holder Blocks shown in the photographs of Figures 1, 2, and 3, has the following overall dimensions: width 1.125", height 1.312", and depth 1.312". It is machined from a block of black delrin. The 35mm Wollensak block will be approximately 0.78 inches longer in depth.

In order to facilitate understanding of the internal wiring of these Lamp Holder Blocks for the Camera Timing Indicator, the design was machined from clear Lucite so that the position of and angles of wiring holes could be better determined. This is shown in Figures 4 and 5. Figure 5 gives a good view of the high voltage threaded connector near the bottom of this block and a Microdot connector for the neon bulb above it in the photograph. A second prototype in black delrin was also made and wired for camera tests. The dimensions in these two earlier prototypes were slightly different, being 1 inch wide and 1-1/2 inches high. The final prototype, No. 3, machined from black delrin has the dimensions as originally stated in the first paragraph above.

Figure 3 gives an exploded view of the black delrin prototype No. 3. In the foreground, on the left, is the brass spark grounding plate with its two fastening screws. Immediately behind is the spark source on the left and a lens system in its barrel to image the neon source on the right. On the delrin block immediately to the rear are the holes for the spark source assembly and the lens barrel. To the right of the lens hole is the wire grounding contact to the brass plate (for the spark grounding electrode).

The neon lamp assembly shown in the right foreground consists of three elements. a brass tube bulb holder, the neon lamp, an NE2J, and the screw cap which accurately positions the electrode. These three elements are easily inserted into the hole on the front of the Lamp Holder Block. They are keyed to position the brass tube bulb holder port and the lighted neon electrode directly below the lens.

In the right rear, from left to right, the high voltage connector for the spark source with its delrin or nylon threaded screw connector and the Microdot connector for the neon lamp source are shown.

Lamp Holder Block for the Waddell and Nova 16mm Cameras

Figures 6 and 7 show the Lucite prototype No. 1 for the Waddell and Nova 16mm cameras. The interior dimensions and positioning of the neon lamp, the spark source, and the lens barrels are identical with the Wollensak block. The exterior dimensions and shape of both the plastic lamp holder block and the brass grounding plate are dimensioned and shaped so as to be readily insertable in the Waddell and Nova cameras from the front.

The block is easily mounted in the camera with a mounting screw for which the hole is shown on the left-hand side in Figure 6. It is positioned by it and by a locating pin in block on the right-hand side at the rear.

Due to space considerations, the electrical connectors are positioned on the right-hand face of the block rather than on the bottom face as is done in the Wollensak block. The final path of the electrical leads will be determined by the configuration of the film stripper roller and cutoff micro-switch on the various Waddell models existing at the AFMDC.

Installation and Positioning of the Lamp Holder Block in the Camera

Figures 8 and 9 show these various prototypes installed in the Wollensak Fastex 16-3 and Waddell 16-1 cameras. The clearance between the top of the brass grounding plate and the sprocket teeth is set at 0.010" with a feeler gauge. With this setting, the lens is on focus to give a sharp edged image of the slit and the spark hole image is also sharply defined.

The high voltage and the low voltage leads from the block installed in the Wollensak camera follows the curve of the camera wall to connectors mounted in the camera body, generally on the back plate. However, some of the AFMDC cameras already have connectors mounted at the rear of the camera, and if desired these can be retained and utilized.

Before deciding on the location of the pass through for the high voltage and low voltage leads of the Waddell and Nova cameras, we recommend that a study be made of the three models of Waddell and Nova cameras at the AFMDC. These are also pictured in the photographs (Land-Air 64-481 A, B, and C, dated 10 June 1964) supplied to us by AFMDC. They were also shown to Dr. Dearing during a visit to Holloman AFB by Wayne Melton, Hugh Ferguson, and Ray Knight. Our notes indicate that there are:

Four of the oldest model (see Land-Air 64-481-A) with a long horizontal box type timing light marker and stripper roll with film cutoff micro-switch.

Four of the next model (see Land-Air 64-481-C) with the bottom entering timing light marker and a shortened film stripper roller and film cutoff micro-switch. The camera supplied to us by AFMDC is this model.

Three Nova 16mm cameras with a smaller stripper roller and micro strips (see Land-Air 64-481-B).

On the latter, the Nova cameras, it appears from these Land-Air photographs that the high voltage and low voltage electrical leads could go underneath the stripper roller and micro-switch assembly, pass through the existing opening for the electrical leads to the back of the camera. This would be a very simple solution.

We believe it may also be possible on the older models to suitably modify the stripper roller frame and take the high voltage lead through a hole drilled in the micro-switch box so that electrical connectors would be similar on all the Waddell and Nova cameras. This point will need to be studied on the cameras themselves and we are suggesting that one of each of the model cameras be brought here for study during evaluation of the prototypes.

Another possibility is to purchase the smaller type stripping roller and cutoff micro-switch assembly used on the Nova from the James Impollito Company. We understand these are available and could be substituted for the older and larger assemblies.

We believe that these highly efficient Camera Timing Indicators can be installed in the AFMDC cameras at minimum cost. Changes to the cameras are such that they can also be readily removed and again installed in other Air Force cameras should the need arise.

By keeping the installation problems firmly in mind during the construction of these prototypes, the actual installation by AFMDC personnel now appears to be greatly simplified.

SECTION IV

TEST RESULTS

Extensive tests of the various spark and neon light sources have been made on both the optical bench and in the cameras. They show that this Camera Timing Indicator design with spark and neon sources is capable of reliably providing two extremely bright timing marks with sharply defined leading edges at the specified speeds of 200 feet per second. The present tests bear out the promise shown of the tests reported in our report for Item 1 of subject contract "Camera Timing Indicators — Report on Feasibility Studies and Design Drawings for Evaluation" dated 28 August 1964. As suggested by AFMDC technical personnel during the September design evaluation conference, life tests were run with bursts of 30-seconds duration, followed by suitable cooling off period. The duration of the camera runs, is of course, much shorter. At 150 feet per second, the duration is a second or two with the burst starting slightly before the start of the camera run. The duration of the 100-foot film run is approximately 3/4 second.

Spark Gap Sources

The spark gap assembly (see Figure 10 left side) consists of the spark electrode mounted in a brass pedestal, a ceramic insulator (whose length with that of the spark electrode determines the spark gap length), a grounding electrode spark hole, and a Teflon or nylon exterior barrel which press-fits onto both the spark electrode pedestal and the grounding electrode cap to complete the spark source. The grounding electrode with its 0.010" channel or hole fits into the brass grounding plate on top of the block.

We have investigated the effect on light intensity and projected image of both spark gap length and grounding electrode hole depth. Spark gap lengths investigated were 15 mils, 30 mils, 45 mils, and 55 mils. The longer the gap, the brighter the intensity of the spark and the higher voltage required for reliable operation. With the present amplifier which delivers 5 to 7,000 initial volts, a spark gap of 30 mils has been selected as the best compromise. This delivers a bright spark at 10 kc and puts a good mark on all films tested at the 6,000 plus frames per second reached during these tests.

Another factor investigated was the effect on image size and brightness of the depth of the 10 mil spark grounding hole in the grounding cap of the spark source assembly. Depths of 15 mils, 30 mils, and 45 mils were investigated and the conclusion was that the 45 mils was the best in terms of sharpness of the spark image, presumably due to extra collimation provided by the deeper hole. It probably would be useful to investigate still deeper holes. The timing marks from all of these holes are bright and useful but the 45 mil depth is recommended for a present standard for the production units.

The attached sheet of SAMPLE FILM TESTS, Figure 12, shows the results obtained with spark sources operating at 5 and 10 kc with various black and white and color 16mm films at 6,000 plus feet per second. Films tested include Dupont 930 and 931-A, Eastman Tri-X

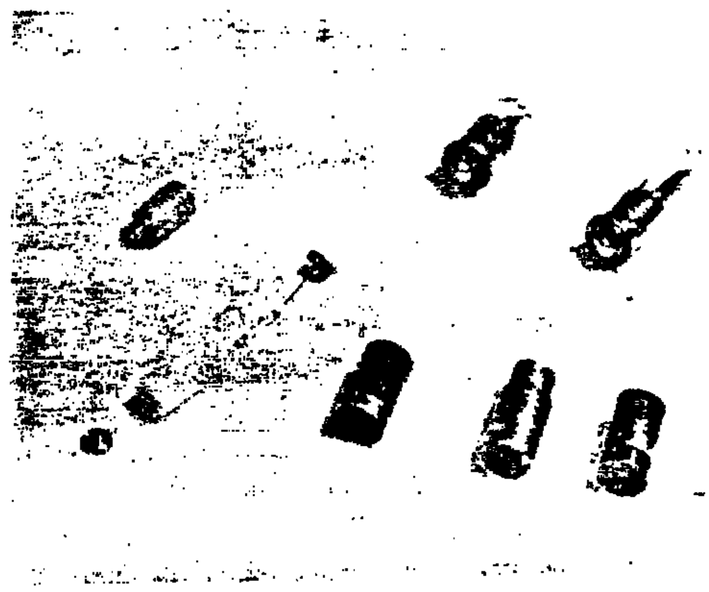


Figure 10 - Spark and Neon Light Sources - Lens System
(End View of Projection Lens).

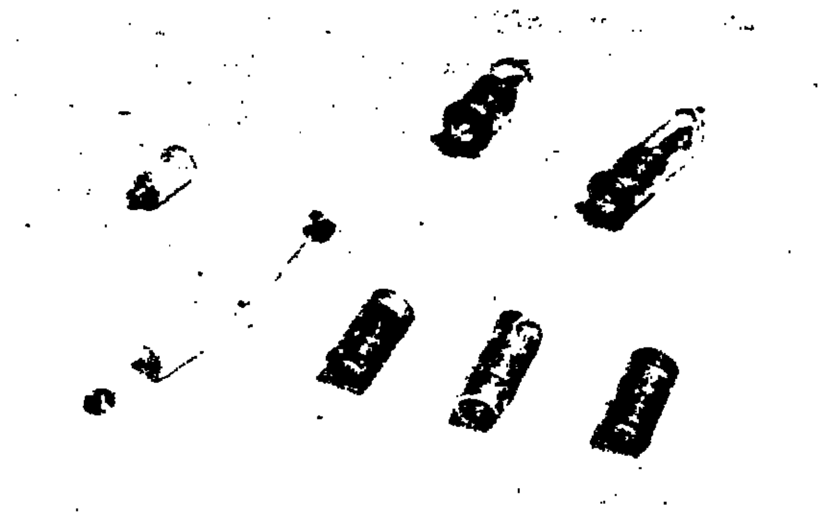


Figure 11 - Spark and Neon Light Sources - Lens System
(End View of Condenser and Diffuser-Slit).

Figure 12 - Sample Film Tests.

Reversal developed to both a negative and a reversal image and Ektachrome MS. Ansochrome 200 was also tested and will be available as soon as it is returned from the Ansco Lab in Union, New Jersey, where it was sent for processing. All marks are easily readable.

Life Tests of Spark Gaps

Life tests were run on various spark gaps. They give every indication that the spark source is a practical, high intensity source for Camera Timing Indicators. With the present amplifier, they are useful up to 10 kc. This is the frequency limit of the high voltage side of the present Camera Pad Amplifier. In the life tests, forty 30-second bursts at 10 kc were made with no measurable deterioration on the spark gap. The 10 kc test was interrupted because the extended use overloaded the amplifier and blew some components. There is every reason to believe that this spark source is practical. It gives a bright, sharp edged, well-placed mark on the film.

Neon Lamp Sources

The NE2J and the BA1C neon lamps were investigated in this prototype stage. All neon tests were done at 20 kc, the design goal of the project. In general, we found the brightness of the BA1C and the NE2J to be on a par with each other. There is some advantage in using the BA1C because of the shorter electrodes (which are brighter near the end of the electrode) and centering under the optical systems so as to fully illuminate the diffuser-slit or the condenser-slit. The Lamp Holder Blocks have been designed and constructed to accept either the NE2J or BA1C by utilizing the brass lamp tube holder and screw cap suited to each lamp. This allows considerable versatility in the system. The final decision as to which to supply as standard equipment and which to supply as accessory equipment can be decided at a later date, perhaps during the evaluation conference.

Life tests show that for either lamp a useful life in excess of sixty 30-second bursts can be expected with the 800 ohm resistor in series and considerably more than this with the 4,000 ohm resistor in series. The brightness of either lamp is reduced approximately 50 percent when the 4,000 ohm resistor is used instead of the 800 ohm resistor.

In the film samples, exhibit runs 47, 49, and 54 were made with the BA1C bulb; numbers 58, 66, and 68 were made with the NE2J bulb.

Illumination Lens Systems

a. Diffuser-slit with 4mm diameter cylindrical lens.

The design approved in Item 1 and the exhibits presented for the early report utilized an illumination and imaging system consisting of a diffusion screen, a 100 x 40 mil slit, imaged by a 4mm diameter cylindrical rod lens with a 2 to 1 reduction. This constitutes a rugged simple lens system of reasonable efficiency and the sample results obtained with it are shown in the second column of Figure 12 in runs 54, 58, and 68. The leading edge of the approximately 20 x 100 mil mark is well defined and readable on all films tested. It is recommended that these elements mounted in a lens barrel be supplied as standard equipment for the production.

b. Condenser-slit with f1.3 projection lens system.

We also undertook the development of two highly efficient illuminating imaging lens systems and obtained ten or more fold gain in light intensity over the standard system even though it is adequate for slower reversal films at film rates 200 feet and more per second. This brightness can be utilized in part by contributing to the life and reliability of neon lamp sources by increasing the series resistance and in part to obtain very bright, easily distinguished marks.

Two lens systems were designed by our optical consultant, Alan Gundelfinger, and ground for us by Herron Optical. The system shown in column 3 gives a 3.7 to 1 reduction of a 100 x 60 mil slit illuminated by an efficient condenser lens which fills the aperture of a f1.3 projection lens, in this case a cylindrical lens. The resultant projected slit image is 100 x 18 mils and is many times brighter than that from the standard cylindrical lens imaging a slit illuminated by a diffusing screen. The difference in intensity is easily seen on the film samples corresponding to runs 49 and 69 of Figure 12, column 3.

The second highly efficient lens system utilizes the same condenser and slit but a spherical f1.3 projection lens to image the slit on the film at a reduction of 3.7. Test results are shown in Figure 12, column 4. The projected slit is now approximately 20 mils by 25 mils. It yields an intense bright spot.

The theoretical gain in the use of the spherical lens over the cylindrical lens with condenser-slit is 4 x times. There is strong indication this was obtained, with, of course, a narrower 25 mil mark width over the 100 mil mark width of the cylindrical system.

The test samples obtained with f1.3 spherical lens system are shown in Figure 12, column 4, for runs 47 and 66.

As far as we know, neither of these highly efficient lens systems have previously been put to use for Camera Timing Indicators, and in this respect can be considered as advancing the state-of-the-timing-art by an order of magnitude. We believe that the marks shown in the film samples of columns 3 and 4 are the brightest neon lamp timing marks that have been placed on film to date. Such images should be extremely useful to the high-speed camera operations of the Track Directorate at AFMDC. Though specially ground lenses and care in mounting to avoid barrel flare is required, they can be made up in lots of 50 or 100 at a reasonable price as accessory items and we suggest this procedure.

L. M. DEARING ASSOCIATES, INC.

Robert E. Hiller

Robert E. Hiller

LeRoy M. Dearing

LeRoy M. Dearing

APPENDIX E

RELIABLE TIMING PRESENTATION ON HI-SPEED CAMERAS

By: M. R. Bradley

Failure of the Nicd batteries used for power sources in the spark gap timing amplifiers delayed timing tests with these units. In addition, difficulty has been experienced with the design of suitable spark gap devices.

In view of these problems, some tests were made using neon lamps to provide hi-speed timing. In order to view the neon presentation to the film, a photo-transistor circuit was used. The output of the photo-transistor circuit was viewed on an oscilloscope in relation to the timing signal provided to the neon. By changing the pulse width of the neon driving signal, we found that although the ionization time of the neon was reasonably fast, the extinguish time was somewhat delayed. In fact, when the driving pulse decayed,the intensity of the neon increased slightly before decreasing.

This problem appears to exist when the driving pulse width is greater than 25 microseconds. By decreasing the pulse width output of the terminal amplifiers to 20 microseconds,we were able to produce 20 kc timing marks on hi-speed film with neon lamps.

During these tests,we found that the neons would not ignite reliably. This problem was solved by incorporating a very low current "keep alive" voltage.

Further tests showed that the timing marks were improved appreciably when the driving voltage was increased to 400 volts. Increasing the drive above 400 volts caused the neon extinguish time to increase. By limiting the pulse width output to 10 microseconds, the neon lamps would provide timing marks up to 50Khz. However, the timing marks were extremely light.

From the results of these tests, Holloman concluded that the neon lamps were superior to the spark gap for high repetitive timing mark.

Use of the spark gap method is superior to neons for timing marks up to 10Khz. Because of the increased weight and cost of timing amplifiers, the spark gap method is unsuitable for timing marks above 10Khz.

When driving neon lamps with short pulses (25 microseconds duration or less), neon lamps are reliable and inexpensive. However, frequent replacing of the neons was still required.

All timing amplifiers at the Holloman Test Track were modified to limit the pulse width output to 25 microseconds.

To improve the quality of the timing marks, the next generation of timing amplifiers incorporated a variable pulse width control. The output signal was also increased to 400 volts in addition to a small "keep alive" voltage.

In 1964, the Holloman Test Track began the procurement for camera timing indicators. These indicators were to improve the quality of the timing marks on film in addition to providing easy access for replacement of the neons.

L. M. DEARING ASSOCIATES, INC.
RESEARCH · CONSULTING · ENGINEERING

12345 VENTURA BOULEVARD
SUITE R
STUDIO CITY, CALIFORNIA 916
TELEPHONE 769-2521
AREA CODE 213

December 9, 1964

Mr. Earl J. Harrington
Administrative Contracting Officer - RWHLAA
U. S. Air Force
Los Angeles Contract Management District
1206 S. Maple Street
Los Angeles, California

Subject: "Camera Timing Indicators" - Test Report for Prototype Sample Film Tests - Supplement #1

Reference: Contract No. AF 29(600)-4727

Dear Mr. Harrington:

We are enclosing Supplement #1 to the Sample Film Tests which are to be added to our 3 December 1964 report, "Camera Timing Indicators", Test Report on Prototypes, Item 2 of referenced contract.

These supplementary film tests, identified as Figure 14a, are being sent to the Procurement Directorate, AFMDC, and to the Deputy for Guidance Test, Track Test Directorate, AFMDC. As mentioned in paragraph four of our 3 December 1964 letter forwarding report, additional tests with brighter diffusing sources were continuing.

We were successful in obtaining a brightness increase of 2 to 4 times which results in the brighter timing mark images as shown in the supplementary film samples. These samples were done with our standard 4mm cylindrical lens imaging a slit and "bright diffuser scree[n]". They are identified as Run #72 at 20Kc with the BA1C neon lamp in our #3 prototype Lamp Holder Block in the Wollensak WF-3 camera running at 6000 fr/sec.

We would propose to use such a "bright" diffusing screen in our production units.

Sincerely,

L. M. DEARING ASSOCIATES, INC.

Leroy M. Dearing,
President

LMD:jn
Encl.

cc - Procurement Directorate, AFMDC
Holloman AFB, New Mexico

cc-Deputy for Guidance Test
Track Test Directorate AFM[DC]
Holloman AFB, New Mexico

APPENDIX G

WP-MDSTI-65-1

WORKING PAPER

Report of Neon Bulb Testing

24 February 1965

Prepared by

William L. Bramlett, Jr.
Electronic Engineer

INSTRUMENTATION DIVISION

Track Test Directorate

Deputy for Guidance Test
Air Force Missile Development Center
Holloman Air Force Base, New Mexico

SPECIAL NOTICES

Publication of this working paper does not constitute AFMDC approval of the findings and conclusions. It is published only for the exchange and stimulation of ideas.

LAWRENCE H. BALLWEG
Colonel, USAF
Director of Track Test

Copies of this paper may be obtained from the Instrumentation Division, Track Test Directorate, Holloman AFB, New Mexico.

The mailing address is: AFMDC (MDSTI)
Holloman AFB NMEX 88330

NEON BULB TESTING

I. OBJECTIVE: To determine optimum criteria for neon bulb operation in regard to light output and bulb life as used for optical timing.

II. DISCUSSION:

A. Procedure:

1. Determine a system for monitoring the light output from the neon bulb.

2. Obtain voltage and current curves.

3. Investigate the possibilities of different wave shapes.

4. Determine the possibilities of using different kinds of bulbs.

B. Results: A photo-transistor circuit, Figure 1, was used to monitor the light output from the neon bulbs.

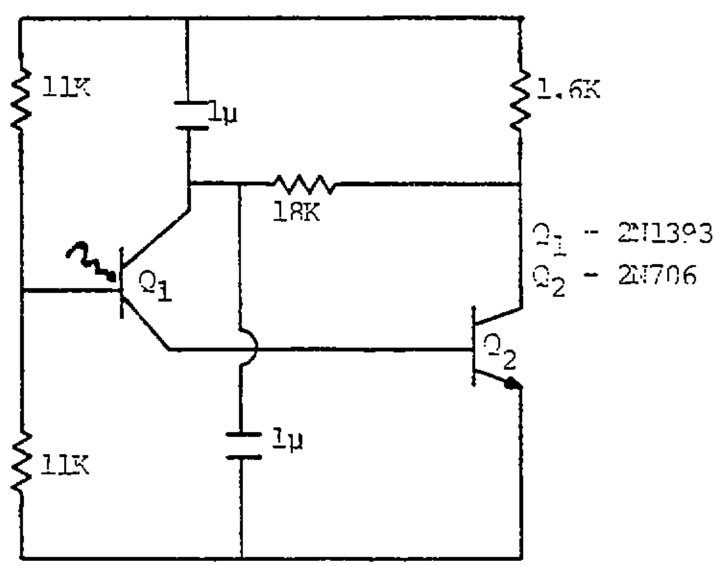


Figure 1
Photo-transistor · Circuit

The photo-transistor and the neon bulb for each test were mounted in opposite ends of a box 3" long by 2" high by 1 1/8" wide. The end of the bulb was pointed toward the photo-transistor. A type NE 51 bulb was used for all tests. This bulb was operated from a Telemetry Magnetics timing amplifier for the first three tests. The remainder of the tests were conducted using an IT&T timing amplifier. The results of these tests are shown in graph form on pages G-5 through G-15.

A total of eleven tests were conducted. The bulb was pre-aged only on the first test.

On Test #11, the bulb was operated from 1200 feet of field wire with different width pulses from the amplifier. All pulses were at a 2 kc rate with a 350 volt amplitude -- no load. With a pulse width of 7 microseconds, the output of the field wire was insufficient to fire a neon bulb.

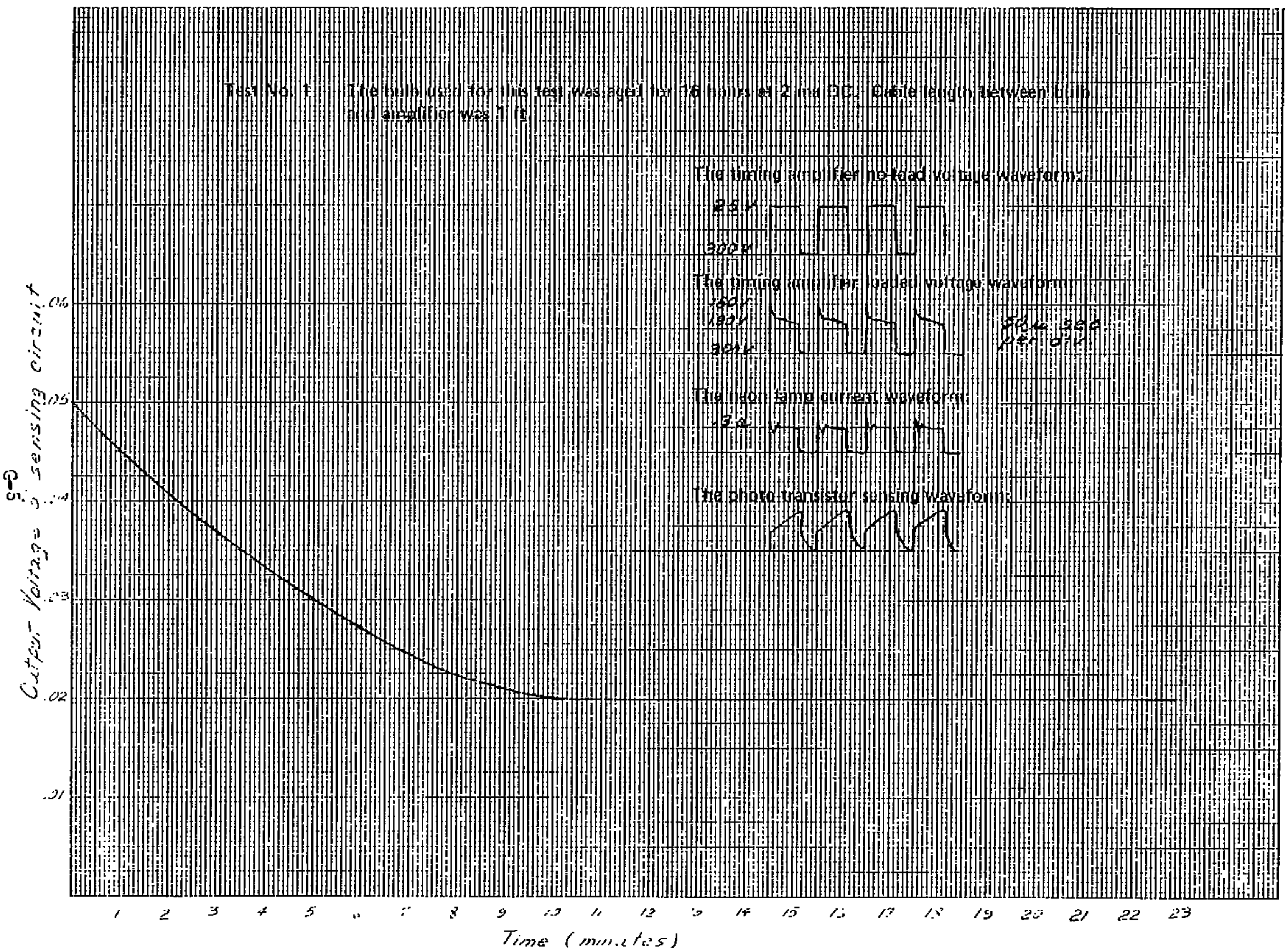
C. Conclusions:

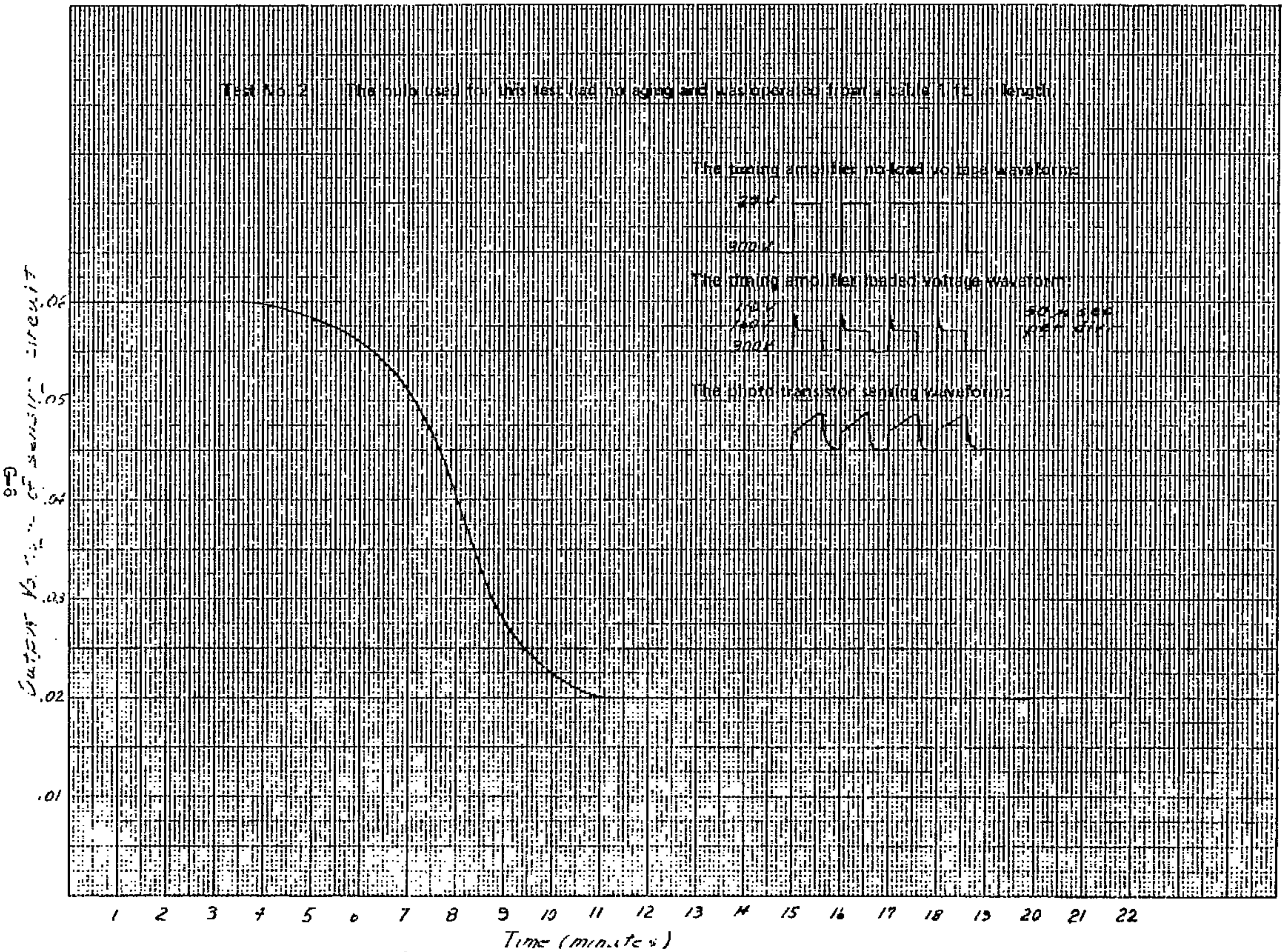
1. From the results of these tests it appears that the pulse width should be narrowed and the output impedance of the timing amplifier should be minimized in order to gain maximum brightness along with long life.

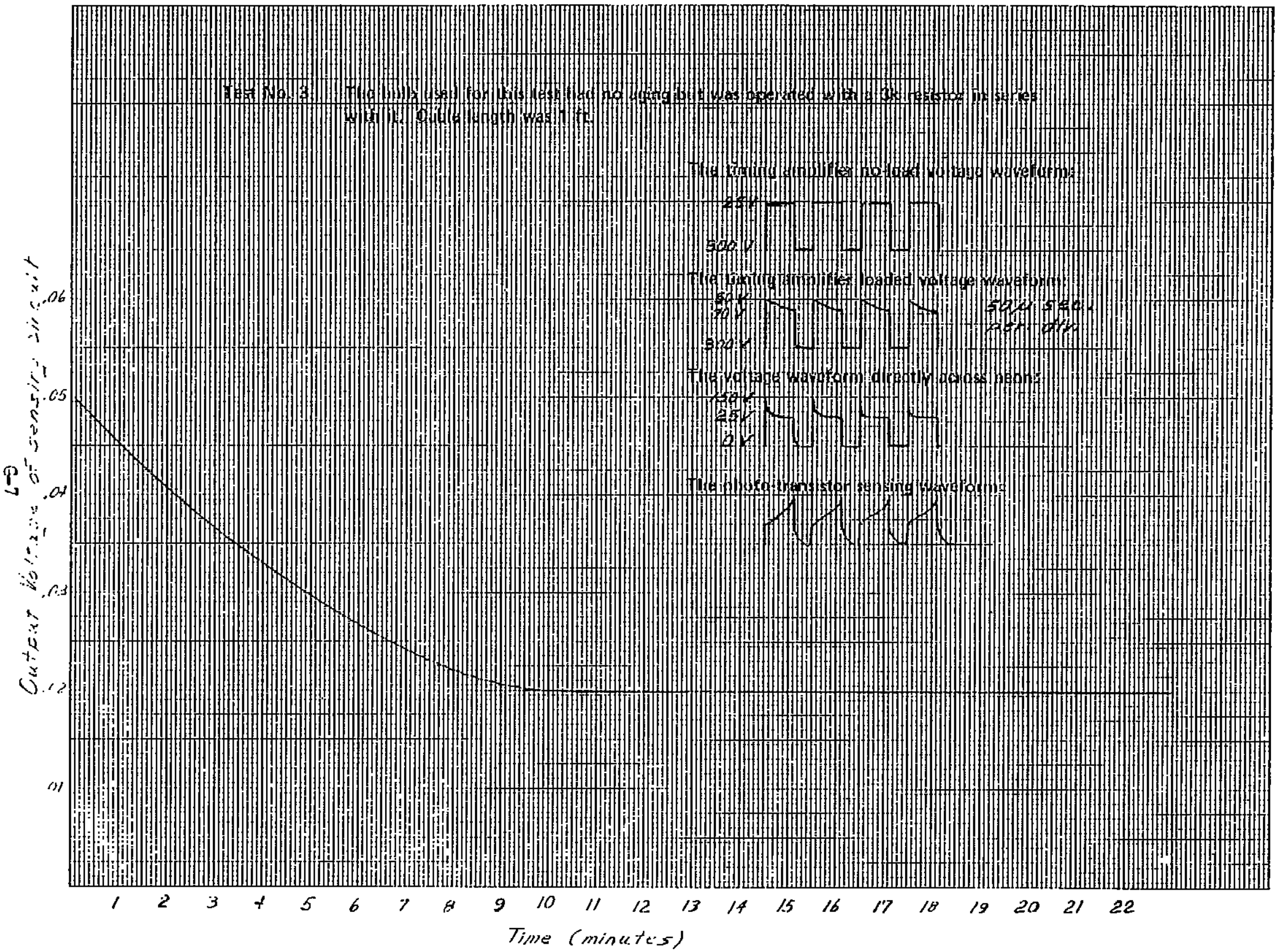
2. The lower output impedance of the timing amplifier will let more current flow without loading the amplifier down; thus increasing the brightness. The shorter pulse will also decrease the loading affect of the neon on the amplifier, as well as decrease the duty cycle on the bulb, which will lengthen the life of the bulb.

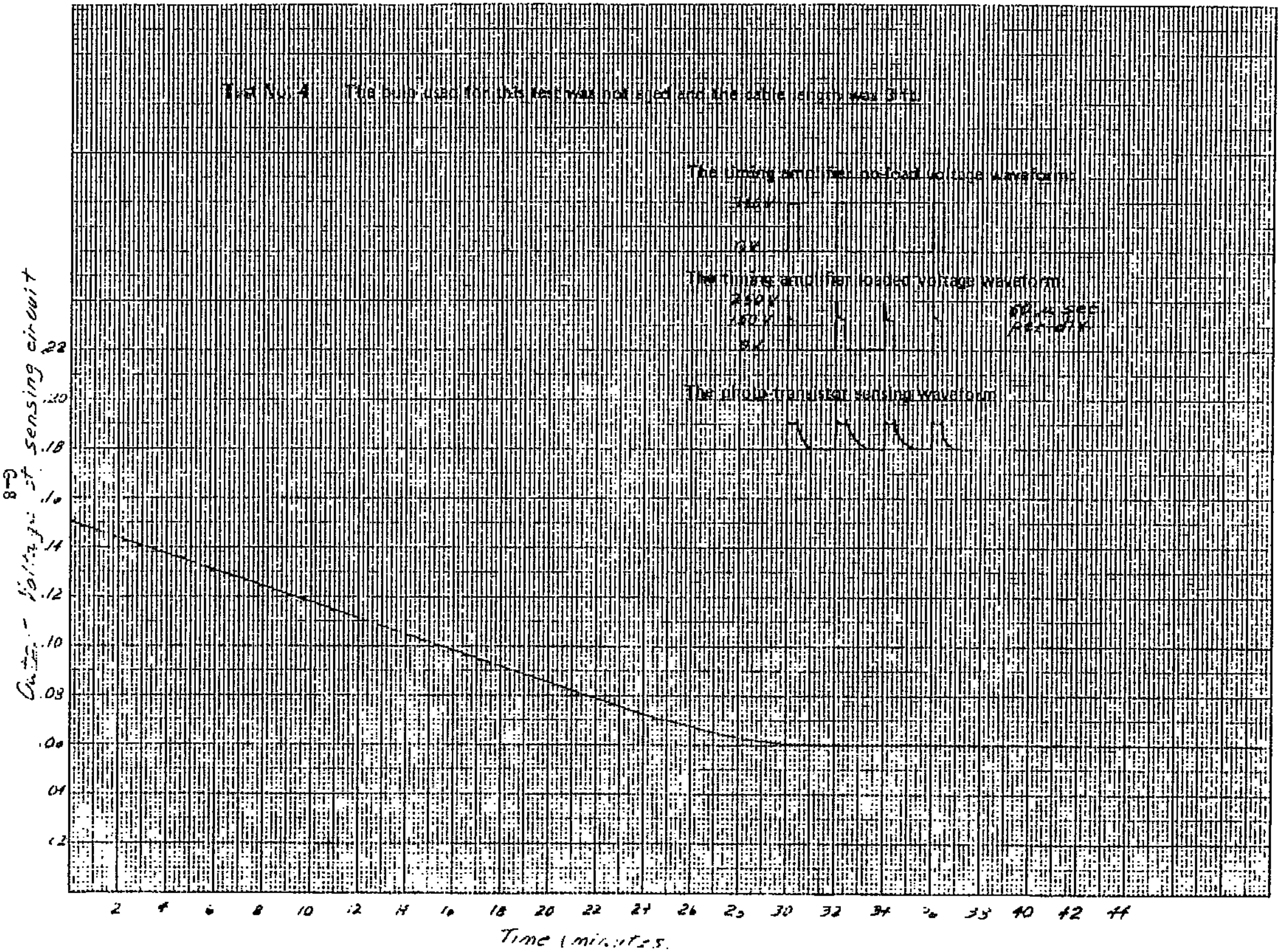
3. If the timing signal is to be fed through 1000 feet of field wire, the pulse should be at least 100 microseconds long in order to avoid excessive deterioration of waveform.

D. Remarks: In general, the film used is most sensitive to the blue portion of the light spectrum. An argon bulb emits a bluer light than does the neon bulb. However, no argon bulbs were available for these tests. The catalogs did not list any argon bulbs with the same base type as the neon bulbs now in use; therefore, no tests could be made using this type of bulb.

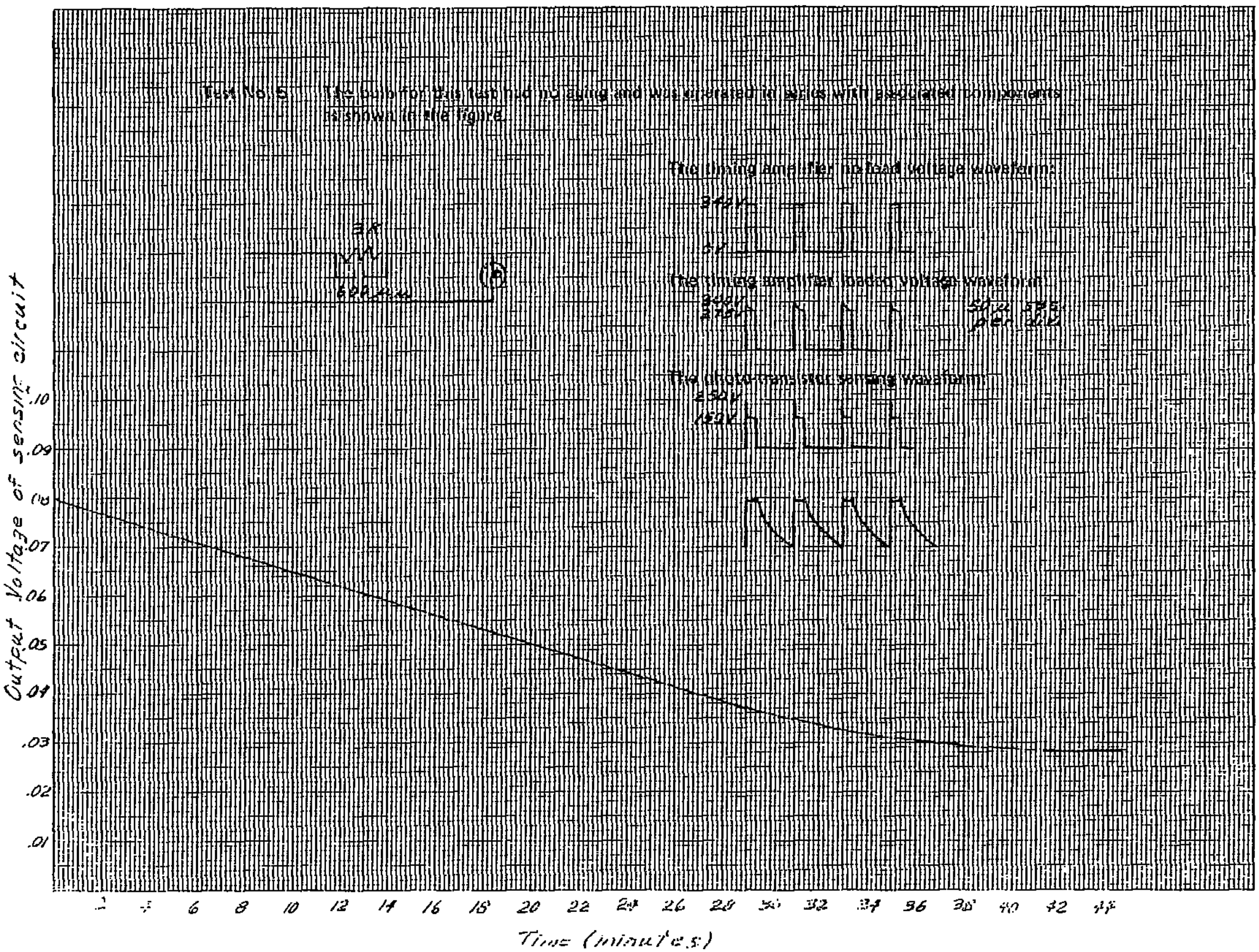

Test No. 1 The bulb used for this test was aged for 16 hours at 2 ma DC. Cable length between bulb and amplifier was 1 ft.
The timing amplifier no-load voltage waveform:
The timing amplifier loaded voltage waveform:
The neon lamp current waveform:
The photo transistor sensing waveform:
Output Voltage of sensing circuit
.06
.05
.04
.03
.02
.01
1
2
3
4
5
8
9
11
12
14
15
19
21
22
23
Time (minutes)

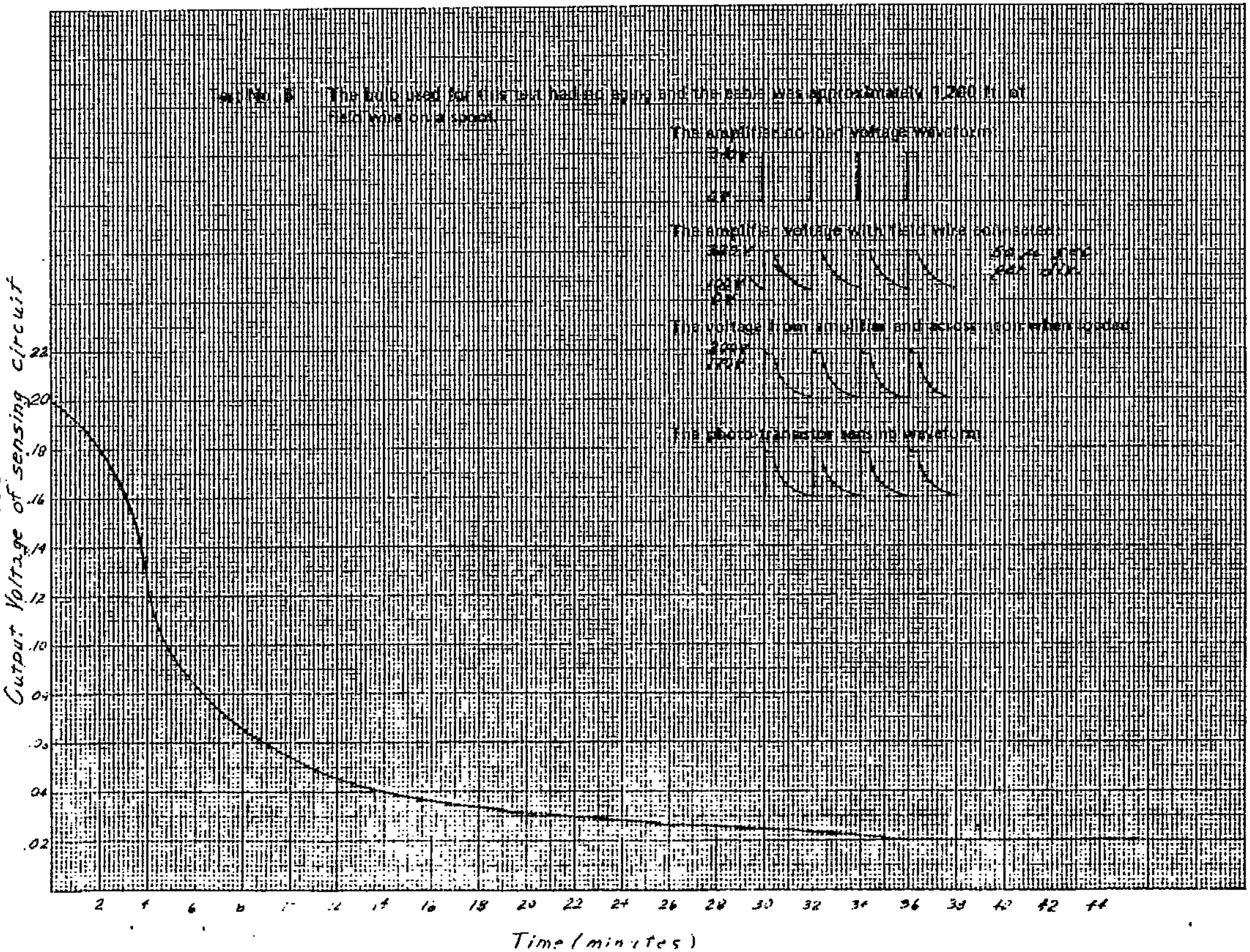

Test No. 2
The timing amplifier loaded voltage waveform
The photo transistor sensing waveform
.06
.05
.04
.03
.02
.01
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22
Time (minutes)

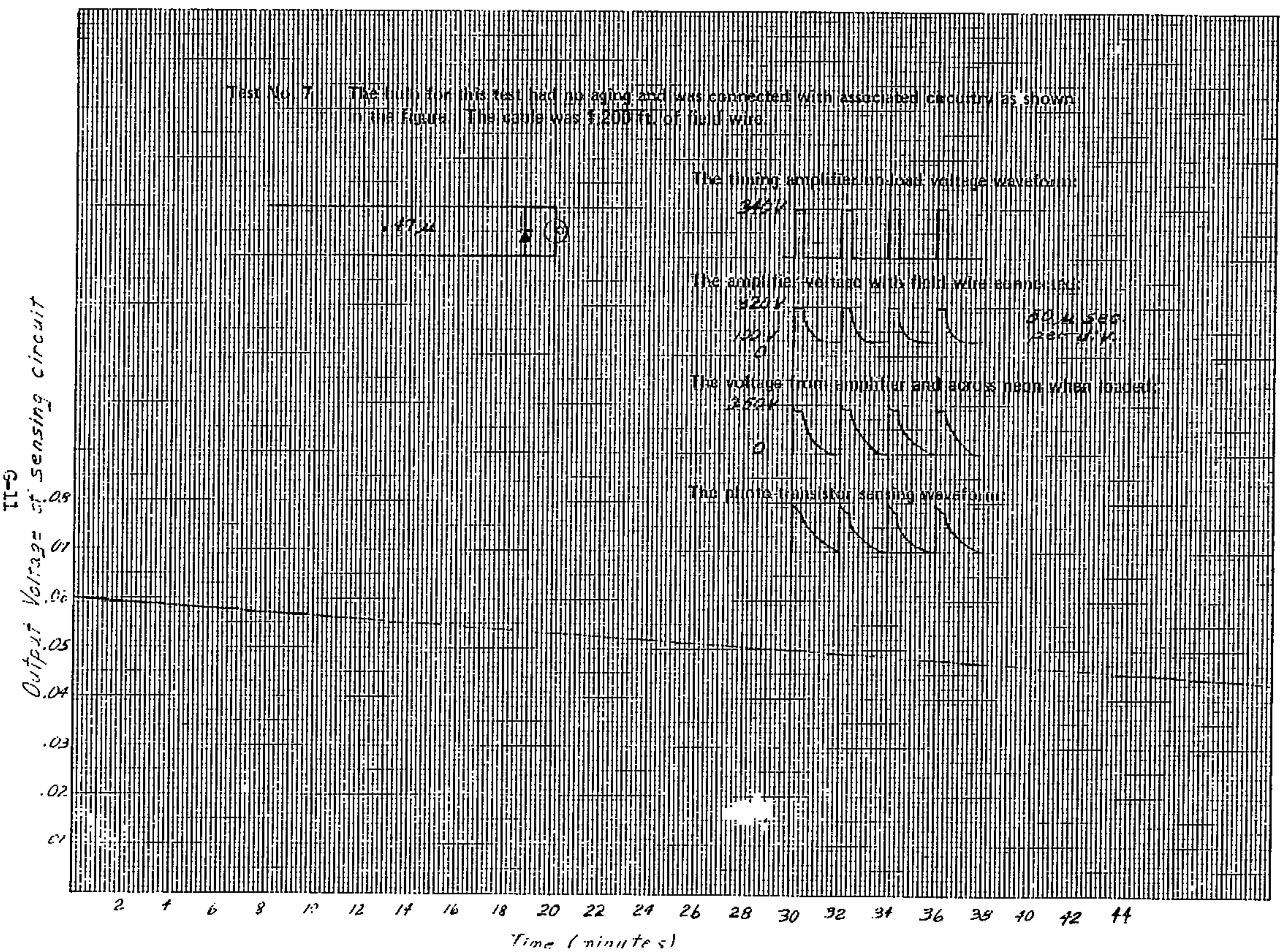

Test No. 3. The bulb used for this test had no aging but was operated with a 3k resistor in series with it. Cable length was 1 ft.
The timing amplifier no-load voltage waveform:
25 V
500 V
The timing amplifier loaded voltage waveform:
80 V
70 V
500 V
50 μ sec. per div
The voltage waveform directly across neon:
150 V
25 V
0 V
The photo-transistor sensing waveform:
.06
.05
.04
.03
.02
.01
Output voltage of sensing circuit
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
20
21
22
Time (minutes)



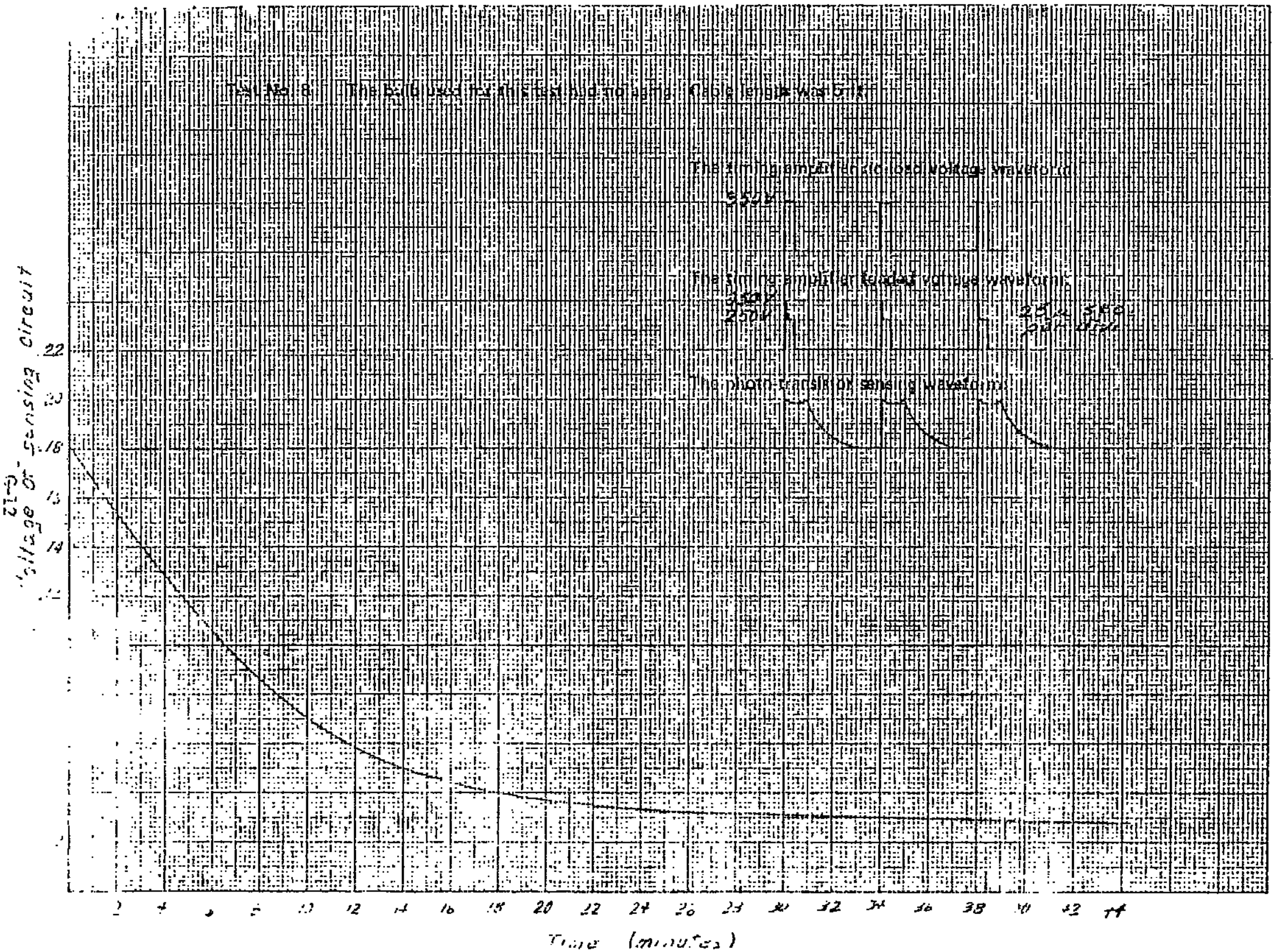
The timing amplifier loaded voltage waveform
The photo-transistor sensing waveform
sensing circuit
.22
.20
.18
.14
.12
.10
2
4
10
18
20
22
26
30
32
40
42
44
Time (minutes

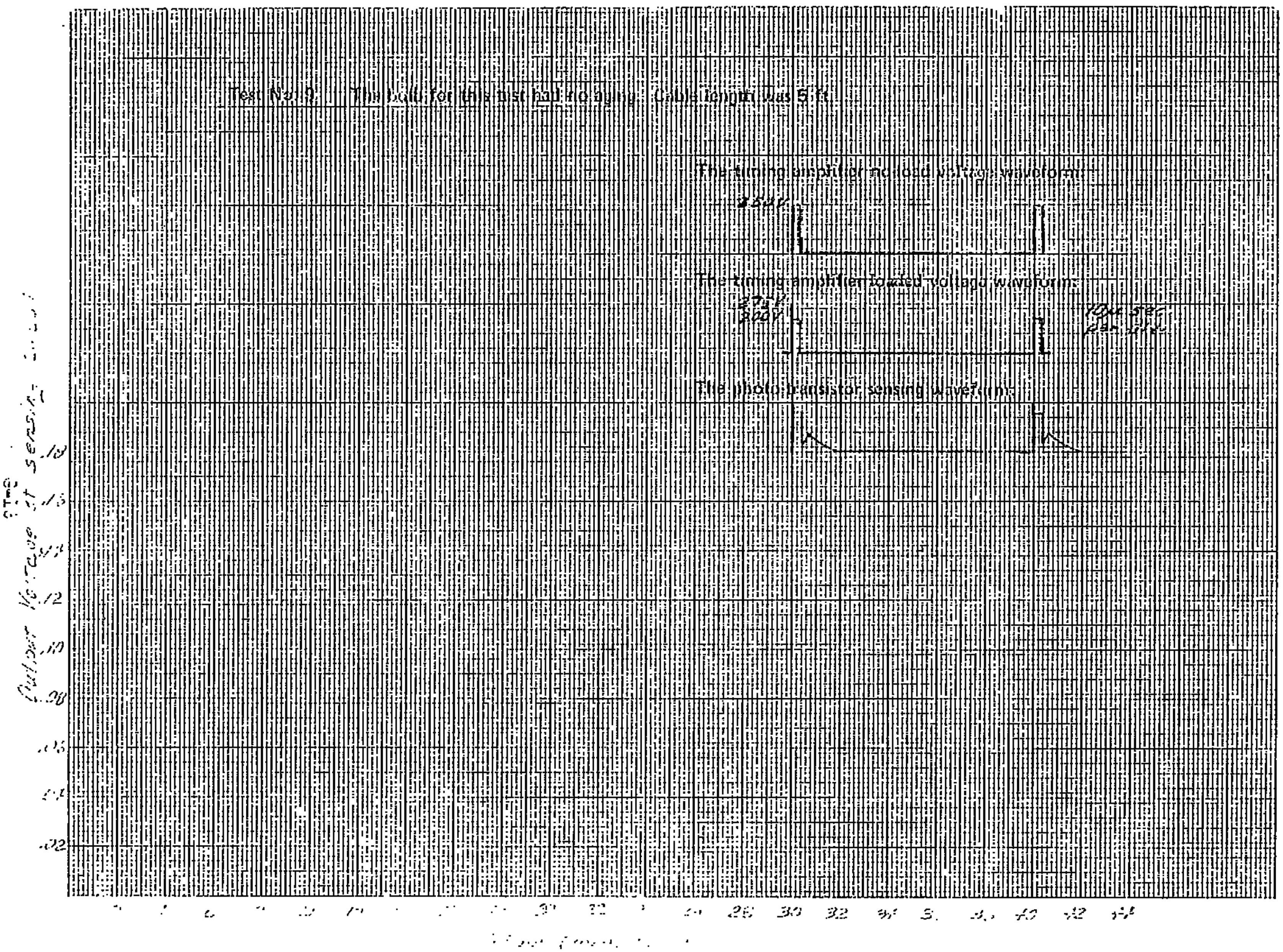

Test No. 5 The bulb for this test had no aging and was operated in series with associated components as shown in the figure.
3K
600 ohm
The timing amplifier no load voltage waveform:
344V
5V
The timing amplifier loaded voltage waveform:
340V
276V
50 ms sec per div
The photo-transistor sensing waveform:
250V
152V
Output Voltage of sensing circuit
.10
.09
.08
.07
.06
.05
.04
.03
.02
.01
2
4
6
8
10
12
14
16
18
20
22
24
26
28
30
32
34
36
38
40
42
44
Time (minutes)

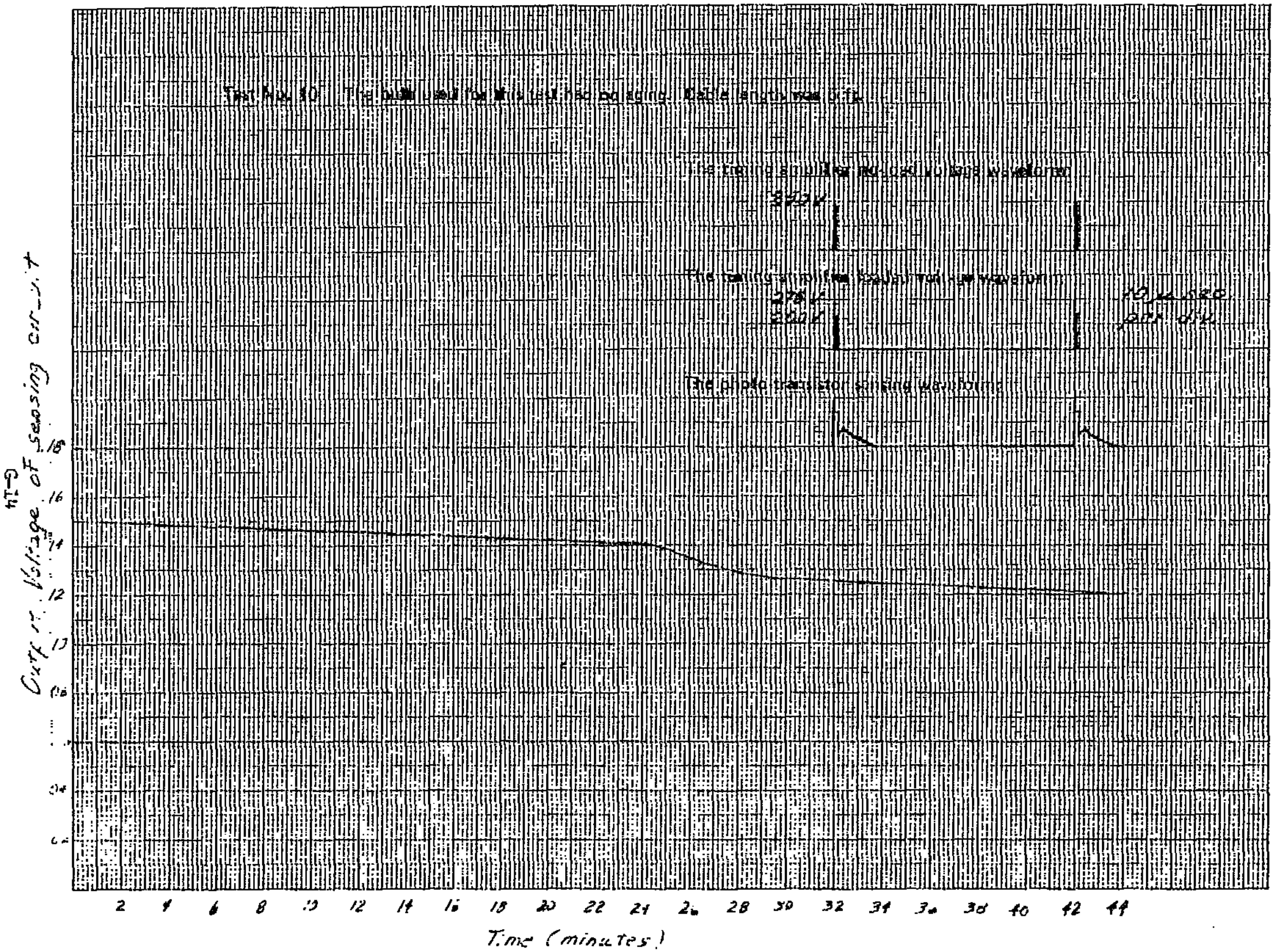

The amplifier voltage with field wire connected
The photo-transistor sensing waveform
Output Voltage of sensing circuit
.22
.20
.18
.16
.14
.12
.10
.02
Time (minutes)
2
4
6
14
16
18
20
22
24
26
28
30
32
34
36
42
44

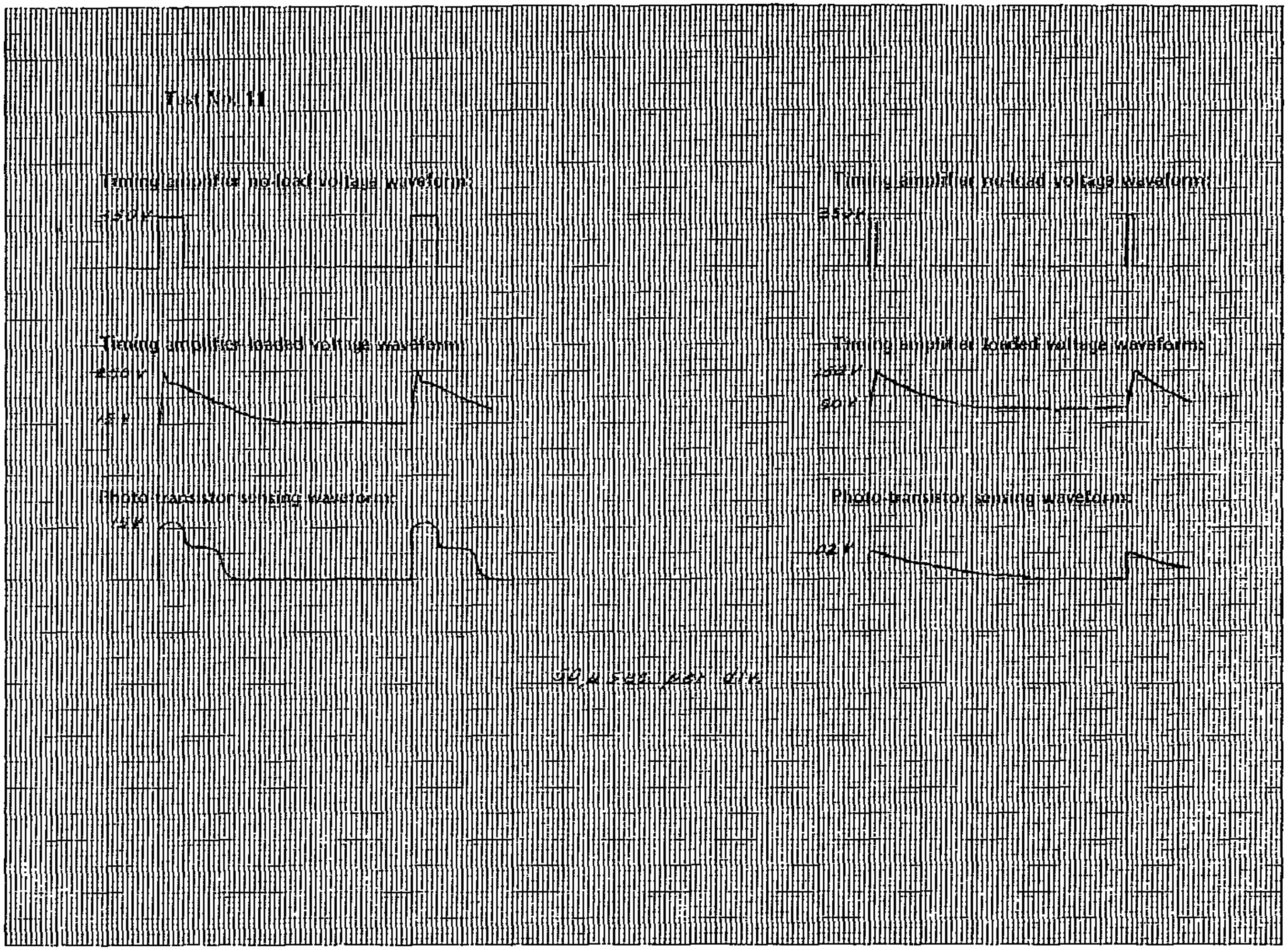


Test No. 7
The timing amplifier no-load voltage waveform:
345V
.47μ
320V
122V
0
80 μ sec.
per div.
260V
0
2 4 6 8 10 12 14 16 18 20 22 24 26 28 30 32 34 36 38 40 42 44
Time (minutes)
.01 .02 .03 .04 .05 .06 .07 .08
Output Voltage of sensing circuit


Test No. 8
Time (minutes)


Test No. 9   The ball for this test had no dying. Cable length was 5 ft.
The timing amplifier no load voltage waveform:
The timing amplifier loaded voltage waveform:
The photo-transistor sensing waveform:
.18
.16
.12
.10
.08
.06
.02
26
30
32
40
42
44


The photo transistor sensing waveform
2
4
6
8
12
14
18
20
22
28
30
32
34
40
42
44
Time (minutes)


Test No. 11
Timing amplifier no-load voltage waveform:
Timing amplifier loaded voltage waveform:
Photo-transistor sensing waveform:
Timing amplifier no-load voltage waveform:
Timing amplifier loaded voltage waveform:
Photo-transistor sensing waveform:
50 μ sec per div

18 December 1964

APPENDIX H

CAMERA TIMING INDICATORS

L. M. Dearing Associates, Inc.
12345 Ventura Blvd., Suite R
Studio City, California 91604

Results of Final Tests and Evaluation Conference with Milton R. Bradley of AFMDC, Camera Timing Indicators, Contract AF 29(600)-4727, Item 2.

The final testing of the prototype Camera Timing Indicators for the Wollensak and Waddell 16mm cameras were conducted at L. M. Dearing Associates, Inc., 12345 Ventura Boulevard, Suite R, Studio City, California, on 16, 17, and 18 December 1964 with Milton R. Bradley, Chief Timing and Programming Section of AFMDC.

After inspection of the Camera Timing Indicator blocks, they were inserted in the Wollensak Fastex WF-3 and the Waddell 16-1 16mm cameras and tests were conducted with M. R. Bradley of the AFMDC. These tests are described in Attachment 1 and demonstrated that the AFMDC specifications were met and in most cases exceeded. Two sets of conferences were held, one, evaluation conference, and the other to consider scheduling, installation, and possible requirements for spare assemblies and parts which can be more economically obtained during the final production run than at some later date.

1. EVALUATION CONFERENCE

An evaluation conference was held with the following in attendance: Mr. Milton R. Bradley, AFMDC; Mr. Robert E. Hiller, LMDA Inc., Project Manager; Mr. Lee Prentice, LMDA Inc.; Mr. Albert E. Edgerton, LMDA Inc., President, Western Instruments; and Mr. Ralph Thiry, LMDA Inc., Photographic Engineer. The meeting was chaired by Dr. LeRoy M. Dearing.

This conference was concerned with two things, one, to check point by point the requirements of AFMDC Exhibit A, Camera Timing Indicators, and two, to point out any areas where choices should be made by AFMDC personnel of alternate possibilities for the production models.

Ability of prototypes to meet requirements, general and specific, of AFMDC Exhibit A, Camera Timing Indicators, dated 11 June 1964.

Section 2 of AFMDC Exhibit A, Requirements — General, and Section 3, Requirements — Specific, were discussed to determine the ability of prototype Camera Timing Indicators to meet these requirements. The conclusions are as follows:

2. REQUIREMENTS — General

2.1 Location of spark gap and neon timing mark images are as specified in Engineering Change A dated 2 September 1964.

2.2 The prototype indicators were installed in the Fastex 16mm Model WF-3 and the Waddell 16mm Model 16.1. Coaxial cables connect the Timing Indicator Blocks to standard connectors on the back of the cameras. These installations were considered satisfactory and of a type which can be installed at AFMDC with a minimum amount of time and modification. The Timing Indicator Blocks can easily be removed if it is desired to return the camera to its original configuration.

2.3 This requirement is exceeded by a factor of 10 in density. The spark gap negative density on speed ASA 64 film is approximately 2.0 density.

2.4 This requirement is exceeded by a large margin. The negative density difference on black and white film of ASA 64 was 1.80 and 1.0 on ASA speed 25 negative, again a factor of 10 over the specified 0.15 density difference for films of ASA ratings of 100.

2.5 Engineering Change A, Paragraph b. At shorter spark gap lengths, 0.010 to 0.020 inches, the 10 kc is possible with the present amplifier. Longer gaps are desirable to obtain higher brightness and greater density difference in the image. Our tests indicate that the spark gap itself is capable of operating at 10 kc or higher, provided the required voltage can be delivered to it. Completely reliable operation has been obtained with 5 kc with gap lengths up to 0.045 inches. Presently we are recommending for the production units 0.025 inch gap with a 0.045 inch deep grounding electrode hole.

2.6 With the Timing Indicator Block installed, there is a clearance of 0.010 inch between the point of the sprocket teeth and the block. LMDA feels that this clearance is adequate for the threading of film.

2.7 The spark assembly and lens barrels assemblies are completely interchangeable. BA1C or NE2J neon lamps are interchangeable; however, the NE2J requires a different length seating ring and cap than does the BA1C. The caps between the Waddell and Wollensak are not interchangeable; however, caps and lamp bulb holders are interchangeable between the same type of cameras.

2.8 Rugged design was used throughout and all elements in the Camera Timing Indicator securely held in position.

2.9 All the electrical connectors are compatible with presently used equipment.

2.10 Standard military type connectors are being used. The spark gap fitting was designed to fit the cable connectors in use at Holloman. The neon connector on the Waddell is the existing camera sync connector MS3102-10SL-4P. This same connector would be used on all Wollensak cameras also. These will be potted with Silicone rubber (RTV).

3. REQUIREMENTS – Specific

3.1 Spark Gap

3.1.1 The spark gap presently preferred is 0.025 inches. This can be greater for operation at 5 kc or less if more intensity is desired.

3.1.2 There is no visible change after 30 minutes total running time. Tests were run by operating the spark gap 30 seconds on and 1½ minutes cooling off period. Previously several spark output transistors had failed. LMDA felt this cooling off period would minimize power transistor failures due to high power dissipation.

3.1.3 The plasma jet emitted from the spark gap hole is believed to give adequate ventilation and is believed to discharge the ionized air. The double image occurs on many of the tests but measurements have indicated that the leading edge of the first dense image is the true mark. The source of the trailing mark is presently not known. Mr. Edgerton believes this may be caused by ringing in the amplifier output transformer circuit.

3.1.4 GFP amplifiers used.

3.1.5 Coaxial cable used throughout and enclosed within the camera case. LMDA feels this should provide adequate shielding for practical range operation. This item could be defined also in terms of micro volts per meter.

3.2 Neon

3.2.1 Engineering Change A, Paragraph c. Requirements exceeded. Tests prove that sufficient density is available.

3.2.2 With 1800 ohm series resistor, the light output is held within 25 percent for thirty to sixty 30-second bursts. With 5150 ohms series resistor, the original light output was reduced 50 percent, the life is doubled (twenty-five percent down in sixty-five to seventy 30-second bursts). Tests on the NE2J indicated that this life is equal to the BA1C. (Resistances include 1000 ohms in amplifier.)

3.2.3 The bayonet types are not practical due to their physical size. Using the BA1C or NE2J sub-miniature flange base lamps, a notch, paint mark, or the solder point on the base is suggested as a means of identifying the hot electrode.

3.2.4 If the lamp bulb holder is keyed, and if procedures recommended in 3.2.3 are followed, alignment will be provided.

3.2.5 Requirements met, both lines to the neon are full floating.

SECOND CONFERENCE – **Bradley, Dearing, and Hiller, Scheduling, Installation, and Recommendations**

Item 3 on the schedule of subject contract calls for the fabrication of sufficient number, i.e., 40 to equip the cameras listed in Paragraph 2 of Exhibit A. No difficulty is foreseen by the contractor to provide the 40 Camera Timing Indicators within the 98 days after receipt of AFMDC prototype approval.

Several approaches were studied and considered during the initial design stages. LMDA felt that the final configuration should be one that required a minimum amount of camera modification. The prototypes proposed provide the optimum requirements for installation and maintenance.

Spares – Spares are recommended and can be furnished during the production run at lower cost than if ordered at a later date. This was discussed and suggested that perhaps four spares of each type of timing indicator blocks should be purchased now. LMDA also recommends that spare elements be obtained for replacement parts due to loss or damage. The parts suggested are:

a. Spark assembly
b. Lens assembly
c. Spark grounding plate
d. Neon lamp bulb holder
e. Neon cap and seating ring
f. Neon and spark springs
g. Neon and spark connectors to Camera Timing Indicator Block
h. Lens and plate holding screws. Mounting screws.

Ten of each part are suggested. Dr. Dearing will write to the contracting officer on costs and recommendations.

Additional Accessory Equipment:

High-speed illuminating lenses – LMDA felt there was a possibility of developing higher efficiency slit-projection illumination lens system over the standard 4mm cylindrical lens and diffusing-slit used in the design and prototype stages and to be furnished as standard.

An independent in-house investigation was made and the specially selected high index glass condenser and projection lens calculated and ground. They were mounted in lens barrels which are compatible with the standard lens. High speed f1.3 condensor lens-slit illuminating systems with either cylindrical or spherical projection lenses are interchangeable with the standard cylindrical-diffuser-slit lens provided as standard equipment. They deliver more light to the film, the spherical in particular will deliver more than an order of magnitude increase of light which could be of great advantage on the slow speed color films and give increased reliability. The lens elements are specially ground and fitted in specially fitted barrels. Dr. Dearing will provide the AFMDC office with price quotations for various lot sizes.

ATTACHMENT 1

Final Tests of Prototype Camera Timing Indicators with Spark-Neon Sources Made at L. M. Dearing Associates, Inc., on 16, 17, and 18 December with M. R. Bradley of AFMDC.

The Prototype Camera Timing Indicators were installed in their respective cameras. Black delrin prototype No. 3 was installed and connected in the Wollensak Fastex WF-3; and the Lucite prototype No. 1 was installed in the Waddell 16-1 16mm camera.

Twelve runs were made; five to test the various spark element marking sources available, and seven to test the neon BA1C and NE2J lamps together with the three slit imaging lens systems available with the neon source. The attached list gives the details for runs 86 through 97.

Final Test Runs of the Waddell Prototype Camera Timing Indicator Spark-Neon Block.

Spark Source

Runs 87 and 88 are two spark source runs with the spark operating at 5 kc. These runs were made at the maximum speed of the GFP Waddell camera, which, due to its small motor, is only some 2500 frames per second. The films were Dupont 931 and Ektachrome MS. These two runs demonstrated the difference in the size and brightness of the image using the 0.045 deep spark grounding hole as compared with the 0.015 deep spark grounding hole. The latter gives a larger, more diffused spot. The 0.045 deep hole is preferred for the sharpness of leading edge with some reduction of brightness; however, either can be furnished.

Neon Source

Run 89 is a neon run at 20 kc with standard 4mm cylindrical lens and diffusing photo slit. Film samples of 931 developed to a negative and Ektachrome MS developed reversal were given to Mr. Bradley.

Final Tests of the Wollensak Fastex WF-3 Prototype Camera Timing Indicator Spark-Neon Block.

These correspond to runs 86 and 90 through 97. Runs 86 and 90 through 94 were run at frame rates of 7000 frames per second. This rate was picked for comparative tests of the various neon and spark elements. Runs 95, 96, and 97 were run at maximum speed of some 8200 frames per second, which provided a slight excess over the 8000 frame, 200 feet per minute specified in AFMDC Exhibit A, dated 11 June 1964.

These tests demonstrated the capability of this dual source Camera Timing Indicator block to deliver satisfactory marks to the film at these high speed rates. Three films were used on runs 90 through 97; Eastman Plus X, ASA 25 Negative ASA 50 Reversal; DuPont 931, ASA 80

Negative and ASA 160 Reversal; and Ektachrome MS ASA 64. In order to obtain greater film travel speed at lower voltage and to run these different ASA speeds black and white and color films on the same run, we utilized what is perhaps the unique technique of pre-splicing with Mylar tape 10 to 15 foot sections of each of the films on the tail end of a thin base (0.0025 inch thick Mylar) Ektachrome ER film supplied to us by the Eastman Kodak Company as a leader. This allows some 150 feet of film on a 100 foot reel and greater film travel speeds are attained.

Spark Source Runs

Run 86 is a spark source run at 5 kc with 0.025 spark gap and 0.045 inch deep channel. The film was 931 speed, approximately 7000 frames per second. Run 94 is with the same spark gap and hole depth as run 86, done with all three films at 7000 frames per second. Run 95 is a 10 kc run with an 0.020 spark gap and an 0.045 hole depth at approximately 3200 frames, or slightly more than 200 feet per second.

Neon Source Runs — Comparison of BA1C and NE2J Neon Flange Based Lamp Bulbs

Runs 90, 90A, and 91 compared to the BA1C used in 90 and 90A with the NE2J bulb in 91. They demonstrated that the two bulbs are approximately equivalent. Actually, a low output BA1C was used in run 90, which gave a light below the NE2J. The replacement BA1C bulb used in run 90A was more representative of our average results.

Either bulb can be used. They should be checked to see that the brightest portion of the electrode is falling within the range of the lens systems which cover approximately 0.100 of an inch of the electrode. The length of the BA1C electrode is 0.140 and the length of the NE2J is 0.300. The lens system and lamp tube holder position the bulb so that the electrode is centered under the lens slightly toward the end of the electrode, which is generally the brightest area.

Comparison of Standard 4mm Diameter Cylindrical Lens with the Accessory f1.3 Condenser Lens Systems

Runs 90, 92, and 93 illustrate the increase in light gathering power of the accessory lens. Run 92 uses the f1.3 condenser plus cylindrical projection lens system. This projects a slit image positioned 2/3 of the way into the perforations and to the edge of the film. Run 93 illustrates results obtained with the f1.3 condenser plus spherical projection lens system. The spherical lens system theoretically should deliver a more concentrated spot with a brightness 3.7 times that of the cylindrical projection system of 92. The visual comparison of the film samples from these runs indicates that this is obtained.

200 Feet Per Second Runs

Runs 96, 96, and 97 were run at the maximum speed of this Wollensak Fastex WF-3 camera, 8000 full frames or 200 feet per second. They demonstrate the capabilities at these high film rates of this dual source Camera Timing Indicator at 10 kc for the spark source and at 20 and 50 kc for the neon source. Run 95 is a spark run at 10 kc. Run 96 is a 20 kc run with BA1C neon lamp and the standard 4mm diameter cylindrical lens and photo-diffuser-slit. Run 97 is identical with 96 except that the signal was pulsed at 50 kc. Good images and densities were obtained on all runs as can be seen from the samples.

The negative developed film samples on Eastman Plus X and DuPont 931 of all these runs were delivered to Mr. Bradley. Samples cf these films and the balance of the Ektachrome MS film developed to reversal are available (if desired) and can be forwarded to the AFMDC.

Sketches of the standard and the two f1.3 condenser lens systems are shown in Figure 1.

LIST AND IDENTIFICATION OF TEST RUNS AND SAMPLES

Run No. 86	Wollensak WF-3 Spark Source 5 kc 0.025" spark gap 0.045" grounding hole depth 7000 frames per second film 931
Run No. 87	Waddell Spark Source 5 kc 0.025" spark gap 0.015" grounding hole depth 2500 frames per second films 931 and Ektachrome MS
Run No. 88	Waddell Spark Source 5 kc 0.025" spark gap 0.045" grounding hole depth 2500 frames per second films 931 and Ektachrome MS
Run No. 89	Waddell Neon Source 20 kc BA1C Standard Lens No. 3 (4mm cylindrical plus ground photo-slit) 2500 frames per second films 931 and Ektachrome MS
Run No. 90	Wollensak WF-3 Neon Source 20 kc BA1C Standard Lens No. 3 7000 frames per second films Plus X, 931, and Ektachrome MS
Run No. 91	Wollensak WF-3 Neon Source 20 kc NE2J Standard Lens No. 3 7000 frames per second films Plus X, 931, and Ektachrome MS
Run No. 92	Wollensak WF-3 Neon Source 20 kc BA1C Accessory Lens (f1.3 condenser plus cylindrical projection lens system) 7000 frames per second films Plus X, 931, and Ektachrome MS
Run No. 93	Wollensak WF-3 Neon Source 20 kc BA1C Accessory Lens (f1.3 condenser plus spherical lens system) 7000 frames per second films Plus X, 931, and Ektachrome MS
Run No. 94	Wollensak WF-3 Spark Source 5 kc 0.025" spark gap 0.015" grounding hole depth 7000 frames per second films 931, Plus X, and Ektachrome MS
Run No. 95	Wollensak WF-3 Spark Source 10 kc 0.020" spark gap 0.045" grounding hole depth 8000 frames per second films 931, Plus X, and Ektachrome MS
Run No. 96	Wollensak WF-3 Neon Source 20 kc BA1C Standard Lens No. 3 (4mm diameter cylindrical plus photo-slit diffuser) 8000 frames per second films 931, Plus X, and Ektachrome MS
Run No. 97	Wollensak WF-3 Neon Source 50 kc BA1C Standard Lens No. 3 (4mm diameter cylindrical plus photo-slit diffuser) 8000 frames per second films 931, Plus X, and Ektachrome MS

L. M. DEARING ASSOCIATES, INC.

4mm Diameter Cylindrical Lens with Diffuser & Slit Standard Lens

F1.3 Lens System with Condenser and Cylindrical Projector Accessory Lens

F1.3 Lens System with Condenser and Spherical Projector Accessory Lens

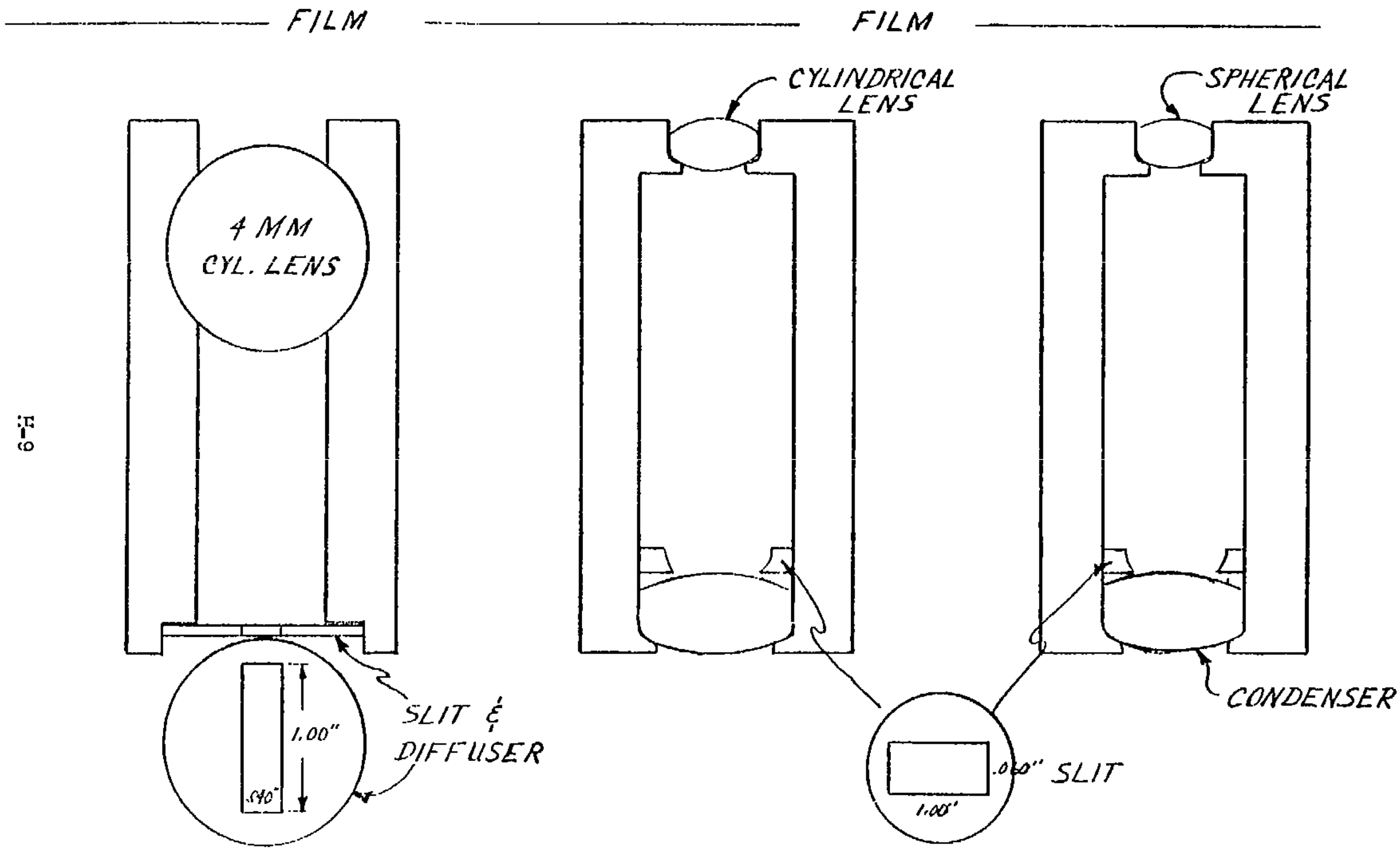


FIGURE 1

APPENDIX I

WSMR TEST RESULTS WITH MODIFIED AND NEW EQUIPMENT

MODIFIED EQUIPMENT

Astrodata Model 6620 Timing Terminal Unit (TTU)

The Astrodata Model 6620 TTU has been used for several years at WSMR and at some of the other ranges to drive neon lamps to mark film with timing. The TTU's at WSMR were modified to drive LEDS. This was done by modifying the Demodulator/Pen Amplifier (DPA) and the Demodulator/Neon Driver plug-in modules. The following is a brief description of the modules functions, how the modules were modified to drive LEDS, test results using the modified modules, and the results and conclusions.

Demodulator/Pen Amplifier

Function

The DPA accepts all IRIG time code signals (A, B, D, E, and H), one at a time, and provides two dc level shift (reconstruction of the modulated carrier envelope) output signals for driving marker pens in strip chart recorders or galvanometers in oscillographs. The pen amplifier dc level shift outputs are also suitable to drive LEDS to mark film in a camera. The main disadvantage of doing this is that dc level shift pulses are nonserrated (dc level shift reconstruction of the modulated carrier envelope instead of each mark carrier cycle), and it is more difficult for the film reader to decipher the timing on the film.

Modification

The pen amplifier circuit, (Figure 1, Demodulator/Pen Amplifier Circuit), can be modified in approximately 20 minutes to output serrated pulses to two LEDS by making the following modifications to the circuit:

(1) Open capacitors C14, C15, and C16 (the pulse stretching network) to convert the dc level shift signal back to a modulated carrier timing signal at the junction outputs of C_3 and C_4.

(2) Open diode CR9 to eliminate the negative portion of the modulated timing signal. This results in half-wave unfiltered rectification of the modulated carrier timing signal instead of full-wave unfiltered rectification at output junctions CR8 and CR9. The half-wave rectified signal is applied to the base of Q9 and fed to the pulse stretching network.

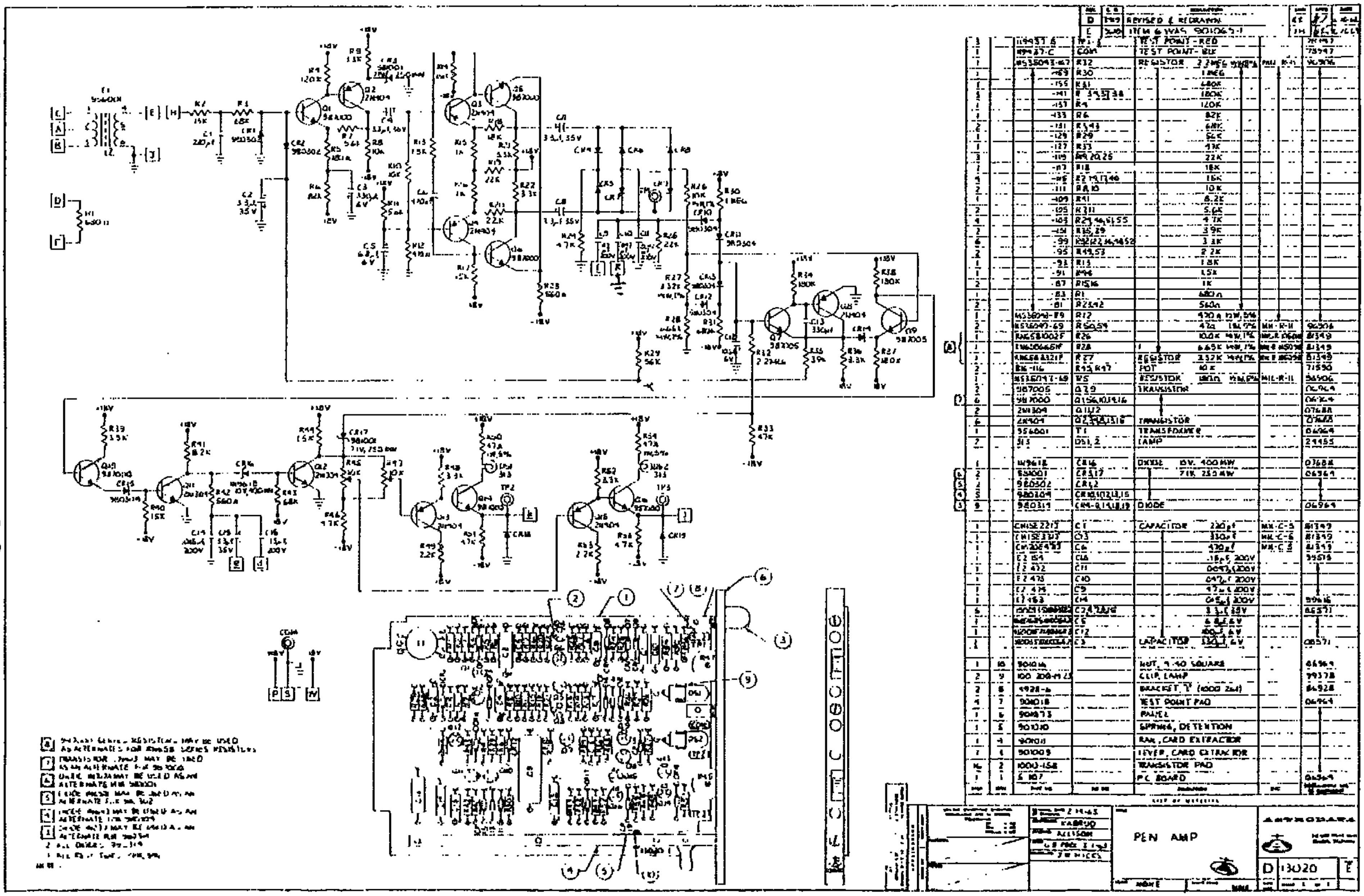


FIGURE 1. DEMODULATOR/PEN AMPLIFIER CIRCUIT

(3) Change resistor R37 from 180 K ohms to 90 K ohms. This causes the trigger level of transistors Q8 and Q9 to trigger earlier, which results in the leading edges of serrated output pulses at J and K to be more on time with the leading edge of the input signal.

With the above modifications, the current to each of the two LEDS in the camera is approximately 48 milliamperes. The pulse width for the serrated pulses is fixed at approximately 40 microseconds for an IRIG A input to the pen amplifier and approximately 280 microseconds for IRIG B, D, E, and H inputs.

If additional current is required to increase the LED brightness, the monitor lamps (DS1 for channel 1 and DS2 for channel 2) may be bypassed.

Field Test Setup

In the field, the Astrodata Model 6620 TTU with modified DPA is used primarily to mark timing on film in the continuous frame camera (CFC). The CFC is usually used as an oscilloscope recorder on radars at fixed installations. The type of film used in the cameras is 2484. The film speed used is 50 and 2,000 inches per minute. The type of LED used is the Monsanto MV10B3. The maximum current to drive the LEDS is 48 milliamperes out of the amplifier and is adjusted to a lower value by a fixed external resistor on the DPA. The timing is IRIG B serrated dc level shift pulses with a pulse width of approximtely 280 microseconds.

Results and Conclusions

The marking on 2484 film, which has low sensitivity at 6,800 angstroms, is good. The slow film speed and high brightness of the LED make it possible to mark film marginally out of the spectral region.

Because the DPA has two outputs, it only takes one module to mark timing on both edges of the film.

In the field and under the following conditions, the Astrodata Model 6620 TTU DPA modifications appear satisfactory:

(1) At a fixed installation where the bulky TTU does not have to be moved from site to site and where the timing lines to the TTU do not have to be continuously checked for correct polarity.

(2) In cameras where current requirements can be met, and pulse width settings do not have to be varied for the type of film, film speed and type of timing used (see Table I, page 4).

Demodulator/Neon Driver

Description

The Demodulator/Neon Amplifier accepts all IRIG time code signals (A, B, D, E, and H), one at a time, and provides one output signal to drive the neon lamps in the instrumentation cameras.

Modification

The neon driver circuit (Figure 2, "Demodulator/Neon Amplifier Circuit") can be modified in approximately 1/2 hour to drive LEDS instead of neon lamps by making the following modifications to the circuits:

(1) Remove resistors R59 and CR25 to disconnect the keep-alive current from the external LED.

(2) Remove neon lamp DS1 to open the neon monitor lamp that is in parallel with the external neon lamp.

(3) Remove jumper wire from the rotary switch position No. 9 to R68 to protect the LEDS from excessive current.

(4) Replace resistors R56, R67, R68 with 1K 2 watt resistors, resistor R66 with a 2K 1/2 watt resistor, and R65 with a 5.6K 1/2 watt resistor to control the amount of current to the LED.

(5) Install an 18K 1/2 watt resistor and a 1N277 diode (with anode grounded) from the junctions of TP4 and R56 to ground to prevent reverse bias voltages to the LED. The 18K resistor and the 1N277 diode are physically placed between C11 and CR18 and below Q12.

The output current at point K to the external LED has the following values for the given rotary switch position:

Position	Current (milliamperes)
5	14
6	30
7	50
8	70
9	0

Field Test Setup

The Astrodata Model 6620 TTU with modified neon driver cards was tested in the field using Photo-Sonics 10A, 10B, and 4C cameras. Both black and white LSB (2476) and color MS (2256) films were used. Frame rates were varied from the minimum to the maximum for each camera.

The amplifier was located about 40 feet from the camera. The signal was fed through shielded wire.

Results

Timing exposure on both types of film was good as long as film speeds were not over 18 feet per second. The modified neon driver (TTU) does not produce enough current nor can the pulse width be changed. Both conditions are necessary for proper exposure at higher frame or film speeds.

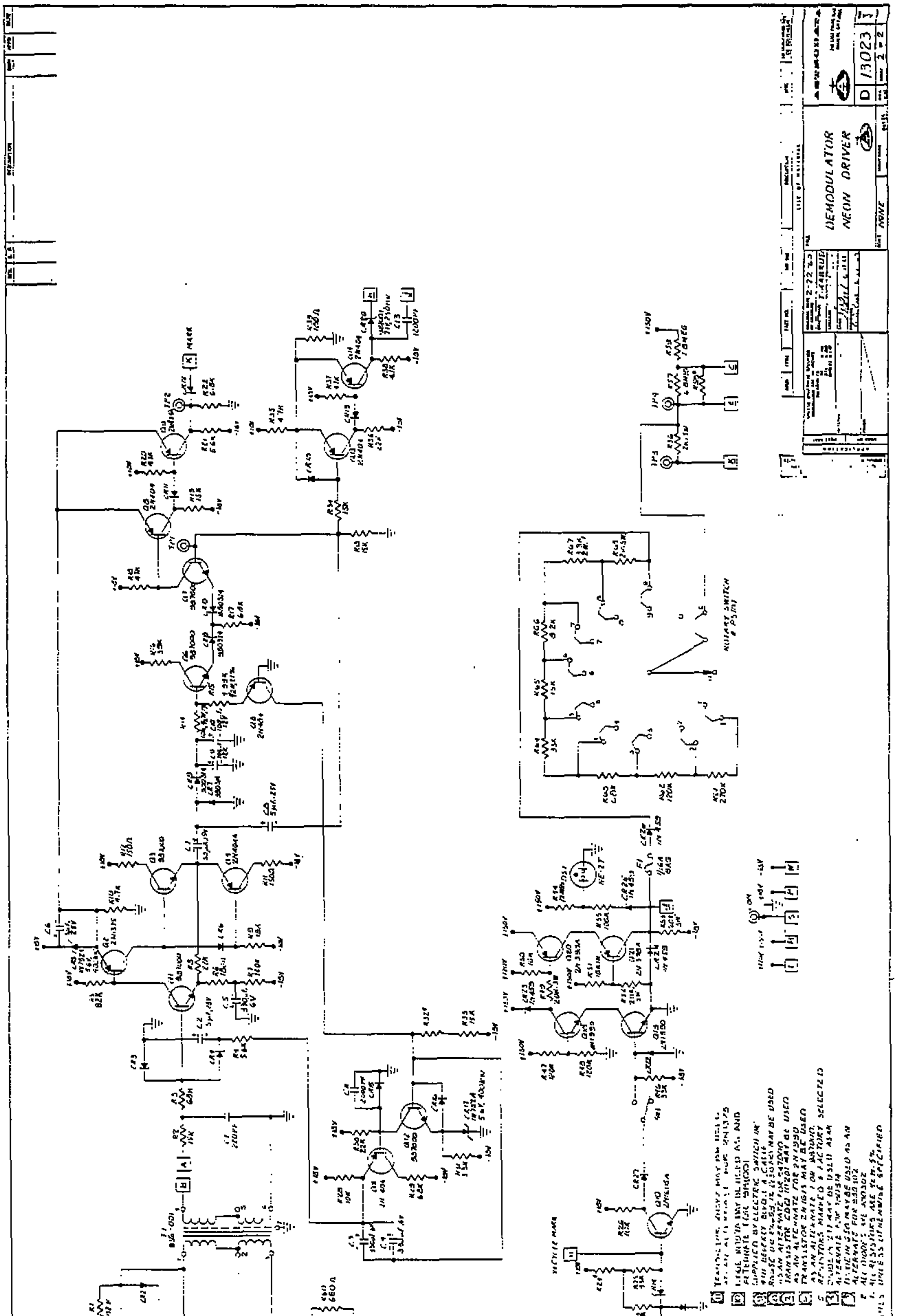


FIGURE 2. DEMODULATOR/NEON AMPLIFIER CIRCUIT

Conclusions

The 6620 TTU modified neon driver has limited applications for the following reasons:

(1) Current is limited to 70 milliamperes.

(2) Pulse width cannot be readily adjusted.

(3) No provisions are made for automatic polarity switching which makes it necessary to check polarity each time the amplifier is connected.

(4) The TTU is not constructed for outdoor use.

(5) The TTU output is not short circuit proof and fuses are often blown.

NEW TIMING EQUIPMENT

Datum Inc., Model 9610 TTU

Description

Figure 3, Datum Inc., Model 9610 Timing Terminal Unit (with rack mounting hardware) shows the equipment that was procured by WSMR. The Datum TTU provides for the transmission and reception of instrumentation timing signals to mark timing data on continuous moving film in optical camera systems. The Datum TTU was primarily designed to replace the Astrodata Model 6620 TTU and incorporates several new features for use with optical camera systems.

NOTE

In the Datum Inc., Model 9610 TTU the following modules performed the various types of functional operations given in WSMR PD-2157-70.

Module	PD Paragraph
Model 9610-200 Dual Line Amplifier	3.3.1 Type 1 Functional Operation
Model 9610-210 Dual DC Driver	3.3.2 Type 2 Functional Operation
Model 9610-201 IRIG Camera Driver	3.3.3 Type 3 Functional Operation
Model 9610-211 DC Camera Driver	3.3.4 Type 4 Functional Operation
Model 9610-207 Pulse Generator	3.3.5 Type 5 Functional Operation
Model 9610-150 Power Supply	3.1.2 Power Supply Requirements

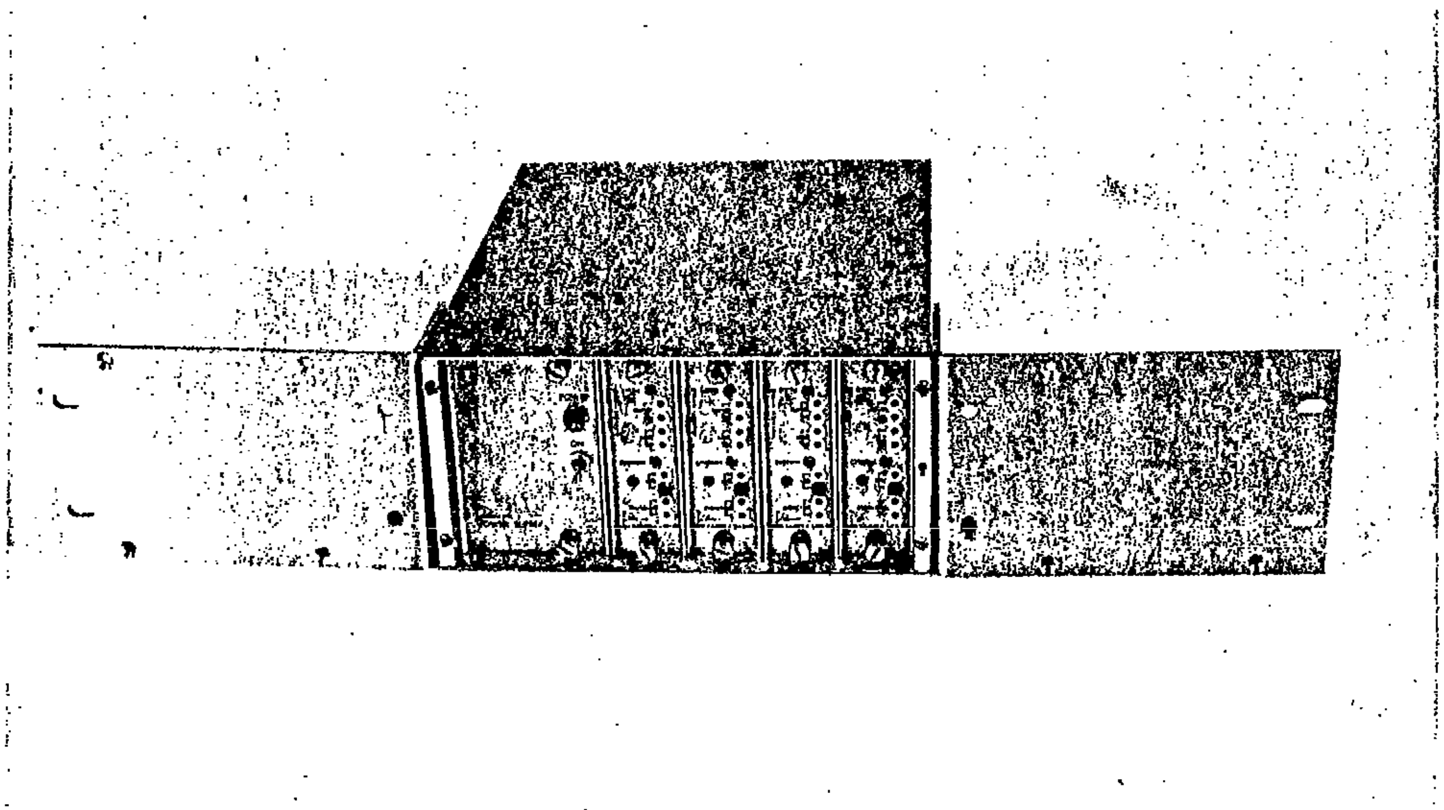


FIGURE 3. DATUM INC., MODEL 9610 TIMING TERMINAL UNIT (WITH RACK MOUNTING HARDWARE)

Light emitting diodes. The TTU was designed especially for LEDS to annotate the film instead of the troublesome neon lamps.

Monitoring. The TTU is designed to drive two LEDS in series. One LED is mounted in the camera and the other is mounted on the TTU base chassis. The camera operator can thus verify timing signal current to the LED inside the camera by observing the LED on the TTU base chassis. If the LED in the camera is out, the LED on the base chassis will also be out. An auxiliary LED driver monitor output is designed into the TTU for GO, NO-GO remote monitoring of the timing signal to the camera's LED. This is important because the cameras may be operated remotely in missile launch areas.

Signal current and pulse width setting. The TTU signal current can be adjusted from 10 to 100 milliamperes so that the LED brightness in the camera can be adjusted for proper film exposure for each type of film used. This capability to adjust the pulse width was found to be important, because (1) in high speed cameras, the current to the LEDS must be set at a high level to mark the film. If the pulse width of the timing pulses is too long, the LEDS overheat and burnout. (2) Timing is easier to decipher if the pulse width is short.

Automatic polarity selection. In field operation, different cameras are fed from separate TTU's. If the IRIG B timing line to one camera's TTU is reversed in polarity in relationship to the timing line of the other camera's TTU, a timing error of 500 microseconds occurs and will degrade the accuracy of reduced data. The Datum TTU has Automatic Polarity Selection to eliminate the potential error caused by inadvertent polarity reversal anywhere in the timing distribution system up to the TTU.

The TTU has two modes of operation. Selection of mode one determines that the "mark" carrier cycles are detected during the first half cycle of a "mark" carrier cycle. Selection of mode two determines that the "mark" carrier cycles are detected during the second half cycle of a "mark" carrier cycle. The two-mode selection allows an intentional offset of 500 microseconds to help adjust for propagation delays between widely separated areas.

Format G time code. The TTU includes two modules to transmit, receive, and process a dc level shift IRIG G time code signal. Using IRIG G timing in high speed cameras (2,500 frames per second or greater), instead of IRIG A, increases film reading efficiency because only one-tenth as much timing data is read to determine the epoch time of a particular point of interest on the film. One module has two independent amplifiers which furnish amplified IRIG G dc level shift output signals from the IRIG G dc level shift input signal. The other module receives the IRIG G dc level shift input signal and drives two LEDS; one in the camera and one mounted on the TTU to monitor the timing to the LED in the camera.

Electrical. The new electrical feature of the TTU is plug-in integrated circuits. The plug-in integrated circuits decrease equipment maintenance time. The outputs are short circuit proof. The TTU employs lighting protection devices on the input.

Mechanical. Figure 4 (Size Comparison of the Datum Inc., Model 9610 with Astrodata 6620) shows the Datum TTU as compared with Astrodata TTU. It was designed with maximum conservation of space to fulfill certain range requirements. The TTU is supplied with mounting hardware so that one or two can be mounted side-by-side in a 19-inch rack or one can be inclosed and made portable (Figure 5, Portable Datum Inc., Model 9610 Timing Terminal Unit) for field use.

Field Test Setup

The Datum Inc., Model 9610 TTU was mounted in a versatile tracking mount (VTM), as shown in Figure 6. The VTM is a tracking telescope mount manufactured by Photo-Sonics. The mount is usually operated with three cameras mounted; two 10B 70mm Photo-Sonics and one 4C or 4E 35mm Photo-Sonics. The 10B's have a Frame Data Recording System (FDRS). The Datum 9610 camera driver furnishes polarity corrected IRIG B or A modulated carrier timing to the FDRS as well as timing to drive LEDS for edge recording on all the cameras. Film used was Kodak 2256 (MS) and 2476 (LSB) with frame rates up to 180 frames per second on the 10B's and 500 to 1,250 frames per second on the 4C. LEDS were MV10B3 mounted in adaptors shown in Figure 7 (Timing Blocks and LED Holders for Various Types of Cameras).

Results

Since the 9610 camera amplifier can output 100 milliamperes of current, the exposure at all tested frame rates or film speed was excellent. The pulse width can also be adjusted and with a pulse width of 20 microseconds a very good exposure of the timing slit is obtained.

Conclusions

The Datum 9610 camera driver is an ideal system with which to drive LEDS. It is relatively small and has automatic polarity sensing and adjustments for current drive and pulse width.

The reliability of this system, as installed in the VTM, has been excellent. Only one case of bad timing on data film has been noted for eight VTM systems in a 14-month period.

High Current Amplifier System

Description

Figure 8 (High Current Amplifier System) shows Datum Inc., Model 9610 with the appropriate plug-in modules to make up the high current amplifier (HCA) system. The HCA system is used to furnish up to 2 amperes of current to drive MV10B3 LEDS, or equivalent, to mark film in high-speed cameras (2,500 to 11,000 frames per second). Below is a short description of each function module used with the Datum Inc., Model 9610 TTU that make up the HCA.

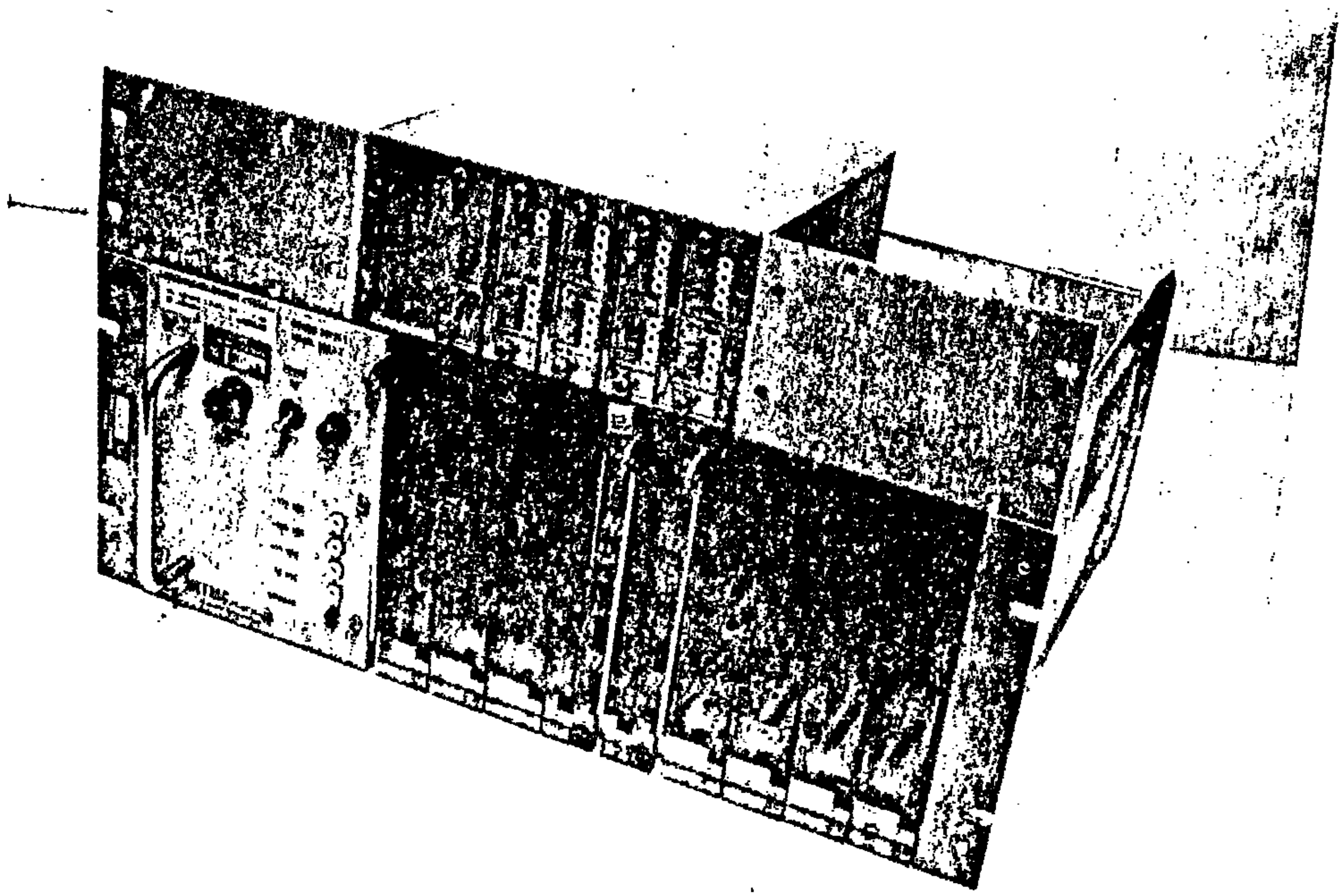


FIGURE 4. SIZE COMPARISON OF THE DATUM INC., MODEL 9610 WITH ASTRODATA 6620

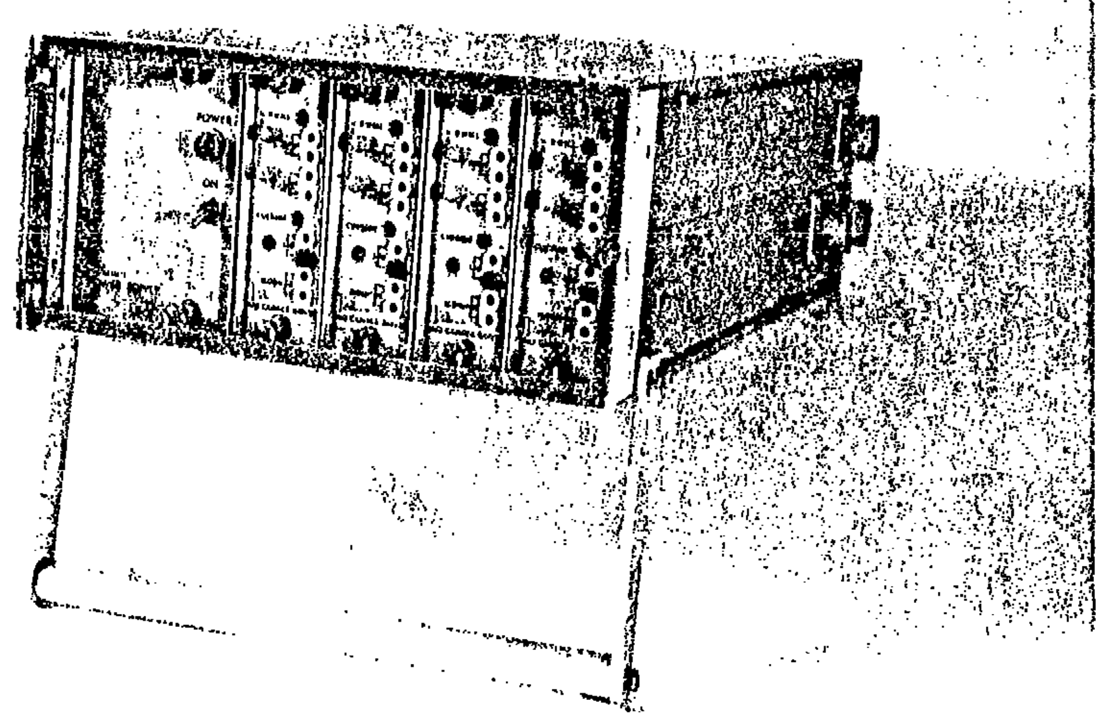


FIGURE 5. PORTABLE DATUM INC., MODEL 9610 TIMING TERMINAL UNIT

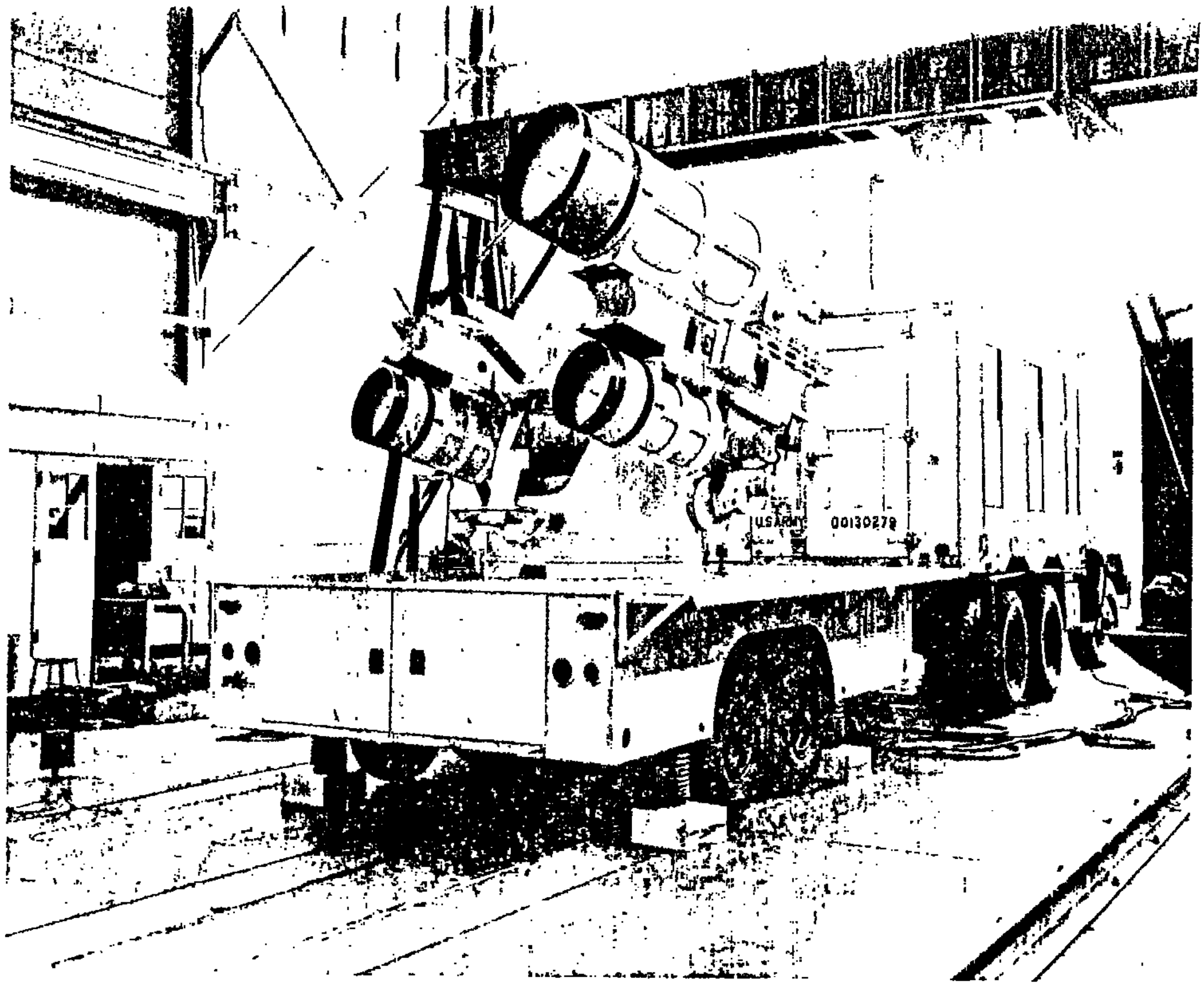


FIGURE 6. VERSATILE TRACKING MOUNT

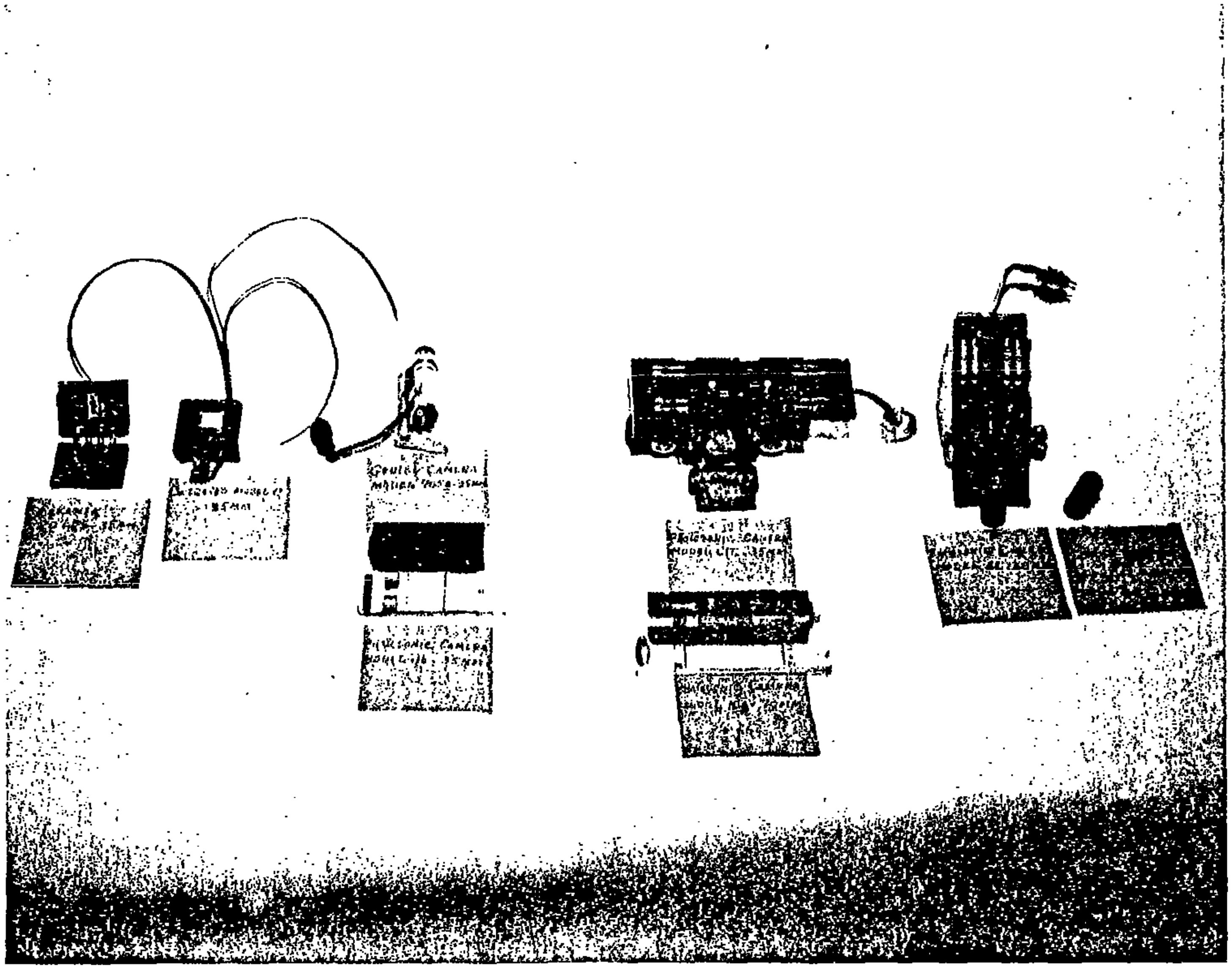


FIGURE 7. TIMING BLOCKS AND LED HOLDERS FOR VARIOUS TYPES OF CAMERAS

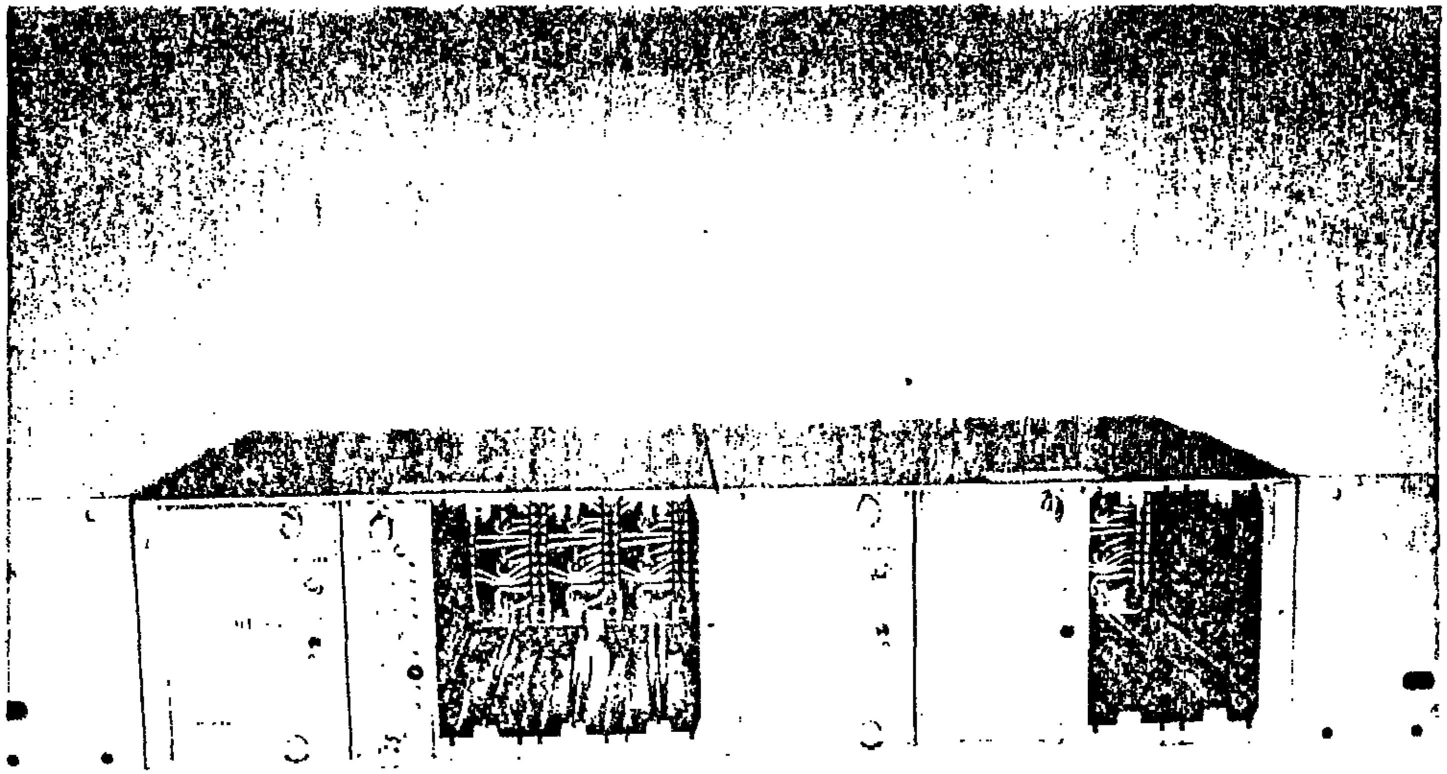


FIGURE 8 HIGH CURRENT AMPLIFIER SYSTEM

Power supply module (Model 9610-153). This power supply module is usable with the Model 9610-213 two-ampere switch module to comprise a high current dual driver system. It also can supply multiple voltages for other modules of the Model 9610 TTU.

Current switch module (Model 9610-213). The high current switch module is designed to operate in conjunction with the Model 9610-201 IRIG camera driver (IRIG A and B codes) or the Model 9610-211 dc camera driver modules (IRIG C code). The switch accepts dc level shift pulse at constant current from 10 to 100 milliamperes from the IRIG camera driver, or dc camera driver, and outputs a dc level shift pulse to drive a LED. The switch output current is 20 times the input current and can be varied from 200 milliamperes to 2 amperes by varying the current control on the IRIG camera driver. The duration of the output pulse is the same as the input (between 10 and 100 microseconds as adjusted) within 2 microseconds (including rise and fall times).

The HCA system is used in conjunction with another Datum Inc., Model 9610 TTU chassis containing the Model 9610-201 IRIG camera driver or the Model 9610-211 dc camera driver and the Model 9610-150 power supply. See paragraphs 3.3.3, IRIG Camera Driver; 3.3.4, DC Camera Driver; and 3.12, Power Supply; in WSMR PD 2157-70, for a more detailed description of these modules.

Field Test Setup

In the field, camera control vans with appropriate camera equipment are used to take data at launch and impact sites. Each van contains 16 control boxes. Each control box can contain a high current amplifier system to drive LEDS in high-speed cameras (2,500 to 11,000 frames per second), such as Nova and Hy-Cam. Table I gives the current setting and pulse width setting for the type of film, frame rates, and type of timing to produce the optimum timing in the field.

Results

There has been no problem with the quality of timing on the film, and there has been no trouble with MV10B3 LEDS burning out at the higher current setting due to the short pulse width setting. The HCA system improves field operation conditions because of automatic polarity and monitor capability of the system. The only disadvantage of using the HCA system is that current supply to the LED has to be measured at the camera input instead of at the HCA output.

Conclusions

The HCA system is very effective to record good quality timing on high speed cameras in the field.

Camera Timing Amplifier

Description

The Datum Inc., Model 9610-401 camera timing amplifier (CTA), shown in Figure 9, receives IRIG A or B time codes and outputs serrated dc level shift signals to drive two external LEDS in the camera and one internal LED mounted on the CTA to monitor the timing signals to the two external LEDS. It also has an auxiliary LED driver for GO, NO-GO remote monitoring. The CTA has automatic polarity selection as described in Timing Terminal Unit System. It also has indexing capability for use with those cameras requiring indexing. The current to each LED in the camera can be internally adjusted from 10 to 400 milliamperes, and the pulse widths of the serrated timing pulses are internally adjusted from 10 to 100 microseconds. The CTA dimensions are small (1-3/4 x 3-3/4 x 2-3/4 inches), and it has a detachable hook to mount the CTA on the camera.

Field Test Setup

At the time of the writing of this report, the CTA's were just procured; therefore, no field experience can be included. In the field, the CTA will be used in nontracking camera installations in launch and impact areas. The CTA will replace the modified Astrodata Model 6620 TTU and the 10 tube type Model 60-1 Aberline TTU now used.

Expected Results

The following are the expected results of using the CTA in the field:

(1) The CTA will be able to mark high quality timing for all types of cameras, film, timing and frame rates given in Table II because of the wide range of adjustment for current and pulse widths.

(2) The timing at the camera can be monitored remotely or at the CTA on the camera.

(3) No time will be wasted in determining the correct timing polarity to the LEDS in the camera because of automatic polarity selection capability.

(4) Indexing of film will be quicker and index marking will be sharper and will not smear as it had before.

(5) Film reading efficiency will be increased because of improved timing.

(6) Only one LED will be needed for timing. The other LED in the timing block will be used for automatic indexing where applicable.

(7) Because of the small size of the CTA and the ease of field setup, there will be a decrease in time needed for field installation.

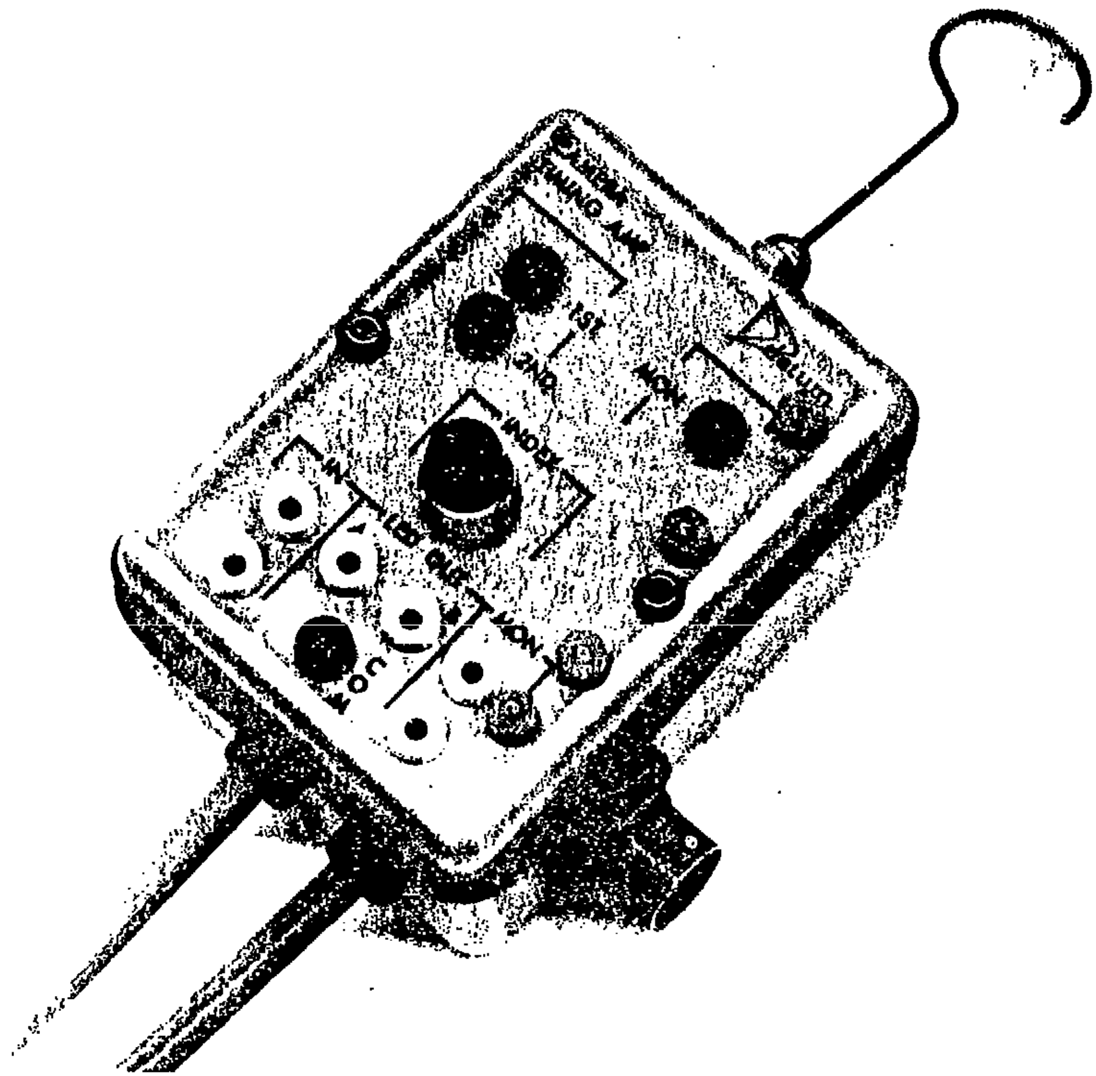


FIGURE 9. DATUM INC., MODEL 9610-401 CAMERA TIMING AMPLIFIER

(8) There will be a decrease in maintenance time and cost because the integrated circuits in the CTA are mounted on sockets for quick repair or replacement, and the LEDS will probably last the life of the camera. Also, the output circuits are short circuit proof and there will be no need to replace fuses if the outputs are shorted.

Conclusions

Using the CTA will result in overall improvement in field operation, reduced maintenance cost, and a reduction of improperly timed film.

TIMING BLOCKS FOR LEDS

Modification

Figure 7 shows the timing blocks for various types of cameras and the holders that fix LEDS in the timing blocks. The holders were machined out of phenolic material at WSMR.

Figure 10 (Various Types of Cameras with the LEDS installed in the Timing Blocks) and Figure 11 (Flight Research and Hy-Cam Cameras with the LEDS Installed in the Timing Blocks) show how the LEDS were wired into various camera timing blocks without a holder

Results and Conclusions

The modifications will not in all cases project a perfect mark on the film as does a projection type block, but the marks are completely acceptable and present no problem in reading the timing. Because WSMR has many cameras, this technique was chosen instead of a projection type system and has resulted in considerable cost savings.

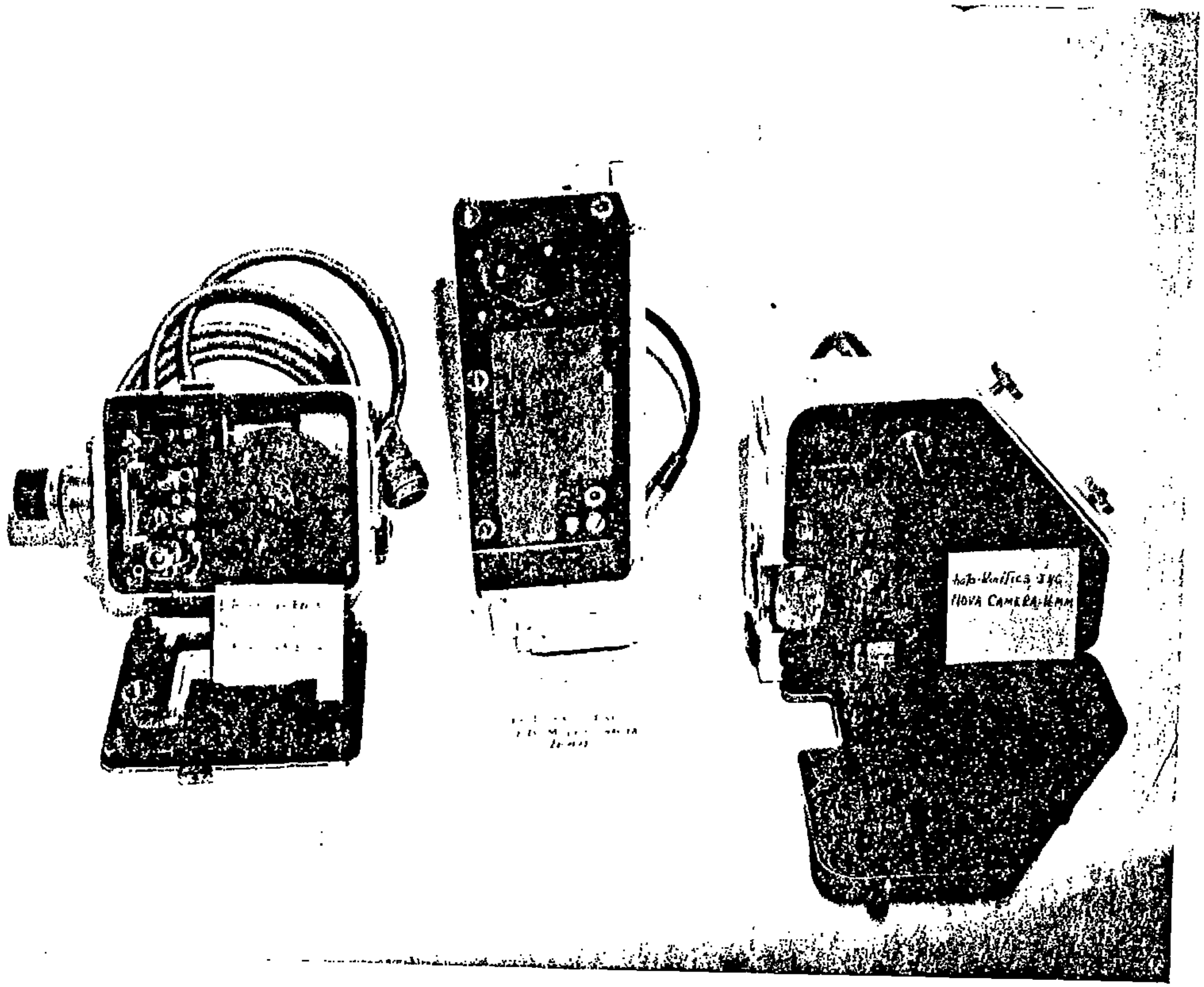


FIGURE 10. VARIOUS TYPES OF CAMERAS WITH THE LED INSTALLED IN THE TIMING BLOCKS

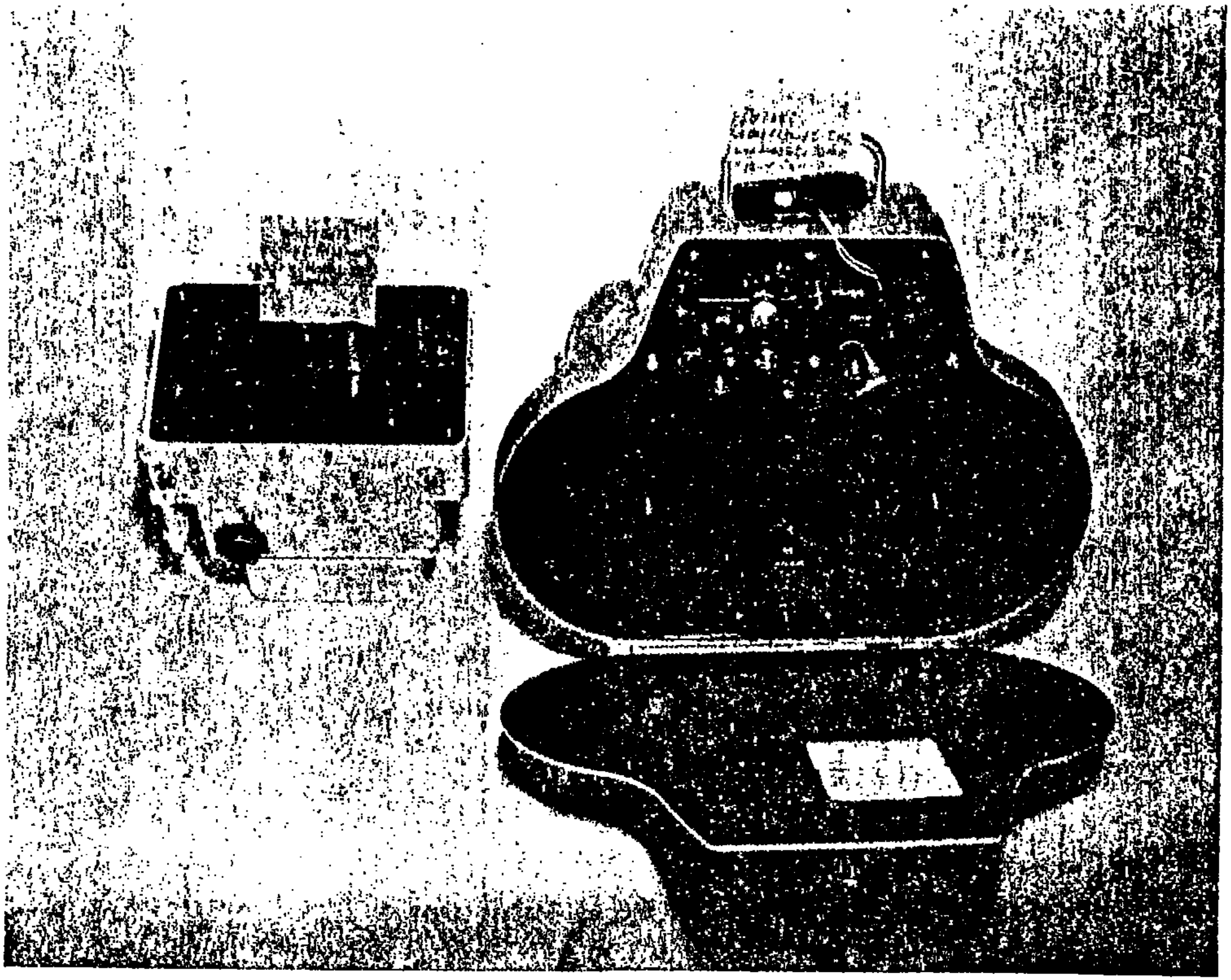


FIGURE 11. FLIGHT RESEARCH AND HY-CAM CAMERAS WITH THE LED'S INSTALLED IN THE TIMING BLOCKS