Memorandum 6M-5649

Sheet 1 of 12 Sheets

Division 6 — Lincoln Laboratory
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SUBJECT: REMOTE DISPLAY I

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Abstract:

The present Remote Display System was built to test the feasibility of producing a Sage-type display from a coded telephone message produced by a large computer and transmitted over existing ground-to-ground communication links. The resultant display is bright enough to be viewed comfortably under normal ambient lighting conditions and is essentially flicker-free. The display cathode ray tube is a newly developed tono-typotron.

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LIST OF ILLUSTRATIONS:

I. INTRODUCTION

For some time a need has been felt for a display similar to the Sage Situation Display which is controlled by some central computer, but which could be located at remote sites such as radar stations, air bases, and various launching sites to provide for monitoring, additional information, acquisition of new information, or faster message transfer than can be handled with teletype. Since the drive requirements on the Sage Display generator would make it impossible to use the standard Situation Display Console for such a purpose, three separate proposals were made as possible solutions for a new type of console to fulfill this need.

The first proposal suggests using a new type of display tube called a tono-typotron. In this system the information would be so arranged that it arrives serially at the console in the order in which it can be used. As each bit of information arrives, it is immediately stored in the particular display register in which it is to be used, and each character is displayed as soon as the complete information on that particular character is assembled.

The second proposal involves the use of the same tono-typotron used in proposal one, together with a two track memory. In this system track information from the phone line would alternate between the "A" and "B" track memories, each being stored in "A" or "B" while the preceding track is being displayed from "B" or "A". Since the tube has a finite storage time (adjustable to two minutes) each track would have to be rewritten at the end of the tube storage time either with the same information, or with any new information which the central computer would have accumulated by that time.

The third proposal involves a console using a standard Charactron such as is used in the Situation Display Console together with a sixty-four track memory. Telephone signals would be converted to standard pulses and stored in the memory. The display logic would then sample the memory and display any stored track information at a flicker-free rate.

With any of the proposals two types of format would be available. The particular meaning of any format described may be changed at will and the system discussed below is only meant to be representative of information which might be sent.

The first format is the track message. This format may consist of a vector symbol and twelve characters to supply course, speed, height, identification, and additional track information. The vector symbol consists of one of two direction symbols to indicate the general quadrant of the track rather than a fully directional vector as used in the Situation Display. This is done to conserve information bits in the track message and to simplify the equipment in the console. The vector symbol plus the location of the twelve characters with respect to the vector symbol identify the particular quadrant in which the track is heading while two decimal digits give the exact course to the nearest ten degrees. Since the vector symbols have no amplitude indication, two addition decimal digits are used to give the speed indication to whatever scale is chosen. Several constraints on the choice of characters in this message are necessary in order to be able to specify twelve characters in the available fifty-one information bits for character selection. Thus the first character of course information is constrained to the digits 0-3, the second course character to the digits 0-9, the first character of speed information to the digits 0-7, the second speed character to the digits 0-9, the first character of height information to the digits 0-7, the second height character to the digits 0-9, and the third and fourth track information characters to the digits 0-9. The two identity characters and the first two track information characters are constrained only by the sixty-four available characters on the matrix.

The second type of format available is the Data Message. This format consists of eight characters which may be chosen arbitrarily from the sixty-four available characters on the display tube matrix. Two bits of information, X and Y, permit the location of this format directly under a track message at a given address so that these eight characters may be appended to a track message for additional information on a given track, or the data message may be used independently of any track message to permit rapid information transmittal to the remote console. Figure 1 (SC82450) shows typical arrangements of these messages as well as the character matrix, the constrained character codes, and the arrangement of the telephone message for Proposal one.

In building Remote Display I the objective was to test out the feasibility of using the tono-typotron as a display tube, and to do this as quickly and simply as possible. Since proposal one did not involve the use of any memory devices other than the usual display storage registers, it was felt that this was probably the simplest system to build. Figure 2 (A86777) shows the resultant breadboarded version of this system.

II. SYSTEM DESCRIPTION

The information to be displayed on the Remote Display Console has to be generated by some central computer such as WWI or the Sage Computer. The information for any given message is then assembled by the computer on its output buffer drum as five seventeen-bit words in the order shown in Figure 3 (SA86780). A digital data transmitter takes this information from the output buffer drum, mixes the data, timing, and synch signals, modulates a 1.95 KC carrier with the composite signal and transmits it over a telephone line. In removing the information from the drum the DDT removes the first bit of each of the five words in succession, then the second bit of each word, and continues removing successive bits of each of the five words until all seventeen bits of each word have been transmitted. It will be noticed that the final five bits transmitted are the parity bits on each of the five words. This fact will bring up a special problem in the present system which will be discussed later. (For a more complete description of the DDT see 6M-3402, "Digital Data Transmitter" by E. B. Glover.)

At the remote site of the display console the telephone message enters a digital data receiver where the message is divided into its three components: data, timing, and synch. At present a WWI DDR is being used. This DDR presents the three components as 0.1 microsecond pulses on three separate lines. (For a more complete description of this DDR see 6M-3403 "Digital Data Receiver and Gap Filler Input Receiver" by E. B. Glover.) The Bell Telephone System can also supply a DDR of its own for the reception of digital data messages. This DDR again supplies the data, timing, and synch signals on three separate lines, but the form of these signals differs from the WWI DDR. The timing signal is a continuous 1300 cps sine wave, and the data and synch signals consist of one complete cycle of a 1300 cps sine wave (a dipulse) for each "1" of the data and synch.

To make the output of the Bell DDR compatible to the Remote Display a special Data Conversion Receiver is included in the Remote Display logic. This DCR accepts the 1300 cps signals from the DDR and produces the standard one microsecond pulses required for the Remote Display logic at each negative slope zero crossing of the sine wave. Two different types of DCR circuits are used. Since the timing signal is a continuous 1300 cps wave, the timing dipulse receiver contains a resonant circuit which will maintain the 1300 cps chain of one microsecond pulses even if the incoming signal fails momentarily due to line transients. Figure 4 (SB 80939) is a circuit diagram of this timing dipulse receiver. The data and synch pulses however appear at irregular, or regular but not continuous, intervals and the resonant feature of the timing dipulse receiver cannot be used for these lines. The Data Dipulse Receiver therefore produces the standard output pulse only for definite sinusoidal dipulses. Figure 5 (SB 80940) is a circuit diagram of this data dipulse receiver.

It was mentioned that the WWI DDR output consisted of 0.1 microsecond pulses. These will not operate the Remote Display logic directly either and must be converted to the standard one microsecond pulses. Since the Data Conversion Receiver is already required in the logic to make the Bell DDR compatible, and since a 0.1 microsecond to 1300 cps dipulse converter had previously been built to test the DCR, the output of the WWI DDR is now put through the test converter to produce the same type of output as the Bell DDR and then put through the DCR to produce the required one microsecond pulses. Although this is a rather cumbersome procedure it did require a minimum development time.

Figure 6 (C 82454) is a block diagram of the internal logic of the Remote Display I. The data, synch, and timing dipulses from the DDR enter the DCR and are converted to "standard" one microsecond pulses on three separate lines. Four additional series of pulses are generated in relation to the timing pulses. One line supplies a continuous string of one microsecond pulses ninety-six microseconds before the timing pulses, a second line supplies pulses at forty-eight microseconds before the timing pulses, a third line does so at twenty-four microseconds before the timing pulses, and the fourth line does so forty-eight microseconds after the timing pulses. These additional strings of pulses are used to perform preparatory operations for the arrival of data pulses and consequent logical operations on the data pulses.

The resultant pulses enter the timing counter and first level decoder which keep track of the timing signals of any given message. The timing counter is a seve flip-flop index register with an eighth flip-flop used to indicate whether a track or data message is being received. The outputs of the first four flip-flops are dec ded to produce a gating level on one of sixteen lines such that timing pulse one produces a gating level on line one, timing pulse two on line two, and on to timing pulse sixteen on line sixteen. The cycle then keeps repeating with timing pulses seventeen, thirty-three, forty-nine, sixty-five, and eighty-one producing gating levels on line one, and succeeding pulses in any group of sixteen producing gating levels on succeeding lines.

The outputs of the next three flip-flops are decoded to produce gating levels on three sets of five lines. These gating levels indicate the particular group of sixteen lines which is being decoded at any instant by the first four flip-flops. Thus the group of timing signals from 1-16 result in a gating level on the first line of each of the three groups of five lines, the group from 17-32 on the second line, and on to the group from 81-96 on the fifth line. The gating levels of the first group of five lines are present each time the proper count appears. However the second and third groups of five lines are further gated by the eighth flip-flop which indicates the type of message. Thus for a track message the timing counts produce gating levels on the first and second groups but not on the third, while for a data message the timing counts produce gating levels on the first and third groups but not the second. By "AND"ing one line from the first group of sixteen with one line from either of the groups of five, and with the data line, any particular serial data bit can be gated to set up any desired flip-flop in the system. The timing counter is reset for each new message by the synch pulse.

Considering the order which the Digital Data Transmitter removes information from the computer output buffer drum, and the order in which the information is placed on the drum (see Figure 3 again), it will be noticed that the "U" information is the first to arrive at a console serially. This "U" information is used to address a given message to some console. Thus these data bits are gated to four flip-flops in the console identity block, and the result is compared to preset switches in the console which identify the address of the console. If the "U" bits do not compare to the preset switches the timing counter is stopped and no further action is taken until a synch pulse from a new message again presets the timing counter. If the "U" bits do compare with the preset switches then the message is addressed to the given console and the remainder of the message is permitted to take its course.

The following six "L" bits will be necessary for memory address information if proposal three is ever used but do not serve any special purpose in proposal one where there is no memory to be addressed. The following "A" (alarm) bit can be used for setting of a visual or audible alarm, or, in the cases that a charactron should be used in proposal one, to intensify an alarm track more brightly. This information is not used in the present system.

Following the "L" and "A" bits are sixteen "X" and "Y" bits which are used to supply the magnetic deflection information. These bits are gated to the magnetic deflection storage register which in turn sets up the magnetic deflection decoder to position the CRT beam to the position of the track on the face of the tube. It will be noticed that the "X" and "Y" bits are mixed and appear serially in decreasing order of magnitude. This has been so arranged that the maximum deflection which the magnetic deflection yoke will have to make appears as early as possible to give the yoke a maximum time to settle to its final position.

The "TD" bit follows the magnetic deflection bits and is the first indication as to the type of message arriving (whether track or data message). This bit is gated to the eighth flip-flop in the timing counter and the information will govern whether the remaining decoding is to be for a data or track message.

If the message is a track message the next following bit to arrive is the "V" bit which determines which of two vector symbols is to be displayed. The "V" bit is gated to the Character selection and compensation storage register together with a preset signal to set up the six flip-flops to the correct address of the vector symbol on the matrix. The scope beam had previously been preset to the blank address on the matrix so that no character was visible up to this time. Transferring the vector symbol address to the character selection display register and into the character selection decoder now moves the beam to the vector symbol desired and illuminates this symbol on the face of the tube at the track address set into the magnetic deflection decoder. The vector symbol address must remain in the character selection display register for at least two milliseconds to properly store the image on the face of the tube. Meanwhile the next two data bits to arrive determine the first course character. These are gated to the character selection and compensation storage register together with the necessary preset signal to enter the complete six bit address for the "B_1" character. Just before the first data bit of the next character ("B_2") arrives the required two millisecond storage time of the "V" character will have been completed and the "B_1" character is transferred from the character selection storage register to the character selection display register. The "B_1" character is now displayed on the face of the tube and when the first data bit on the "B_2" character arrives it is gated into the character selection storage register. Since the "B_2" character has four data bits to identify it, the two millisecond storage time of the "B_1" character will be completed before the "B_2" character is fully assembled. Therefore the character selection display register is cleared to the matrix blank address at the end of the two milliseconds storage time and nothing is displayed until the complete "B_2" character had been assembled and transferred from the storage register to the display register. This whole process then continues in similar fashion for the remaining ten characters.

Meanwhile when the "V" data bit and the two "B_1" data bits arrived they were also gated into the character position generator. These three bits together with the "TD" bit are decoded to determine the initial position of the "B_1" character. When the "B_1" character is transferred from the character selection storage register to the display register, the decoded position of the "B_1" character is also transferred to the Character position display register so that when the character lights up on the face of the tube, it will be in its proper position with respect to the vector symbol. As succeeding characters are transferred into the character selection display register, the character position display register is merely indexed to its new position without regard to the particular symbol being displayed.

If the message had been a data message then the data bit following the "TD" bit would have been the $\dot{X}$ and the following would have been $\dot{Y}$. Both of these bits are gated only into the character position generator and these together with the "TD" bit are then decoded to supply the initial position of the first data message character. The operation of the character selection registers is the same as for the track message but without the necessity of any preset signals since all six required character address bits are supplied with the data message. After decoding the initial position of the "D_1" character, the character position display register is merely indexed for each successive transfer of a character from the character selection storage register to the display register.

Each data bit as it comes from the data conversion receiver and is gated into its respective display register, also gated into the complement input of one of five flip-flops in the parity circuit. Thus a parity check on each of the five transmitted words is accumulated. When the last five bits of a message (the parity bits) are received, a signal is generated to indicate whether the message had been received correctly or not. If the message was received correctly the various storage registers and timing counters are reset and all further action suspended until the next synch pulse arrives to start the cycle over on a new message. However if the parity did not check, the indication is that the message had an error in it. By this time the message is displayed on the face of the tube and there is no known method for selectively erasing the incorrect message. Since the message cannot be erased, it must be identified somehow that it contains an error. The method used in this system to indicate an erroneous message is to paint the large square (matrix address 77) over the vector symbol.

III. CRT DESCRIPTION

The cathode ray tube used for Remote Display I is a tube, newly developed by Hughes Aircraft Co. called a tono-typotron. It is essentially a combination of a standard Typotron and a Tonotron, having the beam-forming mechanism of the Typotron and the storage characteristics of a Tonotron. Figure 7 (SA86781) is a diagram of the beam forming end of the tube. The electron beam gun is similar to that in any ordinary cathode ray tube with electrostatic focusing. The beam on emerging from the gun structure passes through a set of electrostatic deflection plates called the selection plates. It is to these places that the character selection signals from the character selection decoder and amplifier are applied. After the beam passes these plates, it arrives at the character matrix which is the heart of the beam forming principle. The character matrix is a small metal plate which is perforated with character shaped openings in an eight by eight square array. Figure 8 (A-86554) is a diagram of a typical matrix. The beam had originally been defocused sufficiently so that when it arrives at this matrix it is large enough to completely cover one of the character shaped perforations. As the beam hits this matrix it is completely stopped by the matrix except for that portion of the beam which actually hits the perforation. Thus the beam arrives at the matrix in the form of a solid cylinder, but leaves the matrix in the shape of the perforation. The process can be compared to the extrusion of a shaped aluminum bar from a cylindrical aluminum billet by squeezing it through a properly shaped die.

In order to hit any desired character on the matrix, the beam had to be deflected off axis by the selection plates. If the beam were permitted to continue in this direction it would soon hit the neck of the tube. Therefore it is made to pass through a magnetic field set up by the convergence coil which causes the beam to spiral back toward the axis of the tube. As the beam crosses the axis of the tube it encounters a second set of plates located at this point, and is deflected in the opposite direction by these character compensation plates so that the beam then travels down the axis of the tube again.

Finally the character shaped beam passes through the field of a magnetic deflection yoke which causes the beam to go to the desired position on the face of the tube. Because of the slow speed of the yoke, it is used only to provide the major deflection of the beam. The minor deflections within a target area to make up the format positions have to be fast and for this reason the format deflections are performed by adding an additional electrostatic voltage to the character compensation plates. This procedure gives the desired operating speed but introduces two rather serious problems. First the deflection voltages required for the compensation plates are now almost double that required for compensation only. This quadruples the power dissipation of the electrostatic amplifiers and increases the problems of keeping the console sufficiently cool for operating transistors. Secondly, the beam no longer enters the magnetic deflection yoke on axis. If the electrostatic deflection and the magnetic deflection are in the same direction and of sufficient amplitude, the beam hits the neck of the tube. This causes characters in a format to suddenly disappear about two or three inches from the edge of the tube. Both of these problems can be solved if either more time can be allotted to deflection signals, or if the yoke can be made to respond faster. This would permit doing the format deflections with the yoke and the beam could then be made to enter the yoke on axis and avoid the "neck shadow" problem. This will be tried in the near future.

Figure 9 (SA 86782) is a diagram of the storage and display end of the CRT. This portion of the tube consists of four major parts: the flood gun which emits a broad beam of electrons to cover the entire storage surface, the storage mesh which stores the image of the writing gun beam, the collector mesh which "collects" secondary electrons emitted by the storage mesh and those flood gun electrons which are repelled by the storage surface, and finally the phosphor coating of the faceplate of the tube which emits light wherever the flood gun beam is permitted to pass through the storage mesh.

The storage mesh is a very fine mesh metal screen covered on the "gun" side with an insulating coating of magnesium fluoride which has a very large secondary emission ratio. When the high velocity writing gun beam hits this screen, a large number of secondary electrons are emitted by this coating at the spot which was hit, charging it positively. Figure 10 (SA48377) is a graph showing how the secondary emission ratio of magnesium fluoride varies with the accelerating voltage of the primary electrons. It will be noticed that at 40 volts this ratio is unity which means that for each electron which hits the magnesium fluoride at this potential, one electron is emitted by secondary emission with no net current flow to or from the magnesium fluoride. Below this potential several primary electrons must hit the fluoride surface before a secondary electron is emitted, with a net conventional current out of the fluoride. Above this potential the ratio is greater than unity and for each primary electron hitting the fluoride several electrons are ejected by secondary emission with a net conventional current into the fluoride.

Under normal operating conditions the storage screen mesh is operated about 10 volts positive to the flood gun cathode, and the collector screen at 150 volts above the flood gun cathode. The viewing screen is maintained at three kilovolts above the flood gun. The flood gun beam is accelerated to 150 volts by the collector screen and passes through this screen to be initially decelerated to 10 volts by the storage screen. Since the velocity of these electrons is below the unity secondary emission ratio of the magnesium fluoride, the surface of the fluoride soon charges negatively to flood gun cathode potential. With the storage surface at flood gun potential, no more electrons hit the surface but some do get through the mesh of the screen and are then accelerated to the viewing screen, so that the entire faceplate is lit up at this time.

To darken the tube it is necessary to charge the storage screen surface about eight volts negative to the flood gun cathode. This is done by momentarily raising the potential of the storage screen mesh about ten volts with an erase pulse. The storage surface is also raised by this amount through capacitive coupling between the metallic screen and the surface charge. With the storage surface now ten volts positive to the cathode potential, the flood gun electrons again hit the storage surface and charge it back to flood gun cathode potential. When the erase pulse is removed, the storage surface potential is lowered to ten volts below cathode potential and no further flood gun electrons can hit the storage surface or get through it to light up the faceplate.

The storage surface would remain at its negative potential until the writing gun changed it if the tube had a perfect vacuum in it. However, even with the best vacuum techniques some residual gas remains in the tube and, when the flood gun electrons collide with this gas, positive ions are formed. These ions are attracted to the negatively charged storage surface and tend to charge it positively. As these ions accumulate on the storage surface the potential gradually approaches flood gun cathode potential, and increasingly greater numbers of flood gun electrons are permitted through the storage screen mesh to light up the faceplate. Figure 11 (SA48378) shows how the faceplate intensity varies with the storage surface potential. To keep the tube dark it is necessary to maintain a continuous chain of erase pulses to remove the accumulating positive ion charge.

To write a spot on the storage surface, the writing beam is turned on. This beam hits the storage surface with an energy of three thousand electron volts, which is well beyond the unity secondary emission ratio for the fluoride screen. Since many more electrons are emitted by the storage surface than strike it, and since these emitted electrons are collected by the collector screen, the spot which is hit by the writing beam becomes positively charged. When the writing beam is removed the spot assumes an equilibrium potential at the flood gun cathode potential. Under this condition the flood gun electrons will be permitted to pass through the mesh of the storage screen and will illuminate a spot on the faceplate corresponding to the charged spot in the storage screen.

If an erase pulse of fifty milliseconds or more is applied to the storage screen, the written spot will be discharged to flood gun cathode potential together with the remainder of the storage screen. When the erase pulse is removed the entire screen, including the written spot, will assume a potential negative to the flood gun cathode, and the face of the tube will be dark - thus effectively erasing the written spot. However if the erase pulses are made considerable shorter, only a portion of the positive charge in the written spot will be removed with each erase pulse, and many pulses will be required to completely remove the positive charge. By controlling the duration of the pulses and the repetition rate, the length of time during which the written spot is visible can be controlled. The maximum viewing duration for a written spot is limited by the rate at which the erase pulses must be maintained to counteract positive ion build-up on the background.

IV. SUMMARY

The present Remote Display system has shown the feasibility to producing a Sage type display from a coded telephone message. The use of the tono-typotron has guaranteed a bright, essentially flicker-free display which is an absolute necessity for the type of environment in which such a system would have to operate. Although the display format varies slightly from the Sage format by the abolition of the vector, the use of a vector symbol together with course and speed information makes the format fully as useful as the Sage format. Attempts are being made to circumvent the disturbing "neck shadow" problem which plagues both this system and the Sage system. Programming a computer for this system is a very cumbersome chore, but the form of the message format was an absolute necessity to eliminate any form of memory from this system. A new system is being planned using a core memory plus a charactron which will not only be more flexible and simpler to program for, but will permit the use of additional types of formats, track history messages, and built-in test and alignment routines.

HEZ:mk

WORD BIT

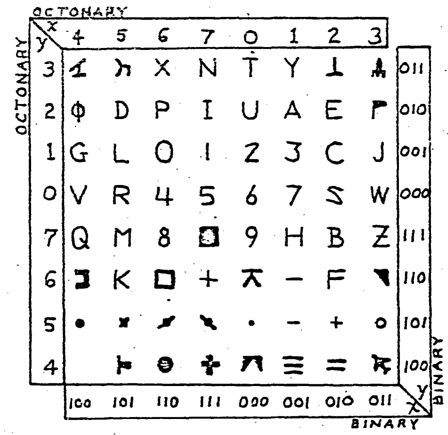
WORD	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
1	U_1 [3]	L_2 [8]	A [13]	X 2^{-2} [18]	Y 2^{-4} [23]	X 2^{-7} [28]	B_1 X_{2^1} [33]	S_1 Y_{2^0} [38]	S_2 Y_{2^0} [43]	I_1 Y_{2^1} [48]	I_2 X_{2^1} [53]	H_1 Y_{2^0} [58]	T_1 X_{2^2} [63]	T_1 Y_{2^0} [68]	T_2 X_{2^0} [73]	T_3 Y_{2^1} [78]	P_1 [83]
2	U_2 [4]	L_3 [9]	X 2^0 [14]	Y 2^{-2} [19]	X 2^{-5} [24]	Y 2^{-7} [29]	B_2 X_{2^0} [34]	S_1 X_{2^1} [39]	S_2 Y_{2^1} [44]	I_1 X_{2^0} [49]	I_2 Y_{2^1} [54]	H_1 X_{2^1} [59]	T_1 Y_{2^2} [64]	T_2 X_{2^2} [69]	T_2 Y_{2^0} [74]	T_4 X_{2^0} [79]	P_2 [84]
3	U_3 [5]	L_4 [10]	Y 2^0 [15]	X 2^{-3} [20]	Y 2^{-5} [25]	TD 0 [30]	B_2 X_{2^1} [35]	S_1 X_{2^0} [40]	I_1 X_{2^2} [45]	I_1 Y_{2^0} [50]	I_2 X_{2^0} [55]	H_2 X_{2^0} [60]	T_1 X_{2^1} [65]	T_2 Y_{2^2} [70]	T_3 X_{2^1} [75]	T_4 X_{2^1} [80]	P_3 [85]
4	U_4 [6]	L_5 [11]	X 2^{-1} [16]	Y 2^{-3} [21]	X 2^{-6} [26]	V [31]	B_2 Y_{2^0} [36]	S_2 X_{2^0} [41]	I_1 Y_{2^2} [46]	I_2 X_{2^2} [51]	I_2 Y_{2^0} [56]	H_2 X_{2^1} [61]	T_1 Y_{2^1} [66]	T_2 X_{2^1} [71]	T_3 X_{2^0} [76]	T_4 Y_{2^0} [81]	P_4 [86]
5	L_1 [7]	L_6 [12]	Y 2^{-1} [17]	X 2^{-4} [22]	Y 2^{-6} [27]	B_1 X_{2^0} [32]	B_2 Y_{2^1} [37]	S_2 X_{2^1} [42]	I_1 X_{2^1} [47]	I_2 Y_{2^2} [52]	H_1 X_{2^0} [57]	H_2 Y_{2^0} [62]	T_1 X_{2^0} [67]	T_2 Y_{2^1} [72]	T_3 Y_{2^0} [77]	T_4 Y_{2^1} [82]	P_5 [87]

TRACK MESSAGE

WORD BIT

WORD	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
1	U_1 [3]	L_2 [8]	A [13]	X 2^{-2} [18]	Y 2^{-4} [23]	X 2^{-7} [28]	D_1 X_{2^2} [33]	D_1 Y_{2^0} [38]	D_2 Y_{2^0} [43]	D_3 Y_{2^1} [48]	D_4 Y_{2^1} [53]	D_5 Y_{2^2} [58]	D_6 X_{2^2} [63]	D_6 Y_{2^0} [68]	D_7 X_{2^0} [73]	D_8 Y_{2^1} [78]	P_1 [83]
2	U_2 [4]	L_3 [9]	X 2^0 [14]	Y 2^{-2} [19]	X 2^{-5} [24]	Y 2^{-7} [29]	D_1 X_{2^0} [34]	D_2 X_{2^1} [39]	D_2 Y_{2^1} [44]	D_3 X_{2^0} [49]	D_4 Y_{2^1} [54]	D_5 X_{2^1} [59]	D_6 Y_{2^2} [64]	D_7 X_{2^2} [69]	D_7 Y_{2^0} [74]	D_8 X_{2^0} [79]	P_2 [84]
3	U_3 [5]	L_4 [10]	Y 2^0 [15]	X 2^{-3} [20]	Y 2^{-5} [25]	TD 1 [30]	D_1 X_{2^1} [35]	D_2 X_{2^2} [40]	D_3 X_{2^2} [45]	D_3 Y_{2^0} [50]	D_4 X_{2^0} [55]	D_5 Y_{2^1} [60]	D_6 X_{2^1} [65]	D_7 Y_{2^2} [70]	D_8 X_{2^2} [75]	D_8 X_{2^1} [80]	P_3 [85]
4	U_4 [6]	L_5 [11]	X 2^{-1} [16]	Y 2^{-3} [21]	X 2^{-6} [26]	$\dot{X}$ [31]	D_1 Y_{2^2} [36]	D_2 X_{2^0} [41]	D_3 Y_{2^2} [46]	D_4 X_{2^2} [51]	D_4 Y_{2^0} [56]	D_5 X_{2^2} [61]	D_6 Y_{2^1} [66]	D_7 X_{2^1} [71]	D_8 Y_{2^2} [76]	[81]	P_4 [86]
5	L_1 [7]	L_6 [12]	Y 2^{-1} [17]	X 2^{-4} [22]	Y 2^{-6} [27]	$\dot{Y}$ [32]	D_1 Y_{2^1} [37]	D_2 Y_{2^2} [42]	D_3 X_{2^1} [47]	D_4 Y_{2^2} [52]	D_5 X_{2^0} [57]	D_5 Y_{2^0} [62]	D_6 X_{2^0} [67]	D_7 Y_{2^1} [72]	D_8 Y_{2^0} [77]	[82]	P_5 [87]

DATA MESSAGE



TONO-TYPOTRON MATRIX CODE

B_1 B_2 S_1 S_2
I_1 I_2 H_1 H_2
T_1 T_2 T_3 T_4
V

TRACK MESSAGE

D_1 D_2 D_3 D_4 V
D_5 D_6 D_7 D_8

DATA MESSAGE

B_1 B_2 S_1 S_2
I_1 I_2 H_1 H_2
T_1 T_2 T_3 T_4
D_1 D_2 D_3 D_4 V
D_5 D_6 D_7 D_8

COMBINED TRACK AND DATA MESSAGES

TYPICAL DISPLAY FORMATS

1 BIT CODE (V)

V	X_{2^2}	X_{2^1}	X_{2^0}	Y_{2^0}
			0	
			1	

2 BIT CODE (B_1)

B_1	X_{2^2}	X_{2^1}	X_{2^0}	Y_{2^0}
0		1	0	
1		1	1	
2		0	0	
3		0	1	

3 BIT CODE

S_1 H_1 H_2	X_{2^2}	X_{2^1}	X_{2^0}	Y_{2^0}
0		1	0	1
1		1	1	1
2		0	0	1
3		0	1	1
4		1	0	0
5		1	1	0
6		0	0	0
7		0	1	0

4 BIT CODE

B_2 S_2 T_3 T_4	X_{2^1}	X_{2^0}	Y_{2^1}	Y_{2^0}
0	1	0	0	1
1	1	1	0	1
2	0	0	0	1
3	0	1	0	1
4	1	0	0	0
5	1	1	0	0
6	0	0	0	0
7	0	1	0	0
8	1	0	1	1
9	0	0	1	1

COMPRESSED CHARACTER CODES FOR TRACK MESSAGE

REMOTE DISPLAY

PHONE LINE MESSAGE CODES

H.E. Zieman

SC 82450

Figure 1

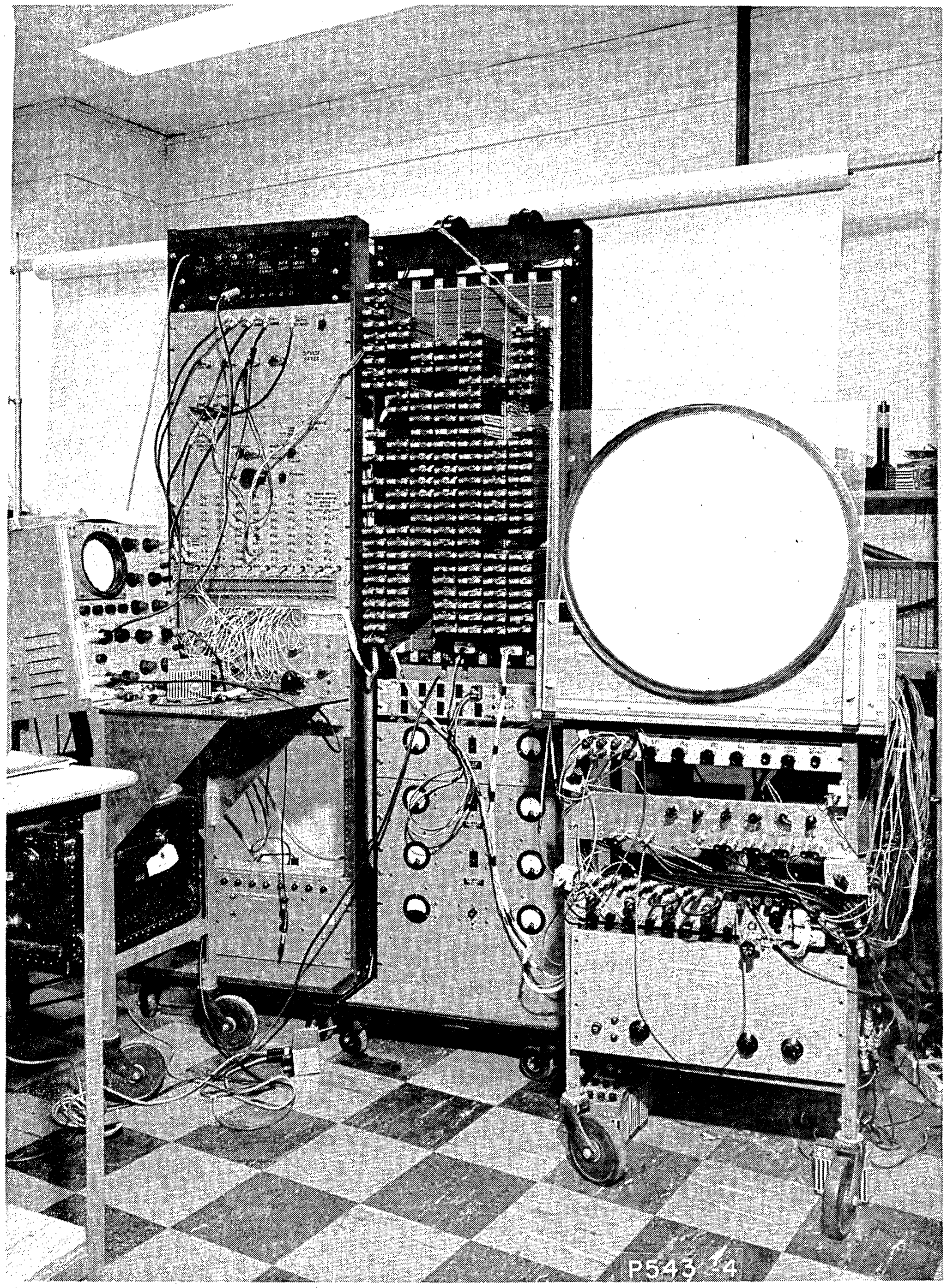


FIGURE 2
REMOTE DISPLAY BREADBOARD

A-86777

SA-86780

WORD BIT

WORD	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
1	U_1 3	L_2 8	A 13	X 18 2^{-2}	Y 23 2^{-4}	X 28 2^{-7}	B_1 33 X_2^1	S_1 38 Y_2^0	S_2 43 Y_2^0	I_1 48 Y_2^1	I_2 53 X_2^1	H_1 58 Y_2^0	T_1 63 X_2^2	T_1 68 Y_2^0	T_2 73 X_2^0	T_3 78 Y_2^1	P_1 83
2	U_2 4	L_3 9	X 14 2^0	Y 19 2^{-2}	X 24 2^{-5}	Y 29 2^{-7}	B_2 34 X_2^0	S_1 39 X_2^1	S_2 44 Y_2^1	I_1 49 X_2^0	I_2 54 Y_2^1	H_1 59 X_2^1	T_1 64 Y_2^2	T_2 69 X_2^2	T_2 74 Y_2^0	T_4 79 X_2^0	P_2 84
3	U_3 5	L_4 10	Y 15 2^0	X 20 2^{-3}	Y 25 2^{-5}	TD 30 0	B_2 35 X_2^1	S_1 40 X_2^0	I_1 45 X_2^2	I_1 50 Y_2^0	I_2 55 X_2^0	H_2 60 X_2^0	T_1 65 X_2^1	T_2 70 Y_2^2	T_3 75 X_2^1	T_4 80 X_2^1	P_3 85
4	U_4 6	L_5 11	X 16 2^{-1}	Y 21 2^{-3}	X 26 2^{-6}	V 31	B_2 36 Y_2^0	S_2 41 X_2^0	I_1 46 Y_2^2	I_2 51 X_2^2	I_2 56 Y_2^0	H_2 61 X_2^1	T_1 66 Y_2^1	T_2 71 X_2^1	T_3 76 X_2^0	T_4 81 Y_2^0	P_4 86
5	L_1 7	L_6 12	Y 17 2^{-1}	X 22 2^{-4}	Y 27 2^{-6}	B_1 32 X_2^0	B_2 37 Y_2^1	S_2 42 X_2^1	I_1 47 X_2^1	I_2 52 Y_2^2	H_1 57 X_2^0	H_2 62 Y_2^0	T_1 67 X_2^0	T_2 72 Y_2^1	T_3 77 Y_2^0	T_4 82 Y_2^1	P_5 87

TRACK MESSAGE

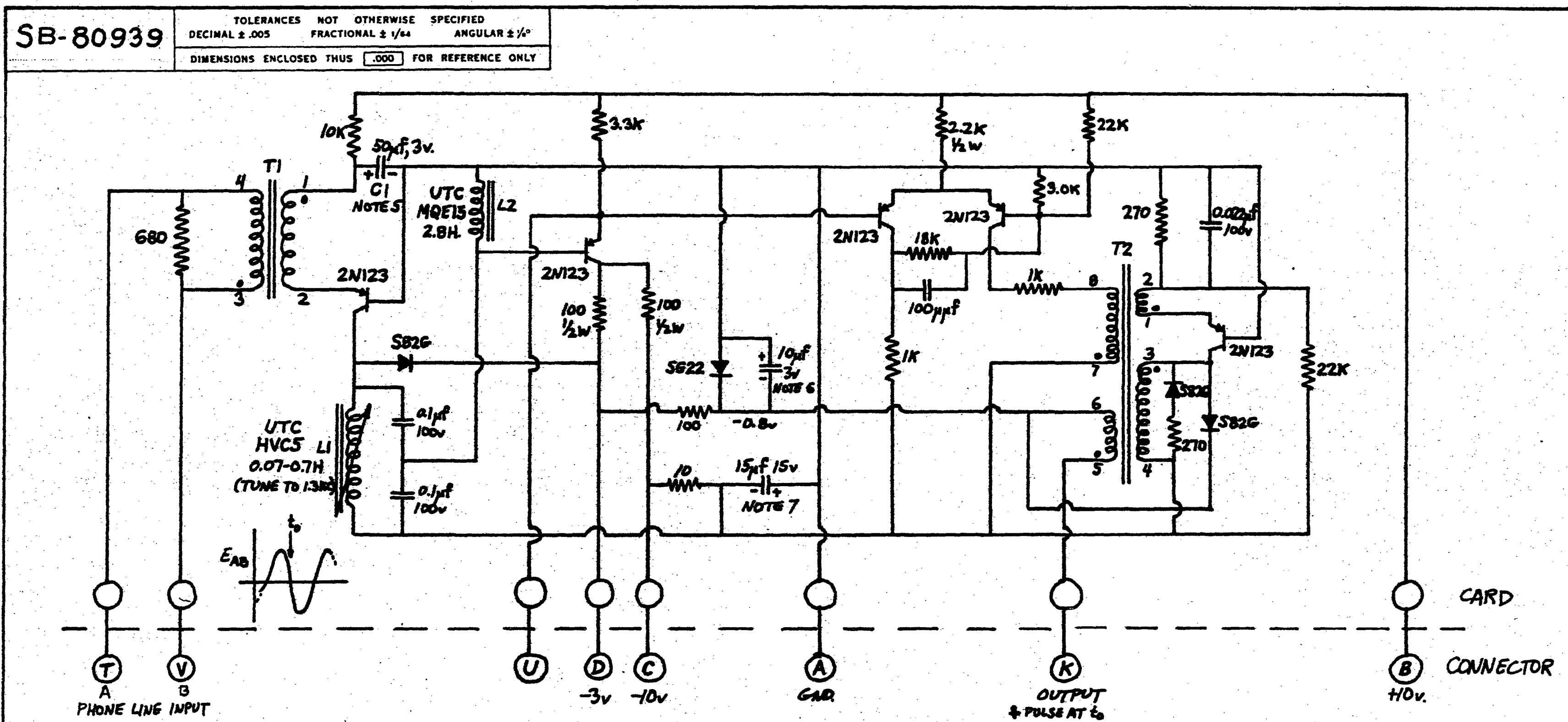
WORD BIT

WORD	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
1	U_1	L_2	A	X 2^{-2}	Y 2^{-4}	X 2^{-7}	D_1 X_2^2	D_1 Y_2^0	D_2 Y_2^0	D_3 Y_2^1	D_4 X_2^1	D_5 Y_2^2	D_6 X_2^2	D_6 Y_2^0	D_7 X_2^0	D_8 Y_2^1	P_1
2	U_2	L_3	X 2^0	Y 2^{-2}	X 2^{-5}	Y 2^{-7}	D_1 X_2^0	D_2 X_2^1	D_2 Y_2^1	D_3 X_2^0	D_4 Y_2^1	D_5 X_2^1	D_6 Y_2^2	D_7 X_2^2	D_7 Y_2^0	D_8 X_2^0	P_2
3	U_3	L_4	Y 2^0	X 2^{-3}	Y 2^{-5}	TD 1	D_1 X_2^1	D_2 X_2^2	D_3 X_2^2	D_3 Y_2^0	D_4 X_2^0	D_5 Y_2^1	D_6 X_2^1	D_7 Y_2^2	D_8 X_2^2	D_8 X_2^1	P_3
4	U_4	L_5	X 2^{-1}	Y 2^{-3}	X 2^{-6}	$\dot{X}$	D_1 Y_2^2	D_2 X_2^0	D_3 Y_2^2	D_4 X_2^2	D_4 Y_2^0	D_5 X_2^2	D_6 Y_2^1	D_7 X_2^1	D_8 Y_2^2		P_4
5	L_1	L_6	Y 2^{-1}	X 2^{-4}	Y 2^{-6}	$\dot{Y}$	D_1 Y_2^1	D_2 Y_2^2	D_3 X_2^1	D_4 Y_2^2	D_5 X_2^0	D_5 Y_2^0	D_6 X_2^0	D_7 Y_2^1	D_8 Y_2^0		P_5

DATA MESSAGE

FIGURE 3

REMOTE DISPLAY MESSAGE LAYOUT



NOTES: 1) T1 IS WOUND ON FERROXCUBE 7F160 CORE, 405F150 BOBBIN, PRIMARY (3-4) 1320t #46HF; SEC. (1-2) 120t #40 HF.
2) T2 IS STANDARD GATE TRANSFORMER, DWG. SB-80052
3) TUNE L1 TO RESONANCE AT 1300 CPS.
4) ALL RESISTORS ±5%, 1/10 OR 1/2 W, UNLESS OTHERWISE STATED.
5) SPRAGUE 102D2 (9/32" D. x 7/8" L). FOR TEMPORARY USE, SPRAGUE TE-1100 (50µf, 6v) (3/8" D x 3/4" L) IS ACCEPTABLE.
6) SPRAGUE 102D1 (3/16" D. x 11/16" L); OR SPRAGUE TE-1055 (1/4" D x 5/8" L)
7) SPRAGUE 102D17 (9/32 D. x 7/8 L"); OR SPRAGUE TE-1205 (3/8" D x 3/4" L)
USE TE-SERIES ALUMINUM ELECTROLYTICS ONLY TEMPORARILY.

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GRADE II PRELIMINARY DESIGN
GRADE III FINAL DESIGN
GRADED BY: DATE:

ITEM	MATERIAL - DESCRIPTION	PART NO.	QTY.

LINCOLN LABORATORY DIV. 6
MASSACHUSETTS INSTITUTE OF TECHNOLOGY
LEXINGTON 73. MASS.

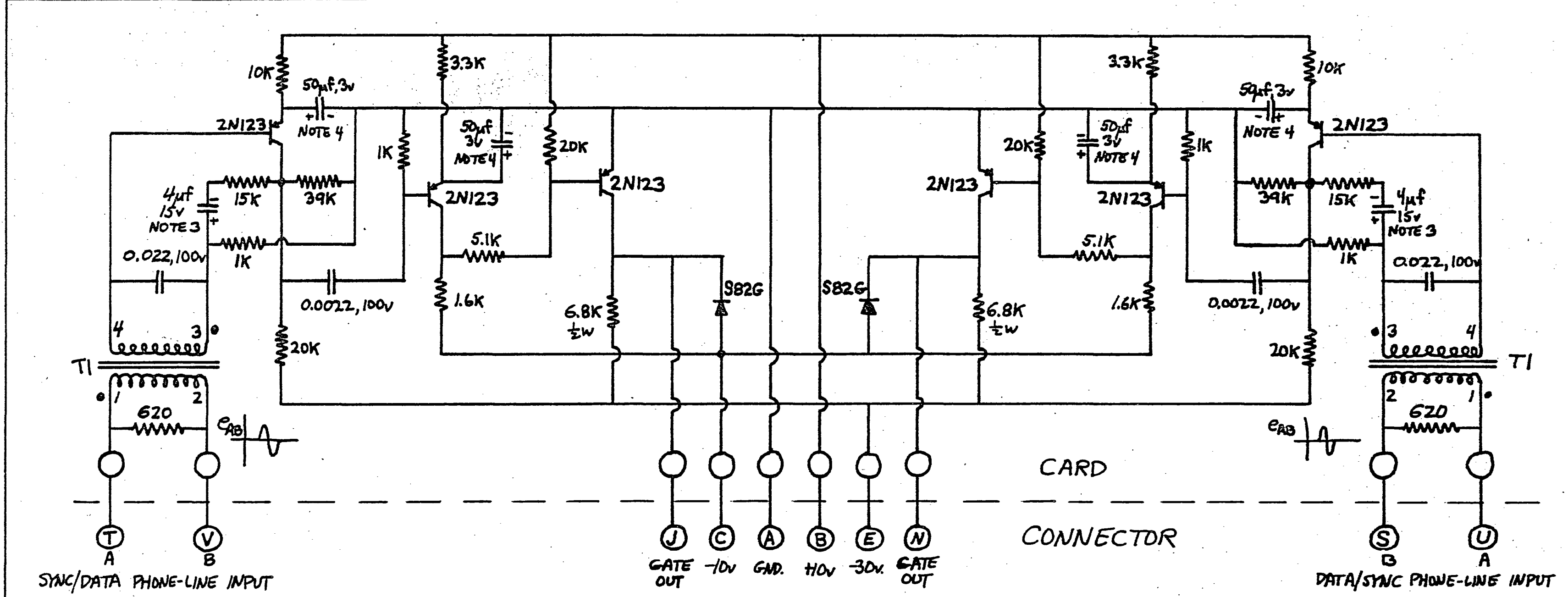
REMOTE DISPLAY TIMING DIPULSE RECEIVER

SCALE: DR. W. F. Santelmann Jr.
ENG. W.F.S. CK. APPD. 4APR57
SB-80939

CHG. CN# DATE APPD. 8APR57 W.F.S.

Figure 4

SB-80940 | TOLERANCES NOT OTHERWISE SPECIFIED DECIMAL ± .005 FRACTIONAL ± 1/64 ANGULAR ± 1/2°
DIMENSIONS ENCLOSED THUS [.000] FOR REFERENCE ONLY



NOTES: 1) T1 IS WOUND ON FERROXCUBE 405F150 BOBBIN FOR 7F1603C CORE. BOTH WINDINGS 650t, #46 HF. 620mh @ 1kc (APPROX.)
2) ALL 100v CAPACITORS ARE GOODALL MYLAR. L.L. STOCK SERIES 246--- OR 241---.
3) SPRAGUE 102D16. 3/16" D. x 11/16" L.
4) SPRAGUE 102D2. 9/32" D. X 7/8" L.
5) ALL RESISTORS ARE 1/10 W OR 1/2 W, ±5% UNLESS OTHERWISE SPECIFIED.

GRADE I FOR REFERENCE ONLY
GRADE II PRELIMINARY DESIGN
GRADE III FINAL DESIGN
GRADED BY: DATE:

ITEM	MATERIAL-DESCRIPTION	PART NO	QTY

LINCOLN LABORATORY DIV. 6
MASSACHUSETTS INSTITUTE OF TECHNOLOGY
LEXINGTON 73, MASS.

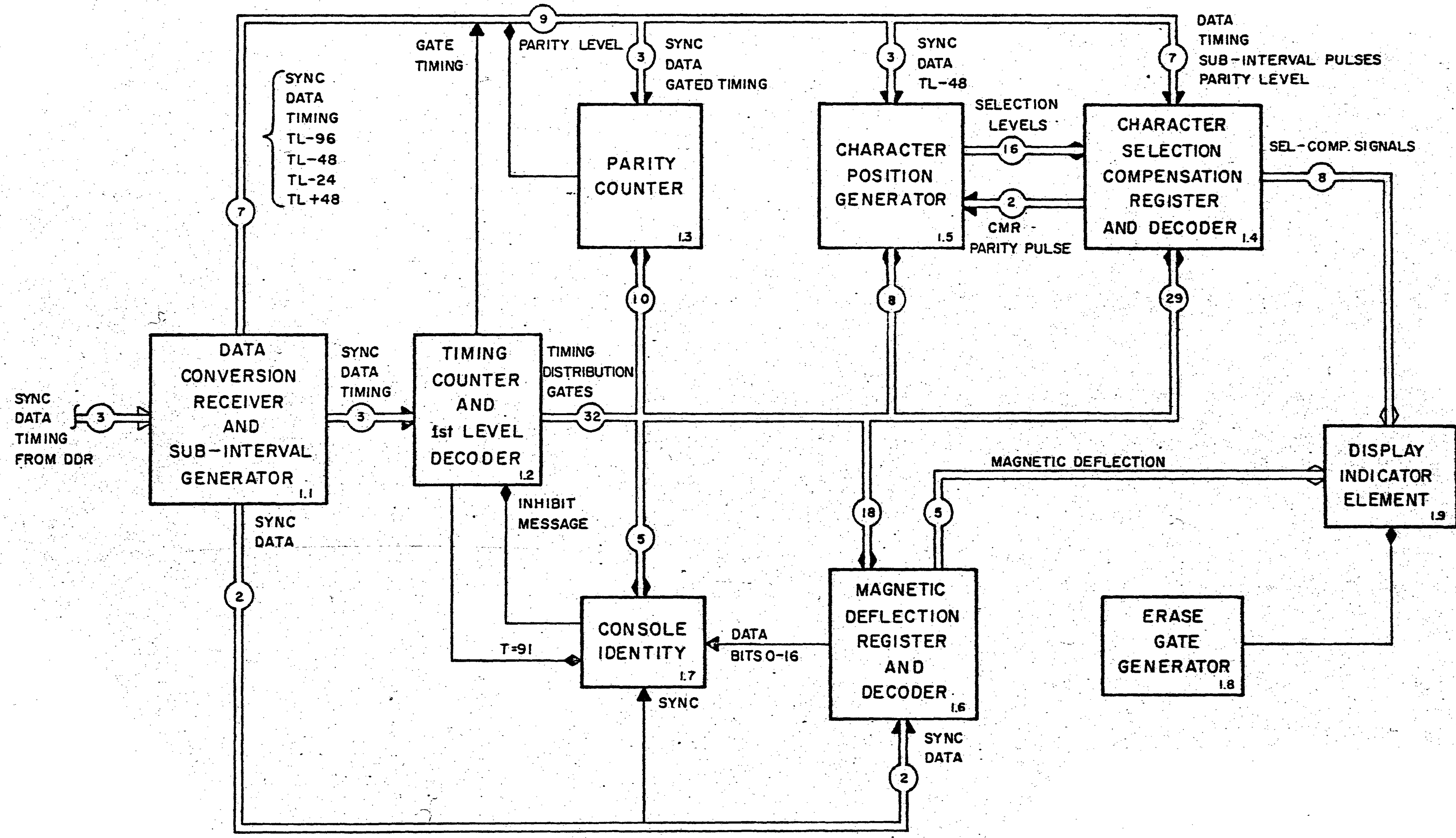
REMOTE DISPLAY SYNC/DATA DIPULSE RECEIVER

SCALE: DR. W. F. Santelmann Jr.
ENG. W.F.S. CK. APPD. 10APR57

SB-80940

Figure 5

C-82454



REMOTE DISPLAY

SYSTEM BLOCK DIAGRAM

Figure 6

SA 86781

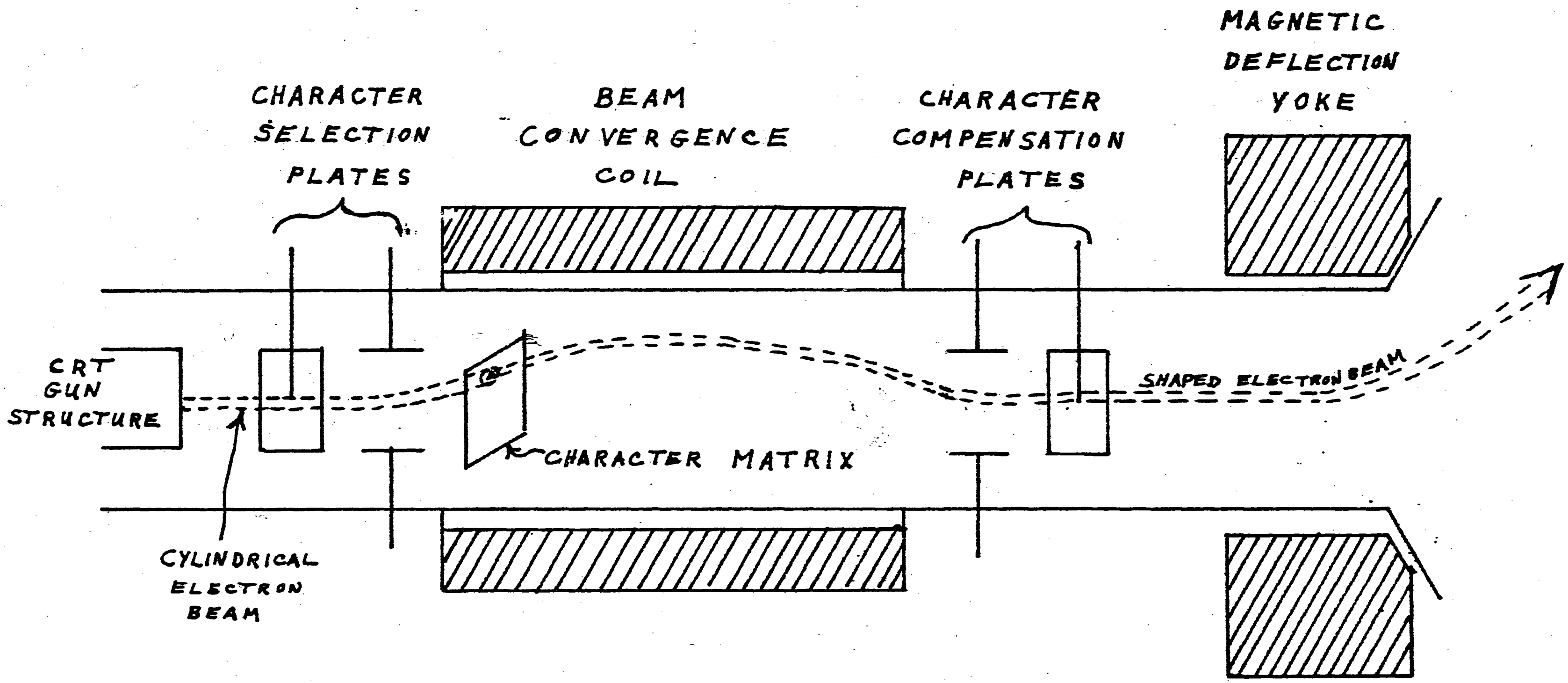
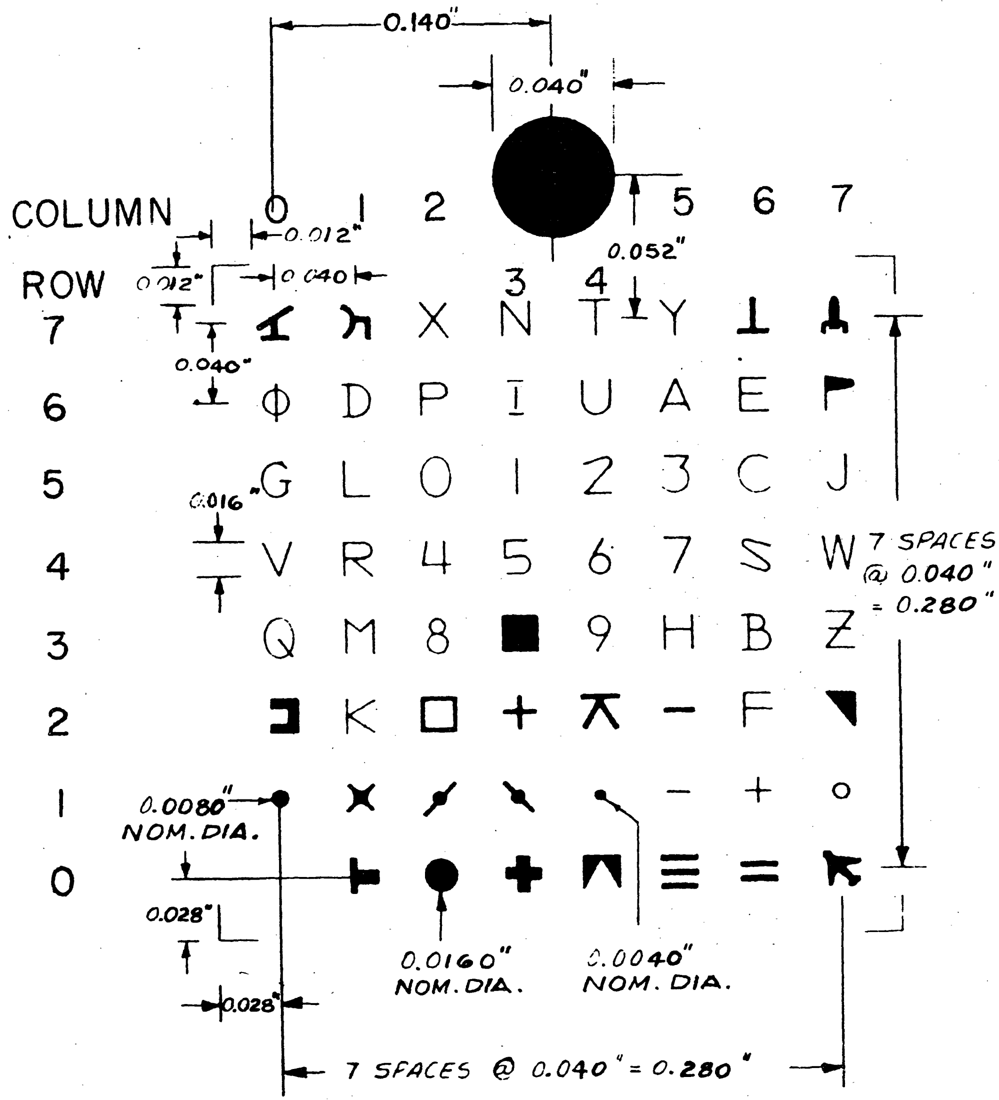
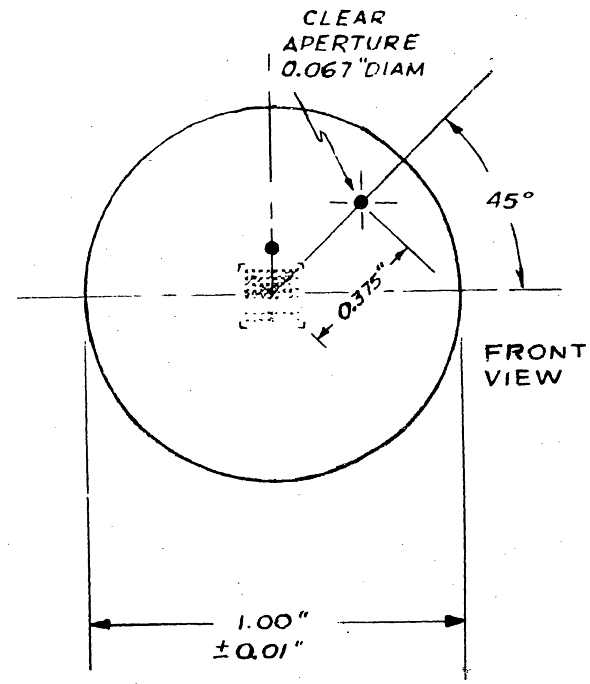


FIGURE 7
BEAM SHAPING END
TONO-TYPOTRON

V.E. ZIEMAN

A-86554





NOTES:
A. DETAIL CHARACTER DRAWINGS ARE GIVEN IN A-86553 (PAGES 1-40)
B. CHARACTER HEIGHT (H) = 0.0160" ± 0.0005"
CHARACTER WIDTH (W) = 0.0120" ± 0.0004"
CHARACTER LINE THICKNESS (T) = 0.0011" ± 0.0001"
C. ALL OTHER TOLERANCES ± 0.001"

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FIG. 8

THIS DRAWING MADE BY
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SA 86782

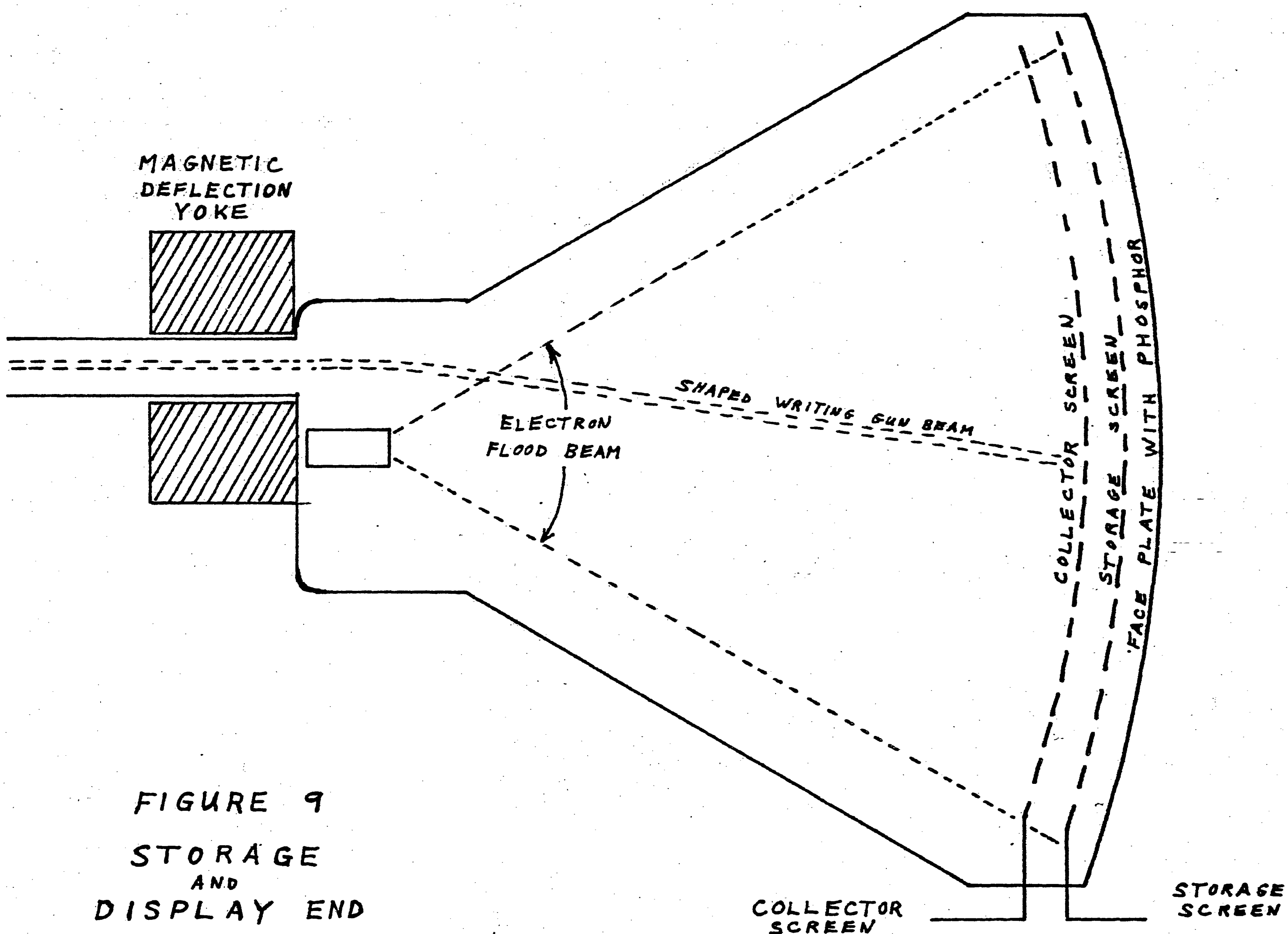

FIGURE 9

STORAGE
AND
DISPLAY END
TONO-TYPOTRON

YE ZIEMAN

SA 48877

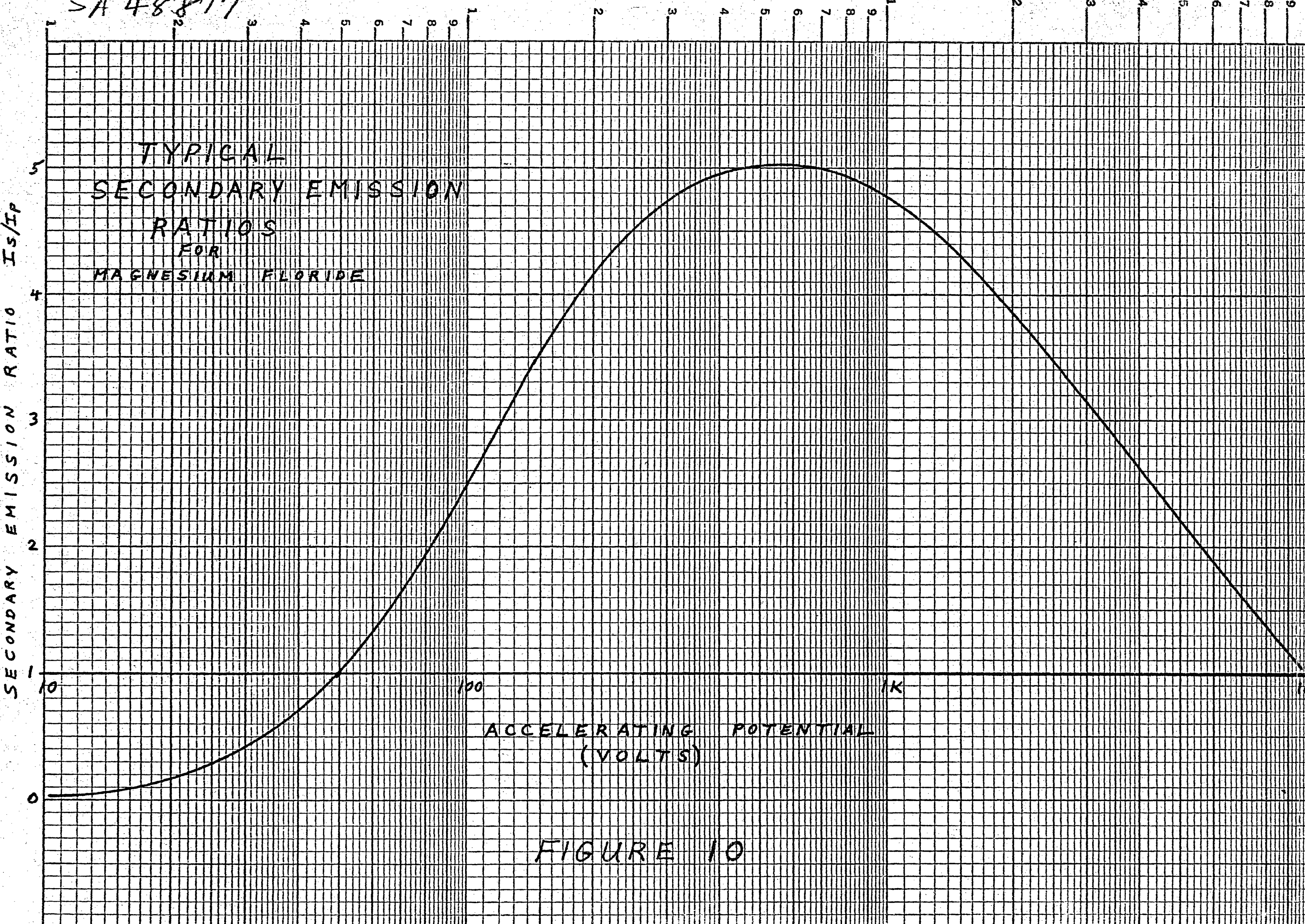

FIGURE 10

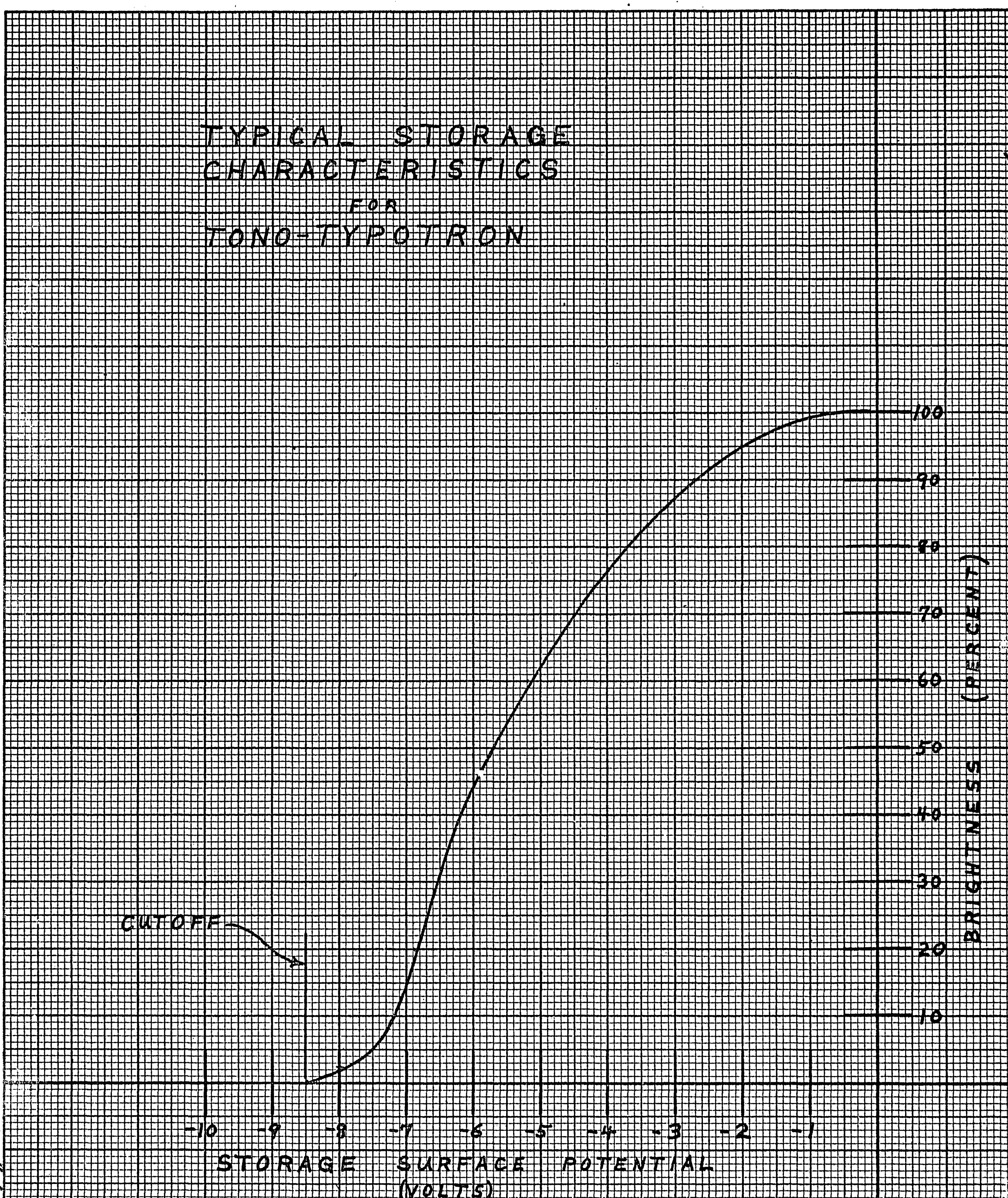

FIGURE 11

SA 48 878