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AIRBORNE RADIO DIVISION  
ENGINEERING ANALYSIS SECTION

25 July 1946

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TELEVISION - INTERIM REPORT  
ON A SYSTEM FOR HIGH SPEED  
COMMUNICATIONS

by FR-2941

Louis L. George, Associate Engineer

Report # R-2941

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Approved by

S. Riccobono, Assistant Section Head

Robert M. Page  
Acting Supt.  
Airborne Radio Division

Commodore H. A. Schade, USN  
Director  
Naval Research Laboratory

Preliminary Pages.....a,b,c,d  
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ABSTRACT

In accordance with the problem directive, reference (A), development work on a system for high speed communications through the use of television is being carried out. Progress toward completion of the problem is herein reported. The operation of the proposed system is explained and block diagrams given. Up to the present time, work has been done on bench models with fairly successful results.

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TABLE OF CONTENTS

	Page
1. Introduction . . . . .	1
2. Automatic (slave) Receiver Synchronization . . . . .	1
3. Determination of Sweep Frequencies . . . . .	2
4. Message form and Automatic Placement . . . . .	3
5. Transmitter Keying . . . . .	4
6. Synchronization of Camera . . . . .	4
7. Acknowledgement . . . . .	4
8. Voice Communication . . . . .	4
9. Channel Selection . . . . .	5
10. Selective Calling . . . . .	5
11. 110 Volt, 60 Cycle Conversion . . . . .	6
References . . . . .	d
Plate 1 Blocking Oscillator Grid Waveform	
Plate 2 Message Form	
Plate 3 Block Diagram - Camera Synchronizer Unit	
Plate 4 Block Diagram - Channel Selection (transmitter)	
Plate 5 Block Diagram - Channel Selection (receiver)	
Plate 6 Block Diagram - Selective Calling - Coding Unit	
Plate 7 Block Diagram - Selective Calling - Decoding Unit	
Distribution List . . . . .	e

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## INTRODUCTION

1. The proposed system for high speed communications through the use of television was developed after considerable thought and discussion were given to all aspects of the problem. The Block III television equipment is being used as the basis for this work as well as the background gained from work reported in reference (B). The problem requires that the time of transmission shall be as short as possible as well as provide some form of acknowledgement. A time of one-quarter of a second has been specified as desirable. It is also necessary that the receiver sweep oscillators become rapidly synchronized with the incoming sync pulses if a picture is to be taken of the viewing screen during the transmission time. The problem also requires that the most practical message form be determined. Provision for sweep frequency change was also requested. Additional features such as provision for voice communication, automatic message placement and remote channel selection, while not requested, were believed to be desirable and were incorporated. Operation of the system may be considered in two parts. The first of these is for a normal picture transmission. The other is when sending an acknowledgement signal, changing channels or when using voice communications. A signal keyer circuit determines the system operation in accordance with the desired function. The following paragraphs discuss the problems involved and explain the proposed functions of the various circuits.

## AUTOMATIC (SLAVE) RECEIVER SYNCHRONIZATION

2. The security advantage inherent in permitting a choice or change in sweep frequencies employed was considered to be desirable and hence provisions for such selection planned. If possible, rapid change in such selection would also be desirable. To be most effective therefore, the receiver sync oscillators should instantly lock in or "follow" the transmitted sync pulses without the necessity for adjusting the vertical and horizontal hold controls. If this could be accomplished satisfactorily, then the receiver hold controls could be eliminated. One method of doing this would be to drive the sawtooth generators directly with the incoming sync pulses. This method has the disadvantage of requiring a definite length of time for the sawtooth generator to stabilize with respect to voltage output. The method described below will be more satisfactory because of the fact that in the absence of sync pulses, the sawtooth generator voltage output will be only slightly different from that determined by the sync pulse frequency. Hence, less time is required for stabilization.

3. The system of synchronization contemplated operates by virtue of the fact that sync pulse amplitude present at any time on the receiver sync oscillator grid voltage waveform must always be of sufficient value to drive the oscillator tube into conduction. Plate 1 shows a waveform similar to that appearing at the oscillator grid with sync pulses superimposed on it. Each pulse corresponds to a particular sweep frequency. In the figure shown, the values given are for the vertical sweep frequencies of 36, 40 and 44 c. p.s. It is seen that the oscillator time must be fixed so as to be free running at a slightly longer time than the longest vertical sweep time used

(36 c.p.s.) as the transmitted vertical sweep time is shortened, (corresponding to an increase in the vertical sweep frequency) the sync amplitude will drive the oscillator into conduction (provided it has sufficient amplitude) and thus initiate the timing of the blocking oscillator. It is also evident that the sync amplitude present at the blocking oscillator grid must be of sufficient amplitude for a weak signal. In other words, synchronization of both vertical and horizontal sweeps must be maintained until the video signal voltage is below that required for a satisfactory picture. From the discussion on the determination of sweep frequencies to be used (given below) and Plate 1, it is evident that the minimum required sync amplitude will be dependent upon the shortest sweep time. These occur at 44 and 17,600 c.p.s. for the vertical and horizontal sweeps respectively.

4. The system of synchronization just described has been made to operate successfully on the test bench by increasing the gains of the respective sync amplifiers in the receiver. It was also found desirable to use a vertical sync pulse of at least 1000 microseconds duration because of filters necessary for rejection of horizontal sweep frequencies in the receiver vertical sync amplifier.

#### DETERMINATION OF SWEEP FREQUENCIES

5. The choice of sweep frequencies to be used was determined by several factors, each of which imposed limitations upon the practical operation of the system. The vertical and horizontal sweep frequencies of 40 and 14,000 c.p.s. respectively, used in the block III equipment provide a scanning rate of 350 lines. Additional resolution provided by any increase in the number of lines is limited by the overall video frequency response of the transmitting and receiving equipment. This value was determined to be approximately 5.5 megacycles per second from the data reported in reference (C). The rate of transmission of picture elements, given in reference (D), assuming equal sweep retrace ratios is:

$$R = \frac{W}{h} m k f n^2$$

Where  $\frac{W}{h}$  = aspect ratio =  $\frac{4}{3}$

m = ratio of horizontal to vertical resolution (assumed unity)

k = utilization ratio = 0.75

f = frame frequency

n = number of lines

For a 350 line system, R is equal to 5.2 megacycles per second. In the case of a 400 line system R becomes equal to 6.75 megacycles per second.

6. It was desired to keep the resolution, and hence the number of lines, constant as different sweep frequencies were selected. In this manner the aspect ratio will be maintained constant since the sweep amplitudes will vary in the same direction and magnitude. For example, if the vertical sweep frequency,  $f_v$ , is decreased 10% from 40 to 36 c.p.s., the amplitude of the vertical sweep will increase approximately 10%. This is true because the parameters of the sawtooth generator stages in the conversion unit, receiver and monitor are fixed values. Similarly, if the vertical sweep frequency is

increased 10% from 40 to 44 c.p.s., the amplitude of the vertical sweep will decrease approximately 10%. In order to keep the number of lines constant, therefore, the horizontal sweep frequency,  $f_h$ , must be changed in the same direction and by the same percentage. The maintenance of a constant aspect ratio is a desirable feature. If this ratio was not held constant as different sweep frequencies were selected, the televised subject matter would appear distorted on the viewing screen at the maximum and minimum aspect ratios used.

7. It was believed that some increase in vertical resolution would be realized by using a scanning rate of 400 lines. It was also desired to vary the vertical sweep frequency from 36 to 44 c.p.s., or  $\pm 10\%$  from a nominal value of 40 c.p.s. Since the number of lines,  $L$ , is equal to:

$$L = \frac{f_h}{f_v}$$

The horizontal sweep frequency ( $f_h$ ) must be varied from 14,400 to 17,600 c.p.s., or  $\pm 10\%$  from a nominal value of 16,000 c.p.s. for a constant scanning rate of 400 lines.

8. This has been accomplished on the test bench using a telephone dial and stepping switch to change the value of grid resistances in the conversion unit vertical and horizontal sweep oscillators. The range from minimum to maximum sweep frequencies is covered in ten steps. Provision for sweep frequency indication can be made but it is reasoned that this is unimportant since a change in the selection previously made (if not known) can be assured by dialing two different numbers.

#### MESSAGE FORM AND AUTOMATIC PLACEMENT

9. Several tests conducted using various size message forms and commercial standard type-written capital letters determined the most practical message form to be the Naval dispatch form, "NavGen-42-1" (size 8" x 6 $\frac{1}{2}$ "). Plate 2 shows a sample of this dispatch form. The message to be transmitted is contained within the area shown (6 x 3-3/4") and may include approximately 220 words when using Navy standard block capital letters.

10. No particular advantage was realized through double spacing of lines or letters. It is contemplated therefore, to use single spacing throughout the message. It was also learned that all information pertaining to origin of message, for whom intended, time, classification, etc., is included in the message so that the scanned area will include this information as well as the message itself.

11. Consideration was also given to a feasible method for automatic placement of each message. A working model capable of doing this was constructed and tested. Its operation is such that the standard Navy dispatch form is printed on a roll of paper, mounted on a typewriter so as to feed through the roller and then to the automatic "message placer". The message form is then passed under the television camera at the correct distance from the lens and fed into a take-up roller which will move each message into place and hold it when a push button is depressed. The take-up roller is driven by a small motor having a quick stop clutch to disengage the roller the instant the message form is in proper position. Maximum speed for message placement was realized at two

per second. An arrangement is contemplated whereby the transmitter is automatically keyed for one-quarter of a second as soon as the message form is placed.

#### TRANSMITTER KEYING

12. The time desired for transmitting the information contained on one dispatch form has been specified at one-quarter of a second. Accordingly, that time can be obtained through the use of a single-shot multivibrator. A relay whose normally open contacts are placed in series with the transmitter oscillator and power amplifier filament center-tap leads, keys the transmitter for the required time when energized by a pulse derived from the multivibrator. Triggering of the single-shot multivibrator is obtained when a push button is depressed or when a message is automatically placed.

#### SYNCHRONIZATION OF CAMERA SHUTTER

13. A working bench model of a camera shutter synchronizing unit has been constructed and operates successfully. The vertical sync pulses are taken from one of the receiver vertical sync pulse amplifiers and fed into the device. A relay in the output stage closes when the sync pulses are present, applying power to a solenoid which actuates the camera shutter. The unit has been designed so as to operate only when the input pulses are within the frequency range from 30 to 50 c.p.s. The unit will not operate unless the pulses within this range have a pulse width in excess of 350 microseconds. Plate 3 shows a block diagram of this unit.

#### ACKNOWLEDGEMENT OF TRANSMISSION

14. Some form of acknowledgement was desired in order for the transmitting station to know that the equipment at the receiving station was functioning. It was thought that a tone reply lasting for one-quarter of a second would be sufficient. When specific acknowledgement of the message or a series of messages is desired, it would be necessary for the receiving station to type a confirmation and televise it. The acknowledgement tone is obtained from a 1000 c.p.s. multivibrator, which in turn frequency modulates another one operating at a frequency of 20 kilocycles per second. When the camera has taken a picture of the viewing screen and the relay which actuates the camera shutter is de-energized, a voltage pulse of the proper polarity is generated and triggers a single-shot multivibrator. The single-shot multivibrator is a signal keyer whose function it is to disconnect the conversion unit video and sync signals from the transmitter and to connect the 20 kilocycles per second frequency modulated pulses to the transmitter sync input terminals. It also keys the transmitter for one-quarter of a second.

15. At the receiver, the 20 kilocycles per second frequency modulated pulses are amplified, limited and demodulated by a discriminator. An audio frequency amplifier and loud speaker follow the discriminator. Plates 4 and 5 show block diagrams of the foregoing description.

#### VOICE COMMUNICATION

16. Voice communication, if desired, can be obtained by frequency modulating the 20 kilocycles per second multivibrator according to the speech wave forms. A grip or push to talk type microphone may be added for that

purpose. The equipment then becomes a pulse frequency modulation communication system. The transmitter is on for as long as the push to talk button is depressed. A working bench model of this system has been successfully demonstrated.

#### CHANNEL SELECTION

17. A system for remote control by radio of transmitter and receiver operating channels is being considered. It would be desirable for the receiving station to be able to change the operating channel in the event of interference or jamming. The system being considered will enable the operator to change frequency by dialing a channel number. All receivers and transmitters within range will then be switched to a new pre-set channel. The Block III transmitters are not readily adaptable to automatic tuning as being considered, but the receivers may be operated with spot tuners and provision for such is now being made. At a future date consideration will be given to converting some Navy transmitter that can be modified for video modulation and is adaptable to dial or spot tuning. The system being designed at present functions in the following manner: When a change to another pre-set channel is desired, the operator dials a single digit number. The contacts on the dial mechanism connect a 5 kilocycles per second signal to the pulse frequency modulator stage which frequency modulates the 20 kilocycles per second sub-carrier. The transmitter is made operative for the length of time required for dialing. The transmitter sync input terminals are also connected to the pulse frequency modulated 20 kilocycles per second sub-carrier. Plate 4 contains the block diagrams of this system. At the receiver, after amplifying and limiting the 20 kilocycles per second signal it is passed through a discriminator and the pulses of 5 kilocycles per second recovered. These are then passed through a 5 kilocycles per second tuned filter, amplified and then used to operate a stepping switch. The stepping switch in turn controls a Yardeny spot tuner for changing receiver and/or transmitter frequencies. The requirement that no action take place until all pulses have been received is met by withholding power from the spot tuner for a definite length of time. Power is then applied and removed after the new channel has been reached. The stepping switch is then reset to a home or starting position. Provision is also made for rejecting random pulses up to four in number. A light indicating the channel in use remains illuminated until a new channel is dialed. A warning light also given indication when a channel is being changed. Plate 5 shows a block diagram of the system described above. Fair success has been realized with working bench models designed for this system.

#### SELECTIVE CALLING

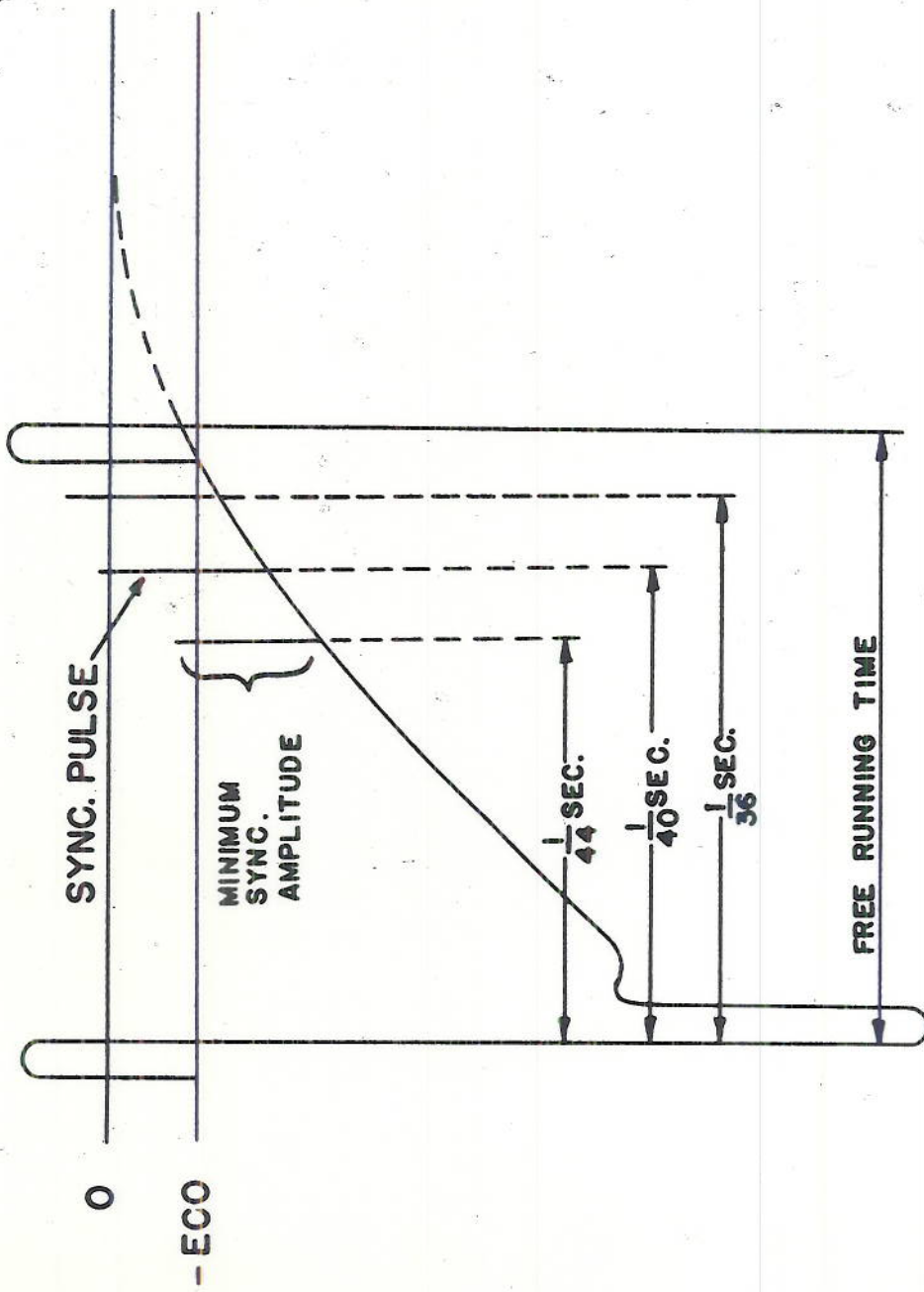
18. No provision for selective calling is being made at the present time. A system for permitting calling of one or all stations is described in reference (E), and is believed to be easily adaptable to the above system. The feasibility of incorporating selective calling will be given consideration at a later date. Operation of the selective calling system is summarized as follows: When a number is dialed, the first pulse turns on a normally cut-off audio frequency amplifier in the receiver which operates a sensitive a-f relay and locks out the transmitter. An indicator light shows that the system is in use. Depending on the wiring of a multi-connector coding plug, the first complete digit dialed either rejects the call or sets up a condition of the stepping switch mechanism for acceptance of subsequent digits. The same form of

selection is used upon the receipt of succeeding digits. If the number dialed corresponds with the station called, a pulsing gate (part of the stepping switch mechanism) remains open for the duration of each pulse sequence of a digit until the stepping switch attains the tenth and last step. The transmitter is then unlocked. If the number dialed is the wrong one for this station, a decoding relay, actuated by the stepping switch and associated wiring operates the release magnet of the stepping switch which resets to the starting position. The transmitter remains locked-out until cleared by a reset signal. To call all stations the operator dials zero, (actually ten steps). To clear the system for re-calling a reset button is depressed. All stepping switches are then brought to the tenth and last step and released by a long dash. The calling number is determined by a plug wiring according to a predetermined definite plan. Any station call may be changed by rewiring the plug. This system using four digit numbers, will accommodate 84 separate stations. Incorporation of selective calling into the present system would require a separate modulation frequency. This means that the sub-carrier of 20 kilocycles per second would probably have to be increased to 30 kilocycles per second or above so that the two modulation frequencies could be far enough apart as to be easily separated in the receiver. Plates 6 and 7 show block diagrams of the selective calling system.

#### 110 VOLT, 60 CYCLE CONVERSION

19. Shipboard use of 110 volt, 60 cycle power requires converting the present Block III equipment for operation from that source. It is considered desirable to eliminate the dynamotors used in the equipment from a noise standpoint. Accordingly, high voltage plate supplies will be constructed. A.C. operation of the heaters and filaments is not considered feasible because of the fact that D.C. centering voltages are taken from some point in the series-parallel filament wiring. In the conversion unit, shading voltages applied to the first video amplifier grid are obtained from the deflection yokes. The circuits providing these different shading signals are tied in between the negative bias supply and the deflection yokes. Thus, it would be necessary to provide low D.C. voltage and high current power for these requirements if the heater circuits were operated from A.C. voltage. It was therefore decided that since a low D.C. voltage and high current power supply would be required for picture centering, D.C. operation of the tube heaters would be continued. Iconoscope bias light power requirement was also another consideration dictating the continued D.C. operation of tube heaters.

- REF:
- (A) BuShips ltr. to NRL 944DA-Ser.08238-944ZA dated 11/16/45.
  - (B) NRL Letter Report C-F42-1/59(317:HG:LLG) C-310-97/45 (amc), dated 11 May 1945.
  - (C) NRL Letter Report C-F42-1/59(317:HG:LLG) C-310-51/45 (rab), dated 23 March 1945.
  - (D) Textbook - Television Engineering by D. Fink.
  - (E) Selective Calling - A Paper by J. K. Kulansky - Electronics Magazine, June 1946.



R-2941

PLATE I

BLOCKING OSCILLATOR GRID WAVEFORM

**U. S. NAVAL DISPATCH**

NAVGEN-42-1

PRECEDENCE

CLASSIFICATION

**From:**

**Action:**

**Info:**

THIS WILL SERVE TO SHOW THE AMOUNT OF INFORMATION THAT MAY BE CONTAINED IN THIS AREA. SEVERAL TESTS CONDUCTED USING VARIOUS SIZE MESSAGE FORMS AND COMMERCIAL STANDARD TYPE-WRITTEN CAPITAL LETTERS DETERMINED THE MOST PRACTICAL MESSAGE FORM TO BE THE NAVAL DISPATCH FORM, "NAV GEN-42-1. THE MESSAGE TO BE TRANSMITTED IS CONTAINED WITHIN THE AREA SHOWN (6" X 3-3/4") AND MAY INCLUDE APPROXIMATELY 220 WORDS WHEN USING NAVY STANDARD BLOCK CAPITAL LETTERS. NO PARTICULAR ADVANTAGE WAS REALIZED THROUGH DOUBLE SPACING OF LINES OR LETTERS. IT IS CONTEMPLATED THEREFORE, TO USE SINGLE SPACING THROUGHOUT THE MESSAGE. IT WAS ALSO LEARNED THAT ALL INFORMATION PERTAINING TO ORIGIN OF MESSAGE, FOR WHOM INTENDED, TIME, CLASSIFICATION, ETC., IS INCLUDED IN THE MESSAGE SO THAT THE SCANNED AREA WILL INCLUDE THIS INFORMATION AS WELL AS THE MESSAGE ITSELF. THIS WILL SERVE TO SHOW THE AMOUNT OF INFORMATION THAT MAY BE CONTAINED IN THIS AREA. SEVERAL TESTS CONDUCTED USING VARIOUS SIZE MESSAGE FORMS AND COMMERCIAL STANDARD TYPE-WRITTEN CAPITAL LETTERS DETERMINED THE MOST PRACTICAL MESSAGE FORM TO BE THE NAVAL DISPATCH FORM, "NAV GEN-41-1. THE MESSAGE TO BE TRANSMITTED IS CONTAINED WITHIN THE AREA SHOWN HERE.

RELEASE

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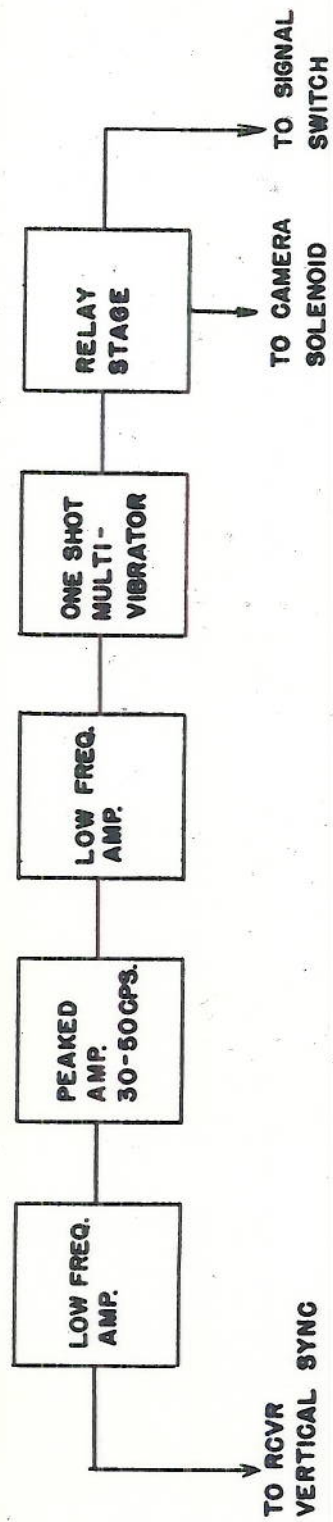
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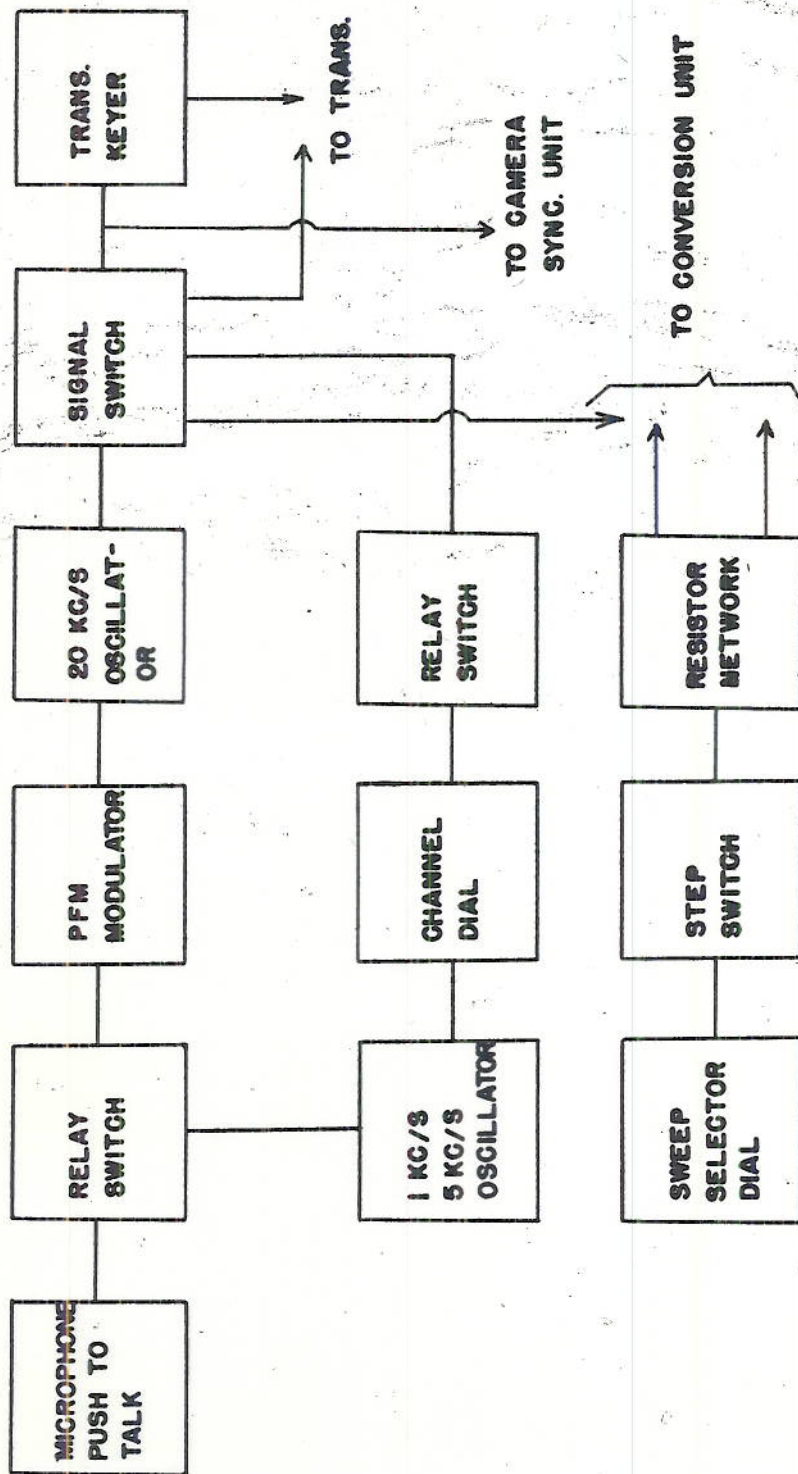
**MESSAGE FORM**



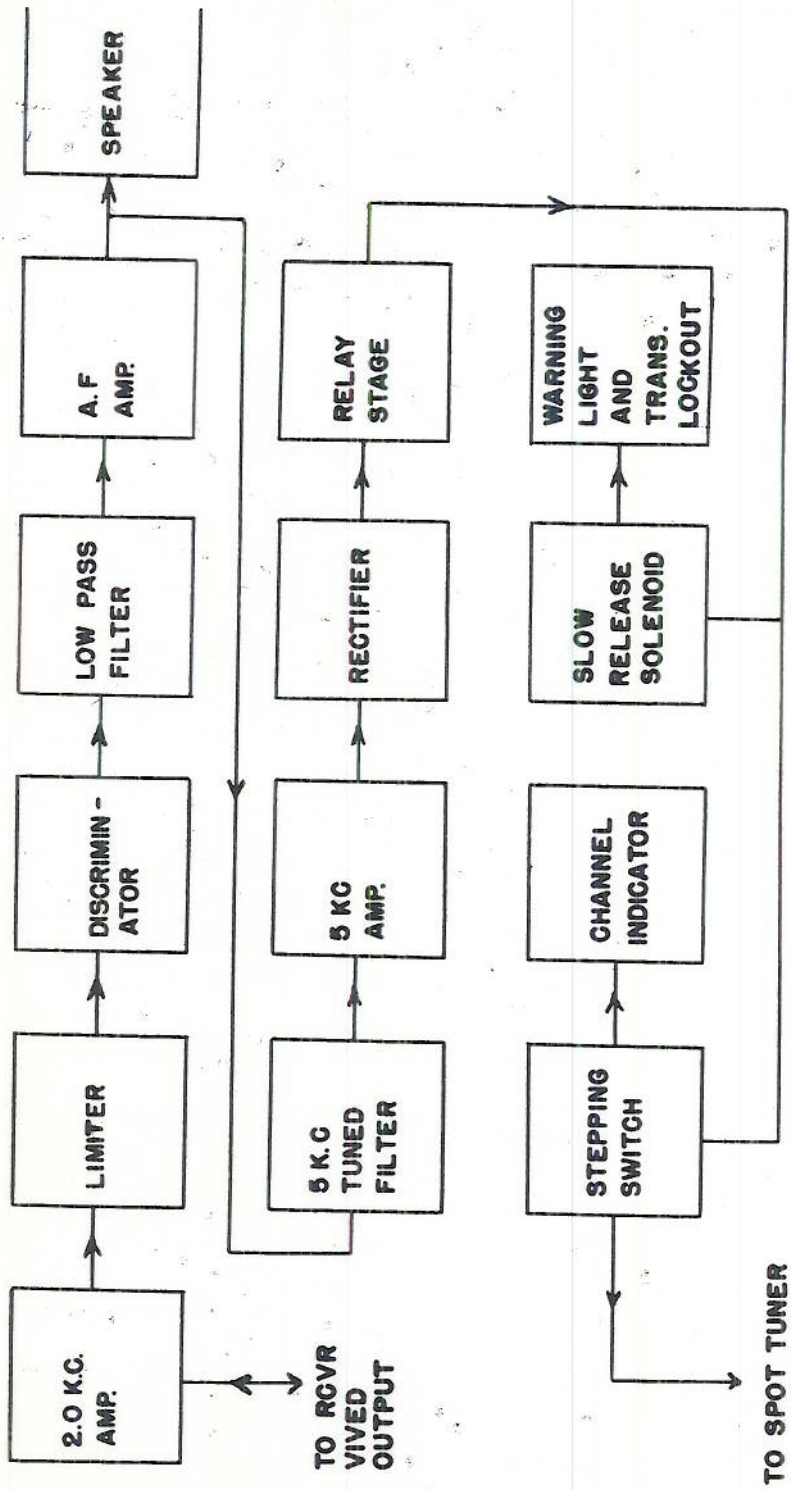
R-2941

CAMERA SYNCHRONIZER UNIT

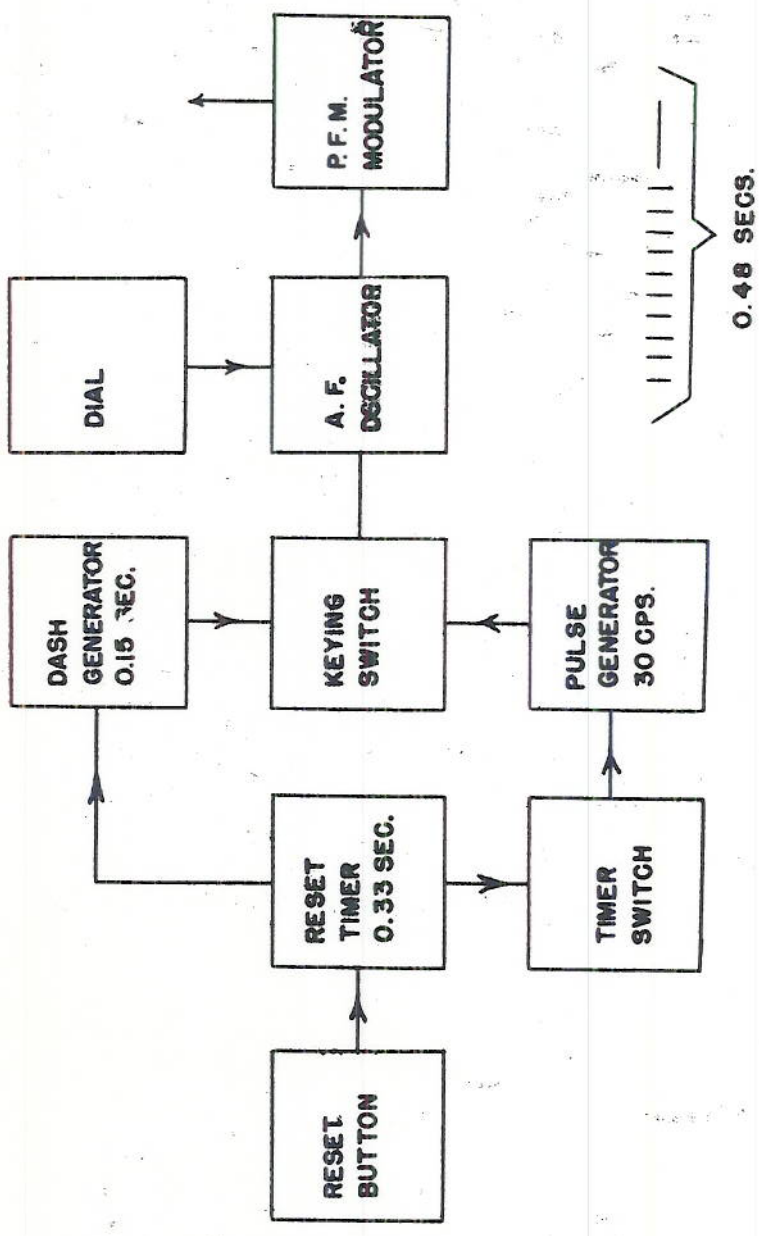
PLATE 3



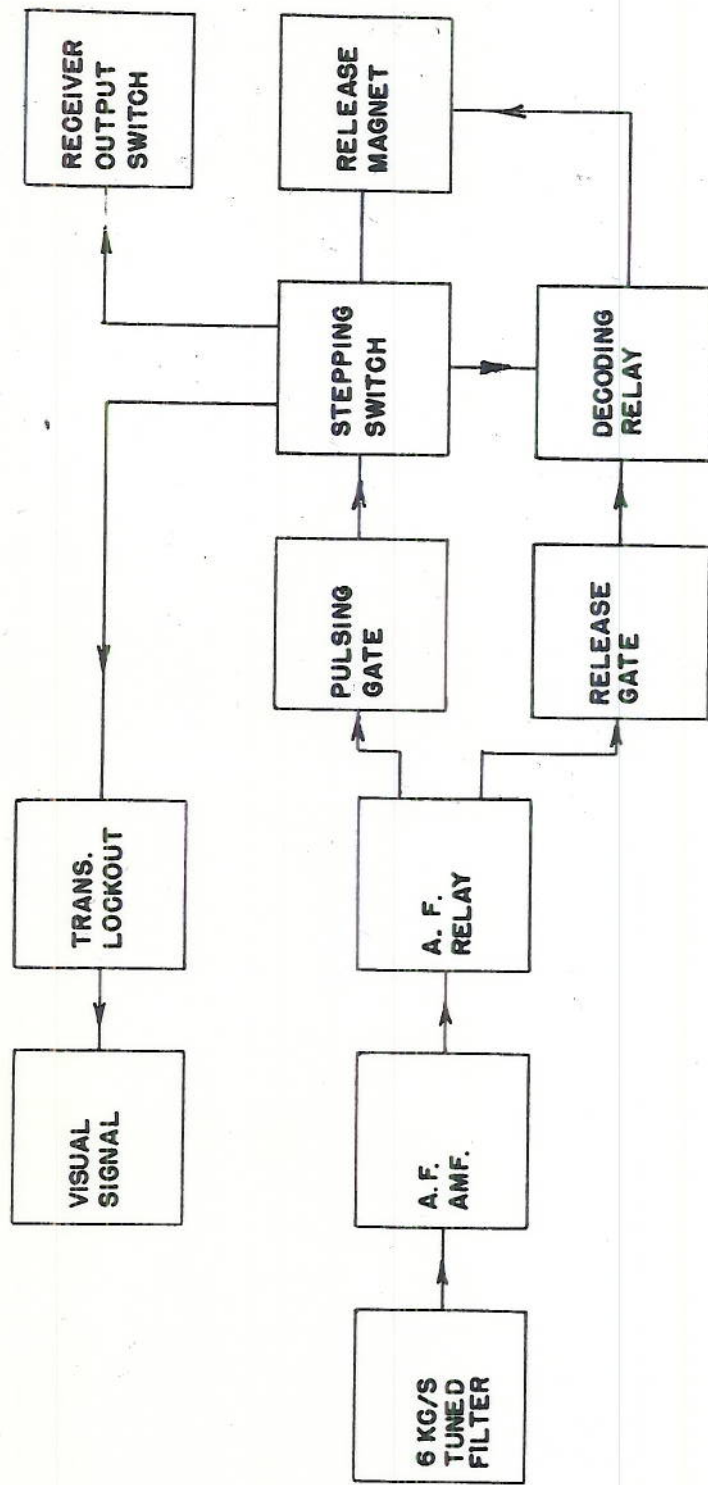
CHANNEL AND SWEEP SELECTION, VOICE COMMUNICATIONS (TRANS.)



CHANNEL SELECTION, VOICE COMMUNICATIONS (RCVR)



SELECTIVE CALLING SYSTEM - CODING UNIT



SELECTIVE CALLING SYSTEM - DECODING UNIT

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