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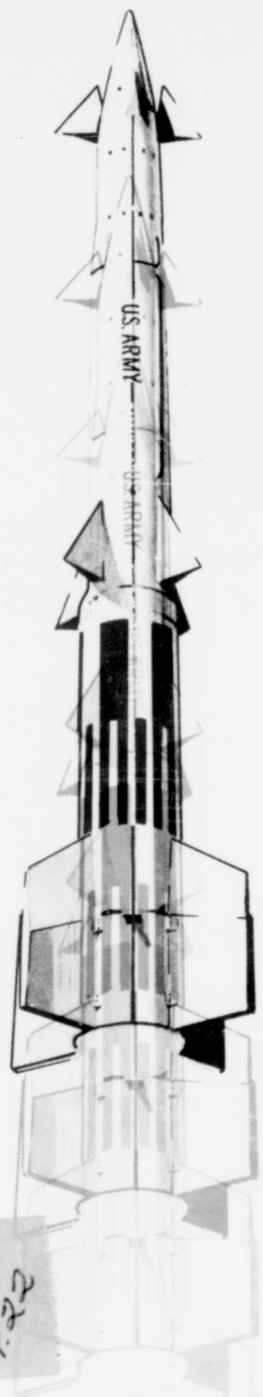
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# BALLISTIC CAMERA SYNCHRONIZATION & CONTROL SYSTEM

CONTRACT NUMBER DA-30-069-ORD-3291

Progress Report No. 4



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Link Division, General Precision, Inc., Palo Alto, Calif.  
BALLISTIC CAMERA SYNCHRONIZATION  
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(July 1, 1961 to July 31, 1961) (Unclassified)

15 pages and 3 illustrations  
Contract No. DA-30-069-ORD-3291  
OMS 5210.11.13506.05.55  
DCN 110.095.006.006.1  
Ser. No. 06-61173  
No Distribution Limitations  
Report is Unclassified

Link, Palo Alto, has submitted to the New York Ordnance District four subsystem schematics, of the Ballistic Camera Synchronization and Control System, for White Sands Missile Range approval. The schematics submitted are: G-4 Averaging and Synchronizing Circuit, Coarse Adjust Synchronization System, Fine Adjust Synchronization System, and Hysteresis Motor Filtering System. The minutes of the Design Review Meeting, that was held at White Sands Missile Range, are included in the Progress Report. The Timing Circuit and the Camera Shutter Detector are discussed.

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**BALLISTIC CAMERA SYNCHRONIZATION  
& CONTROL SYSTEM**

**Contract Number DA-30-069-ORD-3291**

**Progress Report No. 4**

**Link Division  
General Precision, Inc.**

**August 15, 1961**

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FOREWORD

This progress report is submitted in accordance with Article I, paragraph c(1) of Contract No. DA-30-069-ORD-3291. This fourth report documents the period from 1 July 1961 to 31 July 1961.

## SUMMARY

Link, Palo Alto, has submitted to the New York Ordnance District, four subsystems schematics of the Ballistic Camera Synchronization and Control System, for White Sands Missile Range approval. The ~~schematics submitted are:~~ G-4 Averaging and Synchronizing Circuit, Coarse Adjust Synchronization System, Fine Adjust Synchronization System, and Hysteresis Motor Filtering System. The minutes of the Design Review Meeting, that was held at White Sands Missile Range, are ~~included in the Progress Report.~~ <sup>presented.</sup> The Timing Circuit and the Camera Shutter Detector are ~~discussed~~ <sup>discussed</sup>.

*\*\* treated.*

*\* Subsystem schematics are discussed including:*

## 1.0 Introduction

This is the fourth in a series of monthly reports covering the progress of the Ballistic Camera Synchronization and Control System. These reports will provide a technical record of the development program. The work completed in the previous month will be covered, and an outline of the work to be done for the next reporting period will be presented. Major problems which arise will also be reported.

## 2.0 Present Program Status

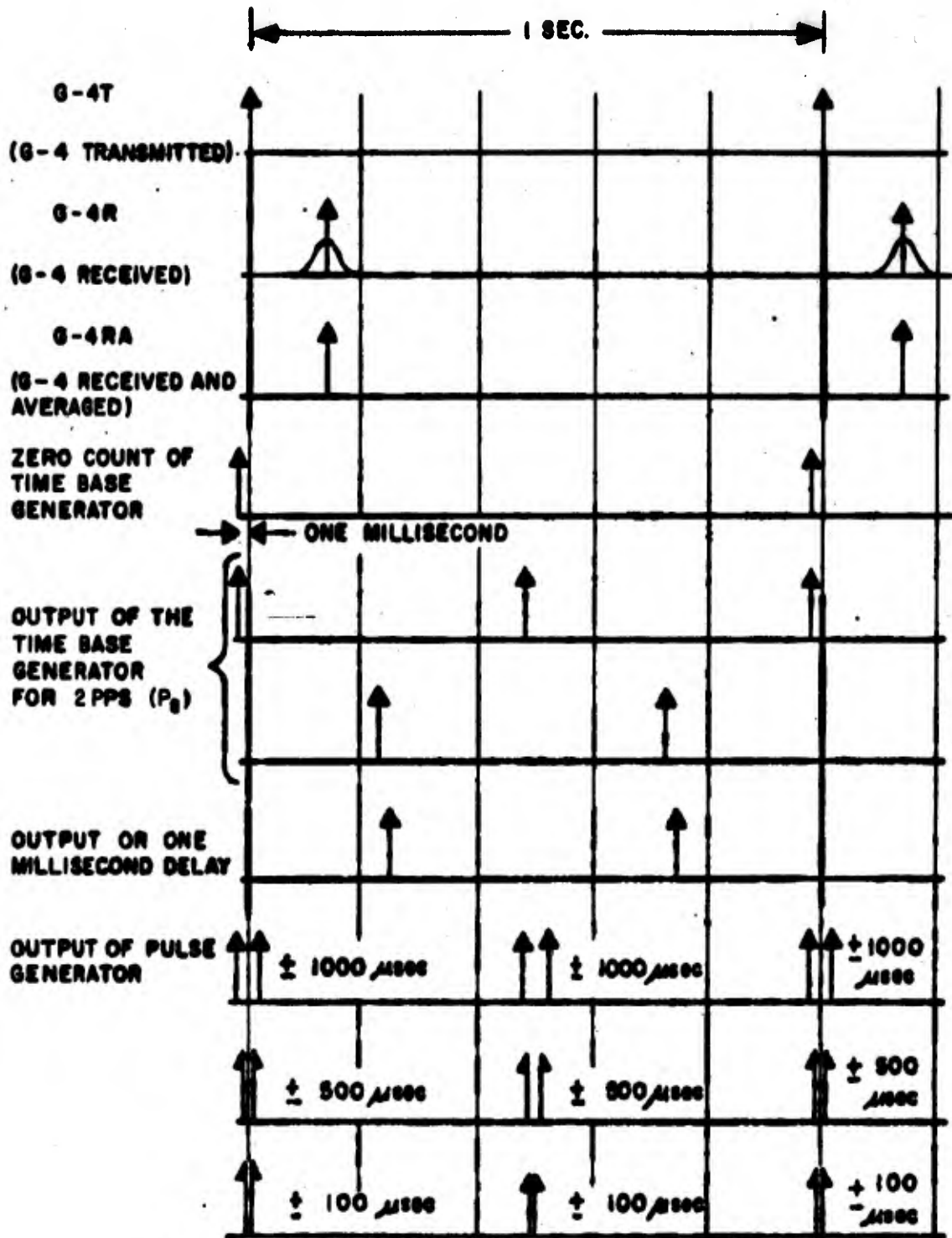
During the month of July, 1961, four subsystems of the Ballistic Camera Synchronization and Control System were forwarded to the New York Ordnance District for White Sands Missile Range approval. The subsystems are the G-4 Averaging and Synchronizing Circuit, the Coarse Adjust Synchronization Circuit, the Fine Adjust Synchronization Circuit, and the Hysteresis Motor Filtering System.

The design of the drawer for the 3C Card Cages and the mechanical design of the servo for the resolver has been completed. The two units mentioned above are now being fabricated. The electrical filters required for the Resolver Circuit are on order; the delivery date is September 15, 1961. The circuit design of the Camera Shutter Detector, Precision Delay Circuit, one millisecond delay circuit, and Pulse Generator has been started.

### 3.0 Timing Circuit

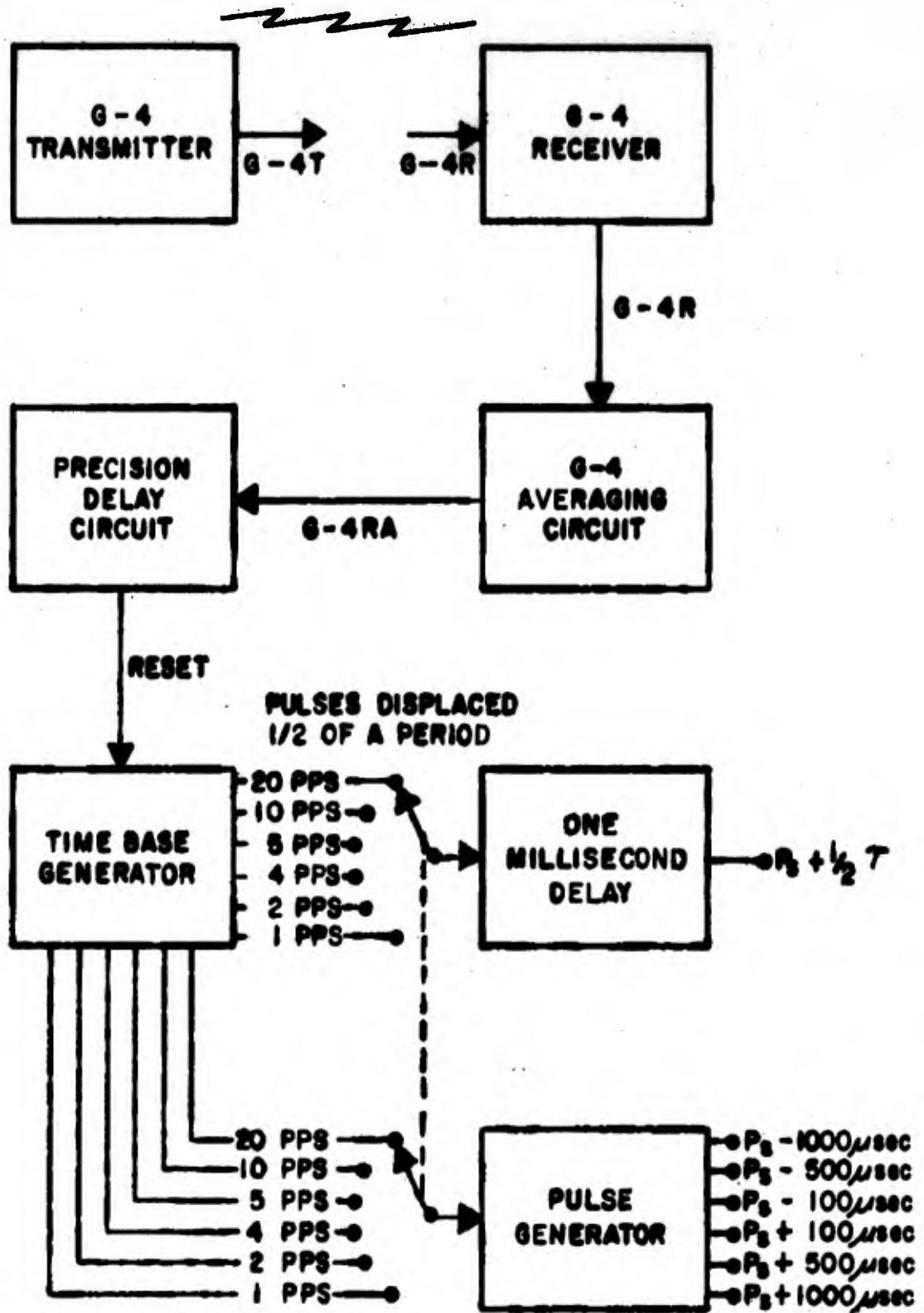
The Timing Circuit furnishes all of the timing pulses required by the Camera Shutter Synchronization System and the coincidence checking circuit. Figure 3-1 is the Timing Chart for a camera rate of two frames per second and Figure 3-2 is a block diagram of the system. The time relationship is shown from the G-4 transmitted pulses to the pulses that are fed to the Camera Shutter Synchronization System. G-4 pulse is transmitted at time zero and is received at time zero plus the transmission delay. The G-4 received pulses are averaged over twenty pulses to remove the pulse jitter. Then the G-4 Averaging Circuit supplies a pulse that corresponds to the G-4 received pulse without pulse jitter. The G-4 received and averaged pulse is delayed 21 milliseconds minus the transmission delay time by the precision delay circuit. The output of this circuit resets the time base generator to a zero count, one millisecond ahead of time zero. The output of the Time Base Generator is 20, 10, 5, 4, 2, 1 pulses per second, referenced to one millisecond ahead of time zero; and 20, 10, 5, 4, 2, 1 pulses per second, referenced to one millisecond ahead of time zero plus one half of a period. The one half of a period displaced pulses are delayed one millisecond to reference them to time zero plus one half of a period. The function is performed by the one millisecond delay circuit. The Pulse Generator is triggered by the one millisecond ahead of time zero pulses. The outputs of the Pulse Generator are  $\pm 1000$  microseconds,  $\pm 500$  microseconds and  $\pm 100$  microseconds.

The output of the one millisecond delay and the Pulse Generator outputs of  $\pm 1000$  microsecond and  $\pm 500$  microseconds are used by the Camera Shutter Synchronization System. The  $\pm 100$  microsecond pulses of the Pulse Generator are used by the coincidence checking circuit.



Timing Chart

Figure 3-1



Block Diagram of Timing Chart

Figure 3-2

## 4.0 Camera Shutter Detector

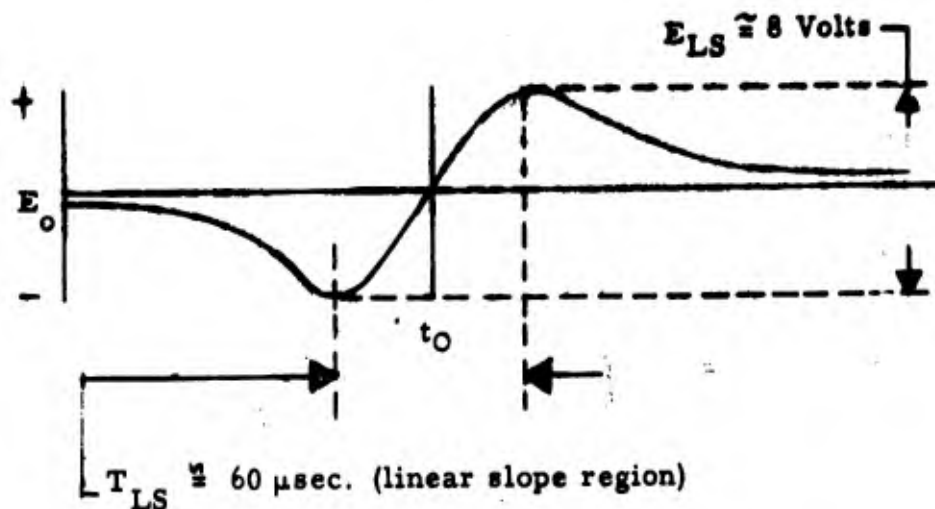
### 4.1 General

Tests have been made, using the Camera Simulator, to determine the characteristics of the output signal from the variable reluctance pickup. A tentative method for detecting the Shutter crossover point has been chosen, as shown in Figure 4-1. It now appears feasible to couple the pickup output to a 50 ohm coaxial cable with a step-down matching transformer, to transmit the pickup signal up to 100 feet distance with negligible distortion of waveform.

The transmitted signal will be amplified sufficiently to permit detecting the zero voltage crossover point by means of a Schmidt Trigger - the output of which will drive a one-shot multivibrator to generate the shutter pulse required for the input to the synchronization system.

### 4.2 Matching Transformer

The no-load output obtained from the VR pickup of the Camera Simulator, for a shutter rate of 40/sec., has the following waveform:



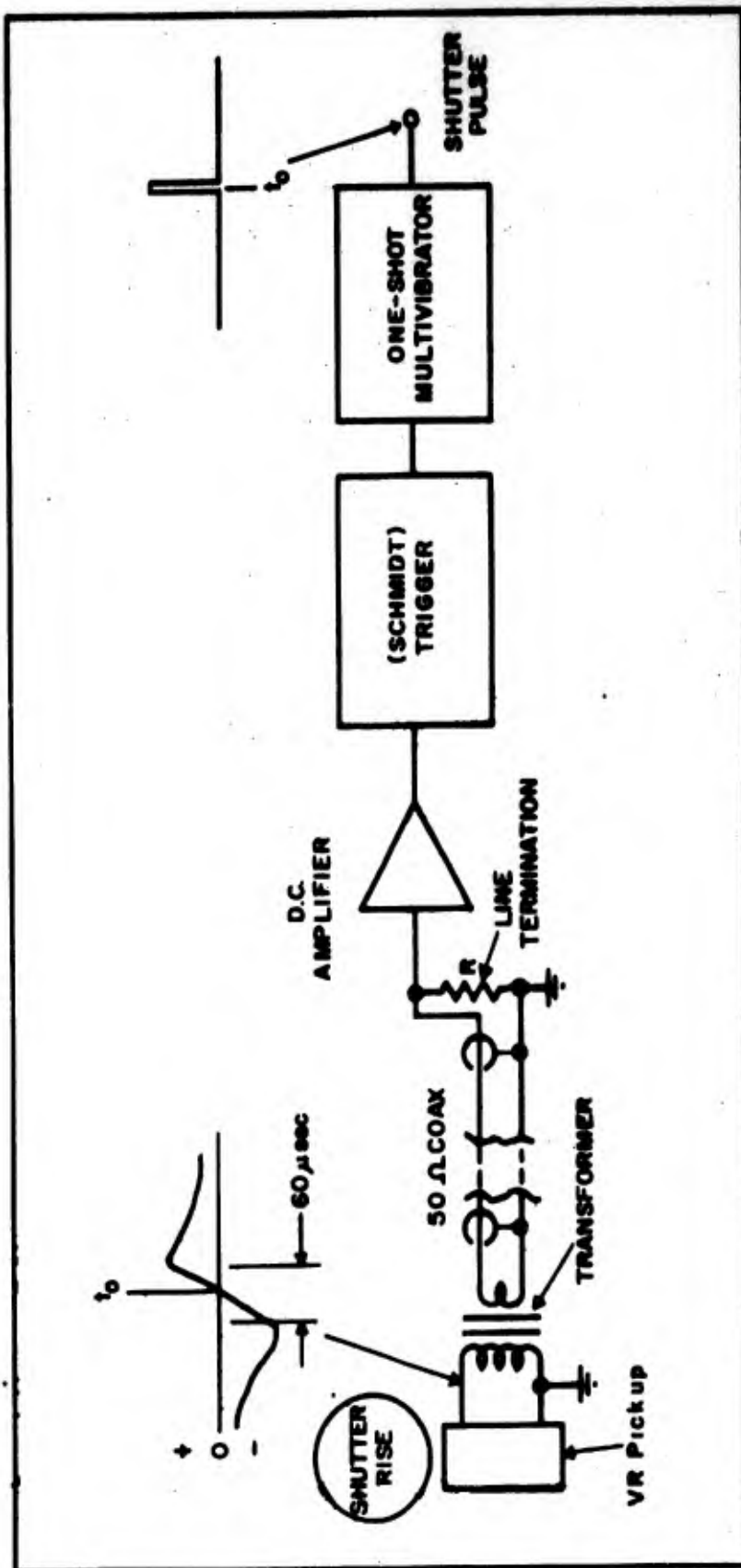


Figure 4-1 Camera Shutter Detector

To preserve the zero crossover time of this waveform, the transmission path through the matching transformer and the coaxial cable should have a broad band linear response to the order of the 100 kc or more. Tests have been made with a transformer having a few turns on a high permeability tape wound core. Results indicate satisfactory transmission of the waveform, although a higher primary impedance is required to pass the low frequency component of the signal. Pickup loading, transformer step-down and transmission losses will attenuate the signal by a factor, K.

#### 4.3 Crossover Point Detection

Crossover point detection will be accomplished by detecting the zero crossover of the linear slope region of the waveform by means of a Schmidt Trigger (3-C card ST-30), adjusted to switch when the input exceeds zero volts in the positive direction. Input to the Schmidt Trigger will be from the output of a linear, stable DC amplifier which will amplify the transmitted pickup signal sufficiently for the zero crossover point to be detected within the required timing accuracy,  $\Delta t = 5 \mu\text{sec}$ .

Assuming a trigger voltage accuracy,  $\Delta E$  of 0.2 volts ( $\pm 0.1$  volt) for the Schmidt Trigger Circuit, the required amplifier gain will be:

$$A = \frac{1}{K} \frac{T_{LS}}{\Delta T} \frac{\Delta E}{E_{LS}}$$

where  $K$  is the ratio of the transmitted signal to the no-load pickup signal,  $T_{LS}$  is the linear slope time,  $\Delta E$  is the trigger voltage accuracy,  $\Delta t$  is the required timing accuracy, and  $E_{LS}$  is the no-load linear slope amplitude.

Initial tests indicate this will reduce at a shutter rate of 40/sec. to

$$A_{40} \approx \frac{1}{0.1} \frac{240}{5} \frac{0.2}{8} = 3$$

However, at the slowest shutter rate of 10/sec.,  $T_{LS}$  increases by 4X,  $E_{LS}$  decreases by 4X, and

$$A_{10} \approx \frac{1}{0.1} \frac{240}{5} \frac{0.2}{2} = 48$$

#### 4.4 Output Pulse

The Schmidt Trigger output will be used to drive a one-shot MV flip-flop (3C card DM-30) to generate a 0.6  $\mu$ sec. shutter pulse.

## 5.0 Notes from Trip to White Sands Missile Range

As a result of the schedule commitments, a design review meeting was held at WSMR on July 18-19, 1961. Those in attendance were John C. Davies - WSMR technical supervisor, Ed L. Becker - Manager, Customer Relations, General Precision-Link, R. L. Peters and Ray Long - project engineer and design engineer respectively from General Precision-Link. The purpose of the meeting was to firm up all designs pertaining to the Ballistic Camera Synchronization and Control System.

The first technical meeting was instituted at 9:00 A. M. , Tuesday, July 18. This conference consisted of a review of the overall system and the related systems design. The points of interest which were discussed will be listed below in their chronological order:

### 5.1 Camera Control Unit

The camera control unit was the first item on the agenda. Link, Palo Alto, notified WSMR the control unit was to be purchased from F. C. Hensen Company - the camera manufacturer. It was noted that this unit met all specifications with the exception of a dial which controlled light intensity. The F. C. Hensen Company used a mechanical timer and linear adjustment. The specifications called for a logarithmic adjustment. It was explained by Link that the control unit could be modified. However, this would include an increase in price of the unit. Mr. Davies took this problem under advisement.

### 5.2 Sixty Millisecond Advance

The next item to be discussed related to the 60 millisecond advance which the specifications called for. It was noted by WSMR that by judiciously utilizing information already available and by a minor redesign, this subsystem could be deleted without affecting overall system performance. The 60 millisecond pulse advance subsystem is to be replaced by a programmed tape reader and the necessary associated circuitry.

Note: It must be remembered that this was a design review, and all tentative decisions which were made are subject to approval by the New York Ordnance District.

### 5.3 Star Tracking Timing

The timing associated with star tracking was then reviewed. By taking advantage of available equipment, and by increasing the number of channels on the event recorder, it was decided that a simple approach was available for measuring time, within the required specifications, which did not necessitate the use of a clock comparator. The method utilizes the frequency standard and the fact that the frequency standard had been related to real time through G-4.

### 5.4 G-4 Averaging System

The next discussion covered the G-4 averaging system. Link, Palo Alto, gave a mathematical sample of the method to be used. Tentative averaging times were then agreed on. The G-4 pulses are to be averaged over a 20 second period. It was also noted that information received from WSMR by Link, Palo Alto, pertaining to G-4 pulse jitter contained a pulse which did not fall within the Gaussian distribution, but was periodic - every tenth pulse. It was explained that this weighted pulse could only be removed by a fixed delay and not by averaging.

### 5.5 One PPS Shutter Rate

It was here noted by WSMR that the 1 pps shutter rate would not be utilized. However, it was decided that the system would not be modified to delete this redundancy.

### 5.6 Automatic Synchronization

Link, Palo Alto, described the system, which was documented in Progress Report No. 3, because it deviated from the original design concept. It was pointed out that preliminary tests had been performed with good results. It was decided that this design could be finalized and WSMR agreed to sign off the logical schematics.

### 5.7 Motor Filtering System

The next discussion covered the motor filtering system. It was explained to WSMR that data was obtained from F. C. Hensen Company that necessitated special filter designs to reduce harmonic distortion and phase shift. WSMR agreed to sign off this design also.

They also agreed to authorize the purchase of 25 of the special filters.

#### 5.8 Frequency Standards

Since information had not been received from Hewlett-Packard Company on the reliability tests, this item was bypassed awaiting additional information. It should be noted here that frequency standard has not yet been chosen. Since this is a long lead time item, this may very well affect the delivery date.

#### 5.9 Recorder

Consideration was now given to the type of recorder to be used. It was tentatively decided to replace the specified recorder with a 100 channel event recorder. R. L. Peters suggested here that an impedance matching problem would exist at the recorder inputs. WSMR agreed to furnish all impedance output information which would be affected.

#### 5.10 Patch Panel

Since a 100 channel recorder has been tentatively chosen, the necessity of installing a patch panel was now questioned. It was pointed out by R. L. Peters that because of stringent environmental conditions, military approved racks were a necessity. WSMR tentatively concurred.

#### 5.12 Trouble Shooting Oscilloscope

It was tentatively agreed that WSMR would ask Link, Palo Alto, for a recommended spare parts philosophy which would be based upon testing experience.

#### 5.14 A. D. Number

WSMR agreed to obtain an A. D. number for the progress report.

The conference began at 8:30 A. M. on Wednesday, July 19. The same people were present. The first item on the agenda was a discussion of a method of solution to a proposed amendment. This amendment introduced a programming system to be used in conjunction with the original camera system.

After a preliminary discussion, it was tentatively agreed that a tape reader should be used in lieu of an IBM card programmer, since a card system would be prohibitive in cost. A system was blocked out, and it was pointed out by Link, Palo Alto, that time synchronization is a major problem. Since the synchronizing pulse (P-1000 Z) can occur at any time with respect to the synchronized shutter pulse, there must be a reference of some sort supplied between the two pulses. If a reference is supplied (this means using a special receiver channel) then the problem is easily solvable. If there is no reference supplied, then the problem is not easily solved. The solution which is obtained has a certain probability of failure. This is a decision which has to be made by WSMR - i. e. whether they want to live with an error probability. WSMR has taken this problem under advisement.

The basic problems which arise in this design are listed alphabetically below:

- a) synchronization with P-1000 Z,
- b) application to star trails,
- c) application in programming synchronization system,
- d) requirements of a computer constant for data reduction,
- e) tape indexing technique,
- f) design a replacement for the comparator clock,
- g) an integrated manual operation for star trail programming.

WSMR also agreed to specify the tape reader or the tape specifications.

Because of the many design changes tentatively agreed upon, John C. Davies informed Link, Palo Alto, that all changes incurred during the discussions would be specifically elaborated on in an amendment. This would alleviate any change of scope memorandums to be instituted. To reduce the paper work, all changes would be added to the original amendment which is being forwarded to Link, Palo Alto. This new amendment would supercede the original amendment.

Specifically, Mr. Davies listed the changes and additions to the original amendment in this order:

- (1) the 60 ms advance subsystem is to be deleted,
- (2) Link, Palo Alto, is to recommend whether the B. C. S. and C. S. should be programmed by the tape reader,
- (3) the synchronizing method for P-1000 Z will be specified by WSMR and Link, Palo Alto, is to implement that particular method,
- (4) in section 4. 4 of the original specification, 5 ms advance is to be changed to 20 ms,
- (5) the clock comparator is to be deleted,
- (6) the WWV receiver may be deleted,
- (7) a different event recorder will be specified,
- (8) the patch panel may be deleted,
- (9) the logarithmic scale is to be deleted from the control unit, and
- (10) WSMR will specify a need for a better scope; Link, Palo Alto, is to decide which oscilloscope should be substituted.

As a result of the design review, WSMR has agreed to approve the following subsystem schematics by August 15, 1961, if received by July 24, 1961:

- (a) G-4 averaging circuit,
- (b) coarse and fine automatic synchronization system, and
- (c) motor filtering system.

Mr. Davies also agreed to take immediate action on the following items:

- (1) transcribe and send to Palo Alto a set of the informal notes,
- (2) rewrite the amendment, and
- (3) forward the design review approval to New York Ordnance after the receipt of the schematics from Link, Palo Alto,

6.0 Program for the Subsequent Reporting Period

The design of the Precision Delay Circuit, One Millisecond Delay Circuit, Pulse Generator and Camera Shutter Detector should be completed during the next reporting period. It is hoped that the frequency standard oscilloscope, and the recorder can be ordered during the month of August.

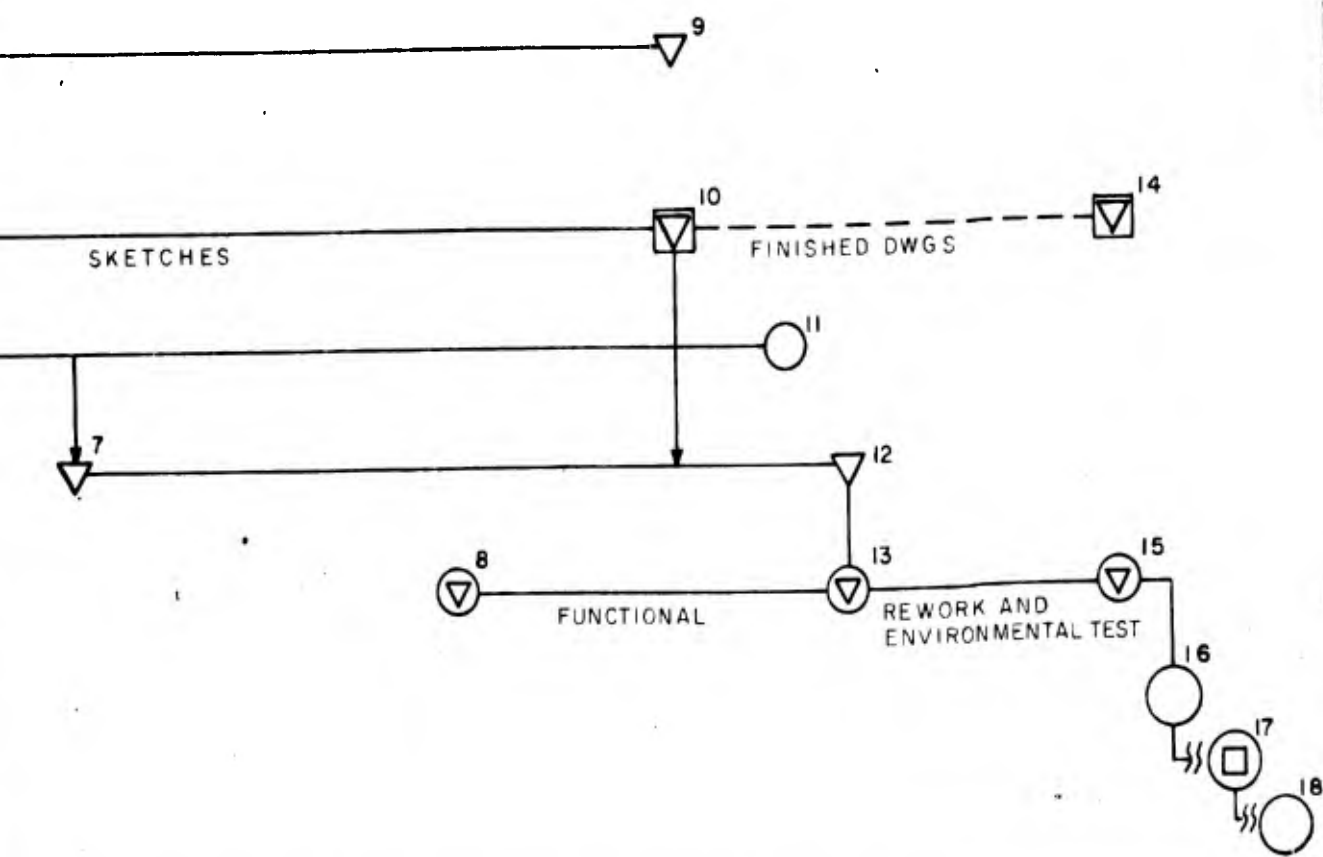
The electrical enclosure will arrive on August 9, 1961, and work will be started to fit the Sola Line Regulator into the enclosure.





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