DECLASSIFIED

NAVAL RESEARCH LABORATORY

REPORT

DECLASSIFIED by NRL Contract
Declassification Team
Date: 4 OCT 2016
Reviewer's name(s): H. DO, P. HANNA

Declassification authority: NAVY DECLASS MANUAL, 1 DEC 2012, OE SERIES

1 February 1947

THE UNIVERSAL ELECTRONIC
TARGET DESIGNATION SYSTEM

By
Paul C. Sherertz

Report No. R-2772

[redacted]

DECLASSIFIED: By authority of
DOD DIR 5200.10

Entered by 1520

DISTRIBUTION STATEMENT A APPLIES
Further distribution authorized by
UNLIMITED only.

DECLASSIFIED

NAVY DEPARTMENT
OFFICE OF NAVAL RESEARCH
NAVAL RESEARCH LABORATORY
WASHINGTON 20, D. C.

[redacted] COPY NO. 34

Navy Department - Office of Naval Research

NAVAL RESEARCH LABORATORY
Washington, D.C.

* * *

RADIO DIVISION III - BEAM WAYS SECTION

1 February 1947

UNCLASSIFIED

THE UNIVERSAL ELECTRONIC TARGET DESIGNATION SYSTEM

UNCLASSIFIED

By Paul C. Sherertz

- Report R-2772-

[redacted]

* * *

Approved by:

J. E. Meade - Head, Beam Ways Section

Dr. R. M. Page
Superintendent
Radio Division III

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

Preliminary Pages ... a-d
Numbered Pages 25
Plates 18
Distribution List ... e

DECLASSIFIED

NRL PROBLEM 0-61R-C

ABSTRACT

The Universal Electronic Target Designation System has been developed by Radio Division III (formerly Missile Control Division) of the Naval Research Laboratory to exploit the possibilities of an all-electronic indicator system for the coordination of shipboard missile control equipment. The circuits and general potentialities of the system have been developed and investigated and are submitted in this report for further evaluation.

The system employs electronic switching to present on electrostatic deflection cathode-ray tubes plan position information from one or more radars simultaneously with several electronic strobes or marks on a time sharing basis. Color differentiation between the target echoes and other indications is obtained through the use of controlled excitation of the various presentations on cathode-ray tubes having P-7 or P-14 screens. Tactical operation of the system envisions the use of intensity-coded circular marks to designate specific targets and the presentation in plan position of the precision sweep of the director radars to show the gated positions and activities of the various directors coordinated by the system.

[redacted]

TABLE OF CONTENTS

[redacted]

TABLE OF CONTENTS (Continued)

[redacted]

INTRODUCTION

1. The Universal Electronic Target Designation System, which shall be referred to hereafter as the UETDS, has been under development by Radio Division III of the Naval Research Laboratory since its proposal in December 1944. Investigation of the system has been authorized under the general target designation problem and by request of the Bureau of Ordnance in Reference 1.

2. It was originally proposed that the target designation system should consist of a plan position indicator upon which targets could be identified by circular marks. Range and bearing control over the marks was envisioned, and it was intended that certain of the marks should be used for designation of targets while others should be used to indicate the gated position of the major directors coordinated by the system. To produce this presentation it was proposed that the sweep and mark indications be switched on to the indicator screen in rapid succession on a time sharing basis.

3. An experimental model of the system was constructed along the lines of the original proposal during 1945. This model, although deficient in many respects, demonstrated the practicality and some of the potentialities of the system. The most striking feature demonstrated by this model was that color differentiation between the marks and the radar sweep is obtained when the presentation of this system is shown on a cathode-ray tube with a P-7 screen. Reference 3 is a previous report written on the use of cathode-ray tubes with screens of this type as two-color indicators.

4. Tests of the experimental model and further investigation of the technical and tactical aspects of the target designation and acquisition problem have led to what is believed to be an adequate and practical design of an electronic indicator system for the tactical coordination of presently installed shipboard radar fire control systems. The system as now proposed will present simultaneously and in accurate relative position on a plan position indicator target information from one or more search radars, coded radial marks showing the location of the precision sweeps and gated target echoes of the various radar directors and the coded target designation and identification marks. Plate 1 shows the proposed target plots of the designation indicator and also the color differentiation of the various indications. It is further proposed that special target acquisition displays associated with the designation plot be made available to radar director operators for the specific purpose of target acquisition.

5. The general target acquisition problem, the technical design of the various components of the system and its tactical application are discussed in this report. It is believed that this equipment has received sufficient laboratory development and that the construction of an operational model of the system should follow evaluation of the system by the Bureau of Ordnance.

OPERATIONAL FEATURES

6. Ideally, each ship should have equipment by which each of the radar directors may be placed on a specific designated target within a few seconds time. One type of equipment which has generally been considered as suitable for rapid coordination of radar directors is an attack plot indicator on which radar targets, director gated positions, and target designation or identification marks can be shown. Repeater units of this attack plot indicator should be located at each of the various directors to provide coordination of the directors under conditions of either central target designation to or local target selection by each of the directors.

7. The UETDS is basically an attack plot indicator system of the type described in the previous paragraph. The various elements of the attack plot indication are presented on a single plan position indicator through a system of time sharing. Color differentiation is obtained through controlled excitation of the various indications on cathode-ray tubes having P7 or P14 screens. Normally, the search radar information is presented at high intensity to give a long persistence orange phosphorescence to the targets, while director and mark indications are visible only by blue fluorescence. Plate 1 shows diagrammatically the proposed indications and plots described below:

(1) Search Radar Indications: Target information from one or more search radars may be shown. Circuits are arranged to limit the visible sweep of each search radar to that range sector within which it gives the best target definition consistent with complete coverage. It is recommended that search radar information be normally provided by one long range radar whose sweep is blanked out at ranges below 30,000 yards, and by two short range high definition radars which cover surface and high elevation targets at ranges within 30,000 yards.

(2) Director Indications: The gated position, activity, and identification of each radar director are shown by presenting in plan position 2000 yard intensified portions of its sweep. The first intensified sweep section is triggered by the precision sweep of the director radar and extends over its range gate. A target appearing at the center of this sweep section, therefore, may be assumed to be gated by the radar director. Coding of the various directors is indicated by the total number of intensified dashes on the sweep.

(3) Designation and Identification Indications: Target marks, which may be coded circles, ellipses, or dots, are provided for designation and identification purposes. It is recommended that circular marks of two distinct sizes and four different codes be used to point out "bogies" and either a dot or a dotted circular mark be used to identify friendly targets.

(4) Designation Indicator Plots: The indicators of the UETDS are designed to present either the total plan position display of the system or, by amplification, either centered or off-center sections of the total display. The maximum range of any of the indications is necessarily the same for all indicators, since the indicators are simply repeaters of the general display. The minimum area which can be amplified to cover the indicator screen is approximately one-quarter of the total display area.

As an aid to target acquisition, the UETDS includes an acquisition display generator unit which generates plan position and height position indications of the director radar scanning. Plate 3 shows a diagram of the proposed height position indicator. The indicators for the acquisition and designation displays are identical units. Therefore, if space limitations dictate the use of only one or at most two indicators at a director, these may be switched to any of the designation or acquisition displays. The acquisition display generator intensity-codes the video output of a director radar to provide the director indications described in paragraph 2. This intensity code appears on the acquisition as well as on the designation displays and provides range correlation of the different displays.

8. A matching accuracy of better than one degree in azimuth and one per cent in range should be attainable between the radar sweeps shown on the designation indicator. The absolute accuracy of any of the displays with respect to external range and azimuth marks may be as low as five degrees in azimuth and five per cent in range if standard cathode-ray tubes are used. This possible distortion of the displays should not hinder accurate electrical matching of the sweeps on the designation indicators, although it may prove undesirable on the acquisition indicators. In this case the use of selected cathode-ray tubes for these indicators should permit reduction of their absolute errors to approximately two degrees in bearing and two per cent in range.

PROPOSED OPERATIONAL PROCEDURE

9. The original proposals for the UETDS were made during the war, and considerable effort was spent designing the system so that it might be used with existing equipment and established procedures. Following the conclusion of the war a few changes have been made in the operational features of the equipment, but in the main the system is designed as a

[redacted]

general attack plot indicator and designation system which may be used to advantage with most types of radar search and fire control equipment.

10. As outlined in the paragraphs on the operational features of the UETDS the system provides both designation and acquisition indicators. The designation indicator presents the general attack plot indication, while the acquisition indicators provide range correlated plan position and height position displays of the director radars. Control of all designation and identification marks should be exercised by a target plot group located either at CIC or at an equivalent gunnery information center. This group should plot with appropriate markers any unidentified target pips and also any identified echoes which are approaching an unidentified target in a zone of action. It is recommended that friendly targets should be indicated either by a single blue dot or by a dotted circle, while enemy targets should be marked by distinctly coded circles. Enemy targets so indicated may be designated Able, Baker, Charlie, etc., as shown in Plate 1.

11. Designation of targets to particular directors may be made in a number of ways. Since each director control officer will have a repeat of the attack plot indication, he will have practically the same information as the gunnery control officer and will thus be equipped to select the most dangerous target not being tracked by other directors. Designation of targets to particular directors may be accomplished by controlling lights at the director designation indicator to illuminate the name of the target designated. A second method, but one which would cause additional complication to the display, would be to have special marks for designation purposes alone. In addition to these visual methods of target designation, it will always be possible for a control officer to designate targets verbally to the directors from any position equipped with a UETDS designation indicator.

12. The fundamental aim of the UETDS is to permit acquisition of designated targets by fire control radars within an interval of a few seconds. Target acquisition time should be reduced to an absolute minimum because, in addition to the tactical desirability of rapid target acquisition, the difficulty and even uncertainty of acquiring a target increase cumulatively with the elapsed time following an accurate target designation. The UETDS indicator will furnish accurate target location information at intervals equal to the rotation periods of the search radars. Target acquisition procedure should be developed to the point where a designated target may be picked up in less than five seconds after its illumination by a search radar. The acquisition indicators have been designed specifically to speed up and simplify target acquisition. The following acquisition procedure is suggested for a fire control radar equipped with the UETDS designation and acquisition indicators:

(1) An operator, who may be called the acquisition operator, slews the director radar precision sweep indication on the designation indicator to the range and bearing of the designated target and sets in a range rate corresponding to the movement of the target. This should place the radar initially

 [redacted]

within about one degree in bearing and 200 yards in range of the target position.

(2) The elevation operator makes a rapid elevation search on the height position indicator until the target is located within the precision sweep range. If the approximate altitude of the target is known by the elevation operator, its position will be defined on the height position indicator, and very little searching should be necessary.

(3) The elevation and train operators center the target within the antenna scanning angle by means of the acquisition indicators until the range operator can gate it.

13. Looking to future simplification and improvement of the control and coordination of radar fire control systems, it is suggested that small remote-control consoles of each major radar director containing acquisition and identification indicators be placed below decks with the main designation indication and target plot facilities. The remote control consoles should permit a single operator to exercise complete control over the director and to acquire, identify, and track targets with the director radar. The inclusion of such facilities at a single below deck station would permit a minimum number of officers and men to keep the entire fire control system of the ship in instant readiness. Immediately upon location of unidentified aircraft or missiles by search radar the watch group at this station could switch on directors, radars, etc., and acquire and track the targets until the regular crews had reached their stations and were ready to take over.

14. Technically, the control of directors and radars from small remote consoles should be straightforward and relatively simple. The system would involve no complex and extensive automatic circuitry as might be required by a system for automatically evaluating and designating targets. Furthermore, the personnel required for a standby watch on the system suggested would exceed very slightly the number required to supervise and exercise master control over an automatic system.

SUGGESTED FEATURES FOR FUTURE TARGET DESIGNATION EQUIPMENTS

15. In the course of designing the UETDS a number of basically different methods and features have been considered for use in target designation systems. These ideas may well have been previously proposed, discussed, and possibly investigated; however, they are included here to give a general picture of some of the possible target designation equipments.

16. Perhaps the most outstanding deficiency of the UETDS and most other indicator systems is the lack of any provision for indication of target elevation. Although at present very few search radars can supply target elevation information, new models are being designed to provide

this information. To automatically indicate target position in range, azimuth, and elevation on a single indicator from information provided by a continuously scanning radar is a problem of considerable proportions. For designation systems composed of an attack plot indicator with repeaters located in each director, it is essential that the indicators be of small size and that the presentation be easily interpreted. From these and other general considerations, it is suggested that color may provide a suitable medium for the indication of target elevation angle on a plan position indicator. It should be possible for operators to easily distinguish at least six different colors and to match at least twice that many. This should enable designation of target elevation to within five degrees, which should be sufficient to eliminate the necessity for director radar operators to search in elevation for a designated target.

17. The use of color to indicate target elevation must, of course, await the development of a suitable color indicator. At the present time the only successful scheme for obtaining multi-colored indications from cathode ray tubes known to the author is that used for color television. This system requires the transmission of separate monocolor frames which are viewed successively through red, green, and blue filters mounted on a disk and rotated synchronously with a similar filter in the pick-up unit. This system could be applied to an attack plot indicator such as that of the UETDS and should work well except for the important limitation that indicators of this type cannot show persistence in a particular color. Thus, it would be impossible to show by persistence the target echoes from search radars.

18. A second possible method for multi-color presentation of persistent indications would consist of the optical superposition of three cathode-ray tubes with red, green, and blue long-persistent screens. Unfortunately, the normal differences in the electrical characteristics of most cathode-ray tubes make accurate superposition of the displays of any three cathode-ray tubes extremely difficult. Furthermore, the installation of such complex indicators in directors and other tactical fire control positions would be ill-advised.

19. Actual televising in color of the attack plot display on three appropriately colored indicators provides a third method of target elevation indication by color. This system would require accurate electrical and optical superposition of the three televised indications at the main unit only and might, therefore, be considered suitable for development and ultimate use. The use of a television scan for the indicator system has a number of interesting possibilities. It is ideal for video insertion of written instructions and diagrams into the general display and is well suited for radio transmission to other ships in the event it is decided to provide visual information links between the ships of a task force.

20. In connection with the televising of cathode-ray tube indications, it would be very desirable to have a storage tube by means of

which an image traced by an electron beam could be televised directly without the necessity for an intermediate optical system. Development of such a tube for this and other applications is strongly urged.

PRESENTATION OF TARGET INFORMATION IN TRUE PLAN POSITION

21. To accurately correlate radar information obtained from points separated by an appreciable distance it is necessary to indicate the horizontal rather than the slant range of targets. The UETDS may be adapted to show targets at their ground range and to present with appropriate displacement plan positions indications of radars separated by appreciable ranges if the radars give elevation angle information. Coordination of shore based anti-aircraft batteries, which are normally separated by considerable distances, is probably the major application for an attack plot indicator system having a true plan position presentation. Aboard ship no advantage would be gained by this method of presentation because the distance between different radar locations is small.

EXTENSION OF TIME SHARING IN THE UETDS

22. The attack plot indication of the UETDS is achieved through a system of time sharing. Although the timing circuits are designed to give a maximum of the available time to the search radars providing target information, it is unavoidable that the secondary search radars have considerable insertion loss because of this method of operation. Furthermore, as the duty cycle of the primary search radar increases, less and less time will be left for all of the other indications.

23. One method for effectively extending the available time for presentation of the various indications of the UETDS is to use multi-gun cathode ray tubes as indicators for the system. The difficulty in matching indications from different electron guns would, however, result in a considerable increase in the complexity of the indicators in addition to a probable loss in accurate range and aximuth correlation of the different elements of the display.

24. A more promising method which has been considered is the use of storage tubes to store radar information during the interval that other indications are being shown. The stored radar information could be removed from the storage tube by a single sweep at appropriate intervals of 5000 microseconds, for example. This procedure would allow the presentation of all target information from several radars in a regular sequence and would eliminate the need for the priority timing circuits which are used in the present design of the UETDS. It is recommended that this method be developed to improve the time sharing capabilities of the UETDS.

GENERAL CIRCUIT DESCRIPTION

25. A block diagram of the UETDS is presented in Plate 4. The system is composed essentially of a number of input units which provide radar and mark indication voltages through electronic switches to a common indicator system. Electronic switching is employed to present on a plan position indicator the information from one or more radars simultaneously with several target designation or identification marks. Electrostatic deflection cathode-ray tubes are used as indicators to permit high speed switching of the various presentations. The switching is done in such a manner that some of the presentations may be given relative priority, and the rest follow a timing sequence without priority. Priority in the time sharing is normally given to the input units generating the search radar plan position indications, while all other input units follow a regular timing sequence. This method of time sharing permits presentation of every sweep of the search radar having top priority and relegates the time for the presentation of all other indications to the dead time of the sweep. If another radar input is assigned second priority, each sweep of this radar occurring in the dead time of the first radar sweep will be presented. The time available for the presentation of other indications will consequently be reduced to intervals when the dead time of both priority radar sweeps coincide. Indications switched into the system in timing sequence, such as marks and director repeat-back indications, are allotted consecutive intervals of about 1000 microseconds in which they may be presented if the time is not taken by a priority input.

26. The mark indication voltages from the Mark Input units and the video voltages from all input units are switched directly into the common output lines. The Radar Input units and the Own Ship's Course Input unit switch dc voltages corresponding to sine and cosine functions of the aximuth angle of the controlling equipment to a common resolved sweep generator which generates dc centered sweeps proportional to the sign and magnitude of the dc input voltages for each such input in accordance with the time sharing scheme. The output deflection voltages of the resolved sweep generator are switched into the common output lines. All indications are generated and transmitted as three separate voltages: the horizontal or X-axis deflection voltage, the vertical or Y-axis deflection voltage, and the video or Z-axis intensity voltage. In the diagrams and discussions of this report these voltages are usually referred to as X, Y, and Z-axis voltages. The common output lines from the input units are fed into isolation units which transmit the X, Y, and Z-axis voltages at low impedance to the indicator units where the signals are amplified to the level required by the indicating cathode-ray tubes.

27. At the screen of the cathode-ray tube, indicator presentations switched into the system in timing sequence are excited for short intervals of time at the timing sequence repetition rate of about 60 cycles per second. At the same time search radar information presented on a priority basis will have repetition rates ranging from about 60 cycles per second up to that of the radar systems providing the information. This rapid excitation of all presentations

causes them to fluoresce continuously at their instantaneous positions. By using a cathode-ray tube with a long persistent screen, such as the P-7 or P-14 which has blue fluorescence and yellow or orange phosphorescence, it is possible to provide color differentiation between the radar map produced by the search radar indications and the mark and director repeat-back indications. This is possible despite the blue fluorescence of all indications at their instantaneous positions because target information is obtained from the radar map traced by the rotating sweeps of the search radars rather than from the sweeps themselves, while coordination information is obtained from the instantaneous position of the marks and director repeat-back indications. The radar map is given orange phosphorescence by high intensity excitation of the rotating search radar sweeps, and the mark and director repeat-back indications are caused to appear blue with negligible phosphorescence by low intensity excitation. Plate 2 shows the two-color presentation of the laboratory model of the UETDS.

MECHANICAL ARRANGEMENT OF COMPONENTS

28. Mechanical design of the components of the UETDS has not been undertaken, but the electronic circuits have been designed to permit their incorporation in individual standardized units which may be added or removed from the system for either tactical or maintenance purposes without interfering with the operation of the remainder of the system. It is felt that the target designation requirements and facilities of the ships of the fleet vary to such an extent that it is desirable for a designation system to be constructed in units which may be assembled in such combination and arrangement to provide the most suitable dissemination of radar information and coordination of directors for each particular ship. Since the UETDS is composed of a number of parallel input, transmission, and indicator units, it is well suited to construction and subsequent assembly in units of this type.

CIRCUIT DISCUSSION

29. The general interrelation of the various units and circuits of the UETDS is shown in the block diagrams of Plates 4 through 9. The detailed circuitry of the individual units is shown in the schematic diagrams of Plates 10 through 18. Since most of the circuits are simple and several are used in more than one unit, discussion will be made for the most part on a circuit rather than on a unit basis.

Resolved Sweep Generator

30. Plates 5 and 10 show the block diagram and the schematic of the resolved sweep generator, respectively. Display of plan position indications on an electrostatic cathode-ray tube requires the generation of dc-centered sweeps for both the horizontal (X)

[redacted]

and vertical (Y) deflection axes of the tube. These sweeps may be accurately modulated in sign and magnitude to be proportional to the sine and cosine of the aximuth angle of the equipment controlling the indication. For the UETDS it was desired to use a single resolved sweep generator to develop in rapid succession the voltages required to produce plan position displays for several different equipments. This imposed three additional fundamental requirements on the sweep generator circuits:

(1) The sweep generators must be modulated by dc potentials which may be varied rapidly to represent the sine and cosine of several different equipments.

(2) The successive sweep voltages must be accurately proportional to the modulation potentials regardless of any change in the value of these potentials, the sweep repetition rate, or the interval between sweeps.

(3) The minimum interval required between successive sweeps must not be over five microseconds.

The circuit which has been developed meets all of these requirements satisfactorily.

31. The modulated sweep generators are composed of an RC charging circuit and a vacuum tube clamper circuit. Modulated sweeps are generated by unclamping a charging circuit from a fixed dc center potential and allowing it to charge either positively or negatively towards the modulating potential. In the X-axis the charging circuit is composed of the resistors R120 and R121 and one of the condensers C108, C109, or C110. V105B and V107 form the X-axis clamping circuit, normally holding the charging circuit to a potential of about + 5 volts. When a negative sweep gate pulse is received by the resolved sweep generator, it is amplified by V101, V102, and V103A and applied to the control grids of the clamping tubes. The negative sweep gate pulse drops the potential of the control grids of the clamping tubes from + 5 volts to approximately -100 volts, completely cutting off the plate current of these tubes and allowing the charging circuits to charge exponentially towards the potential of the X and Y input voltages. The sweep voltages thus generated are accurately proportional to the X and Y input voltages. The time required for the charging circuit to charge up to 23 per cent of the input control voltage is the nominal duration of the sweep. On this basis the condensers shown in the charging circuit will give sweep ranges of approximately 18, 36, and 72 thousand yards. Different condensers may be used to give any desired sweep ranges.

32. The X and Y inputs to the Resolved Sweep Generator are connected to the X and Y outputs of the Radar Input units and the Own Ship's Course Input unit. At a given time the X and Y inputs are

[redacted]

dc voltages equal to 70 sin B_r and 70 cos B_r, where B_r is the azimuth angle of the resolver connected to the particular input unit supplying the voltages. The timing circuits of the input allow one input unit at a time to present its X, Y, and sweep gate outputs to the resolved sweep generator with a minimum interval of four microseconds between sweeps. This interval between successive sweeps is required to permit the clamping tubes to completely discharge the charging circuit.

33. The design of the modulated sweep generators insures that the relative accuracy of successive sweeps of different magnitudes, durations, polarities, etc., will be extremely good providing the clamping tubes release the charging circuits from precisely the same potential for each sweep. The clamping circuit used has an effective resistance of about 130 ohms to both positive and negative potentials and clamps at approximately + 5.3 volts when the control grids of tubes are held to + 5 volts. The low resistances of the clamping tubes limit the change in clamping potential caused by a maximum voltage change of 140 volts across the charging circuit resistor to 0.1 volt, or 0.6 percent of the sweep voltage. The releasing potential of the clamping tubes is also affected by the change in the relative conduction of the two tubes during the initial drop of the sweep gate pulse. This change in relative conduction causes a current to charge or discharge the charging circuit for the interval in which the sweep gate pulse drops from its maximum positive clamping potential to the potential at which both of the clamping tubes are cut off. The amount of change in the releasing potential of the clamping circuit is inversely proportional to the sharpness of the intial edge of the sweep gate pulse and to the capacity in the charging circuit. In the sweep generators under discussion it is about 0.2 volt.

34. If the resistance-capacitance products of the X and Y charging circuits are not equal, the resultant radial sweep shown on a cathode-ray tube will not be a straight line but will be bent in a curve to one side or the other. This will not affect the relative accuracy of successive sweeps but is undesirable, since it will cause angular distortion of the plan position display. Selected resistors and condensers should, therefore, be used in the charging circuits.

35. The simple RC charging circuit used in the modulated sweep generators will produce an exponential sweep with a range non-linearity of about 10 per cent. It is possible to produce an approximately linear sweep from the modulated sweep generators by the addition of positive feedback to the charging circuit, providing the change in the modulation potentials is slow in comparison with the time constant of the feedback circuit. This provision prevents the use of feedback circuits in the Resolved Sweep Generator of the UETDS, since one of the major requirements for this unit is that the modulation of successive sweeps be completely independent of sweep-to-sweep changes of the modulation potentials. It does not, however, prevent the use of such circuits in the modulated sweep generators of the Director Acquisition Display Generator, for the maximum rate of change of the modulation potentials of this unit will be that of the antenna scanning which is generally about 30 cycles per second. With reference to the X-axis modulated

sweep generator circuit of Plate 10, positive linearizing feedback may be added by capacitatively coupling the sweep output from the cathode follower V104A to the center tap of the charging circuit resistance, i.e., between R120 and R121. The coupling capacitor should have a value of 0.05 microfarad or larger.

Timing Circuits

36. The presentations generated by the various radar and mark input units are switched in rapid succession into the common output lines on a time-sharing basis. Since some of the presentations have much greater tactical value than others and some, for example, the radar sweeps, only present their information at certain intervals, the time sharing must be arranged to present each input for such intervals and at such repetition rates as to give the composite indicator picture the greatest tactical value. The timing circuits of the input units are designed to permit time sharing primarily according to relative priority and secondly according to a timing sequence. Normally, information having direct tactical value such as that provided by search radars will be placed on a relative priority basis, while coordination information such as marks and director repeat-back indications will be presented according to a regular timing sequence during the off time of the priority inputs.

37. Coordination of the time sharing by the various input units is exercised through timing sequence, priority control and priority summation circuits. The timing circuits of the Radar Input Units and the Own Ship's Course Input Unit are essentially the same and contain all three of the above-mentioned circuits, while the Mark Input Unit has only the first two circuits. The sweep gate is the summation of the negative priority pulses of the Radar and Own Ship's Course Input Units. In the Resolved Sweep Generator the sweep gate is inverted and transmitted to the Mark Input Units as positive mark priority control pulses.

38. The timing circuits of the input units act effectively as a series of switches each of which must be closed before that unit can present its information to the indicators. If, for example, a Radar Input Unit is operated in sequence timing, it cannot present any information until it receives a "sync" pulse from the radar at the time when its sequence timing multivibrator is on and no higher priority Radar Input Unit is on. A switch is provided on each input unit to eliminate its sequence timing multivibrator from the timing chain. In a Mark or Own Ship's Course Input Unit, turning this switch to the "Off" position will remove the indication from the indicators; in a Radar Input Unit this switch is used to give the unit either sequence or priority time sharing.

39. The timing sequence is initiated by a multivibrator in the Coding Oscillator Unit. This multivibrator, shown schematically in Plate 15, transmits about 60 positive pulses per second to initiate the sequence timing of the various input units. The sequence timing

multivibrators of the input units are triggered upon reception of a positive pulse and, after a period of about 1000 microseconds, are cut off with the transmission of a delayed positive pulse to the next input unit. This method of interconnection causes the sequence timing multivibrators of the various input units to operate one after the other in ladder fashion.

40. In the Radar Input Unit, Plate 11, the sequence timing multivibrator, V201, exercises control over the unit when it is being operated in sequence timing by holding the control grid of the radar sync multivibrator, V202, at about -50 volts and thus prevents the radar sync pulse from triggering the circuit except for the period when V201B is triggered off. This is accomplished by connecting the plate of the normally conducting triode of V201, the sequence timing multivibrator, to R206, the input grid resistor of V202A, and by operating V201 at -150 volts with respect to V202. If the switch SW201 is turned from the Sequence Timing to the Priority position, R206 is disconnected from V201, and the sequence timing output is switched from the cathode of V201 to the sequence timing input. V201 is thus eliminated from the timing sequence ladder and from control over the particular input unit.

41. In the Mark Input Unit, Plate 13, the sequence timing multivibrator feeds a negative pulse directly into the priority control stage, V402. The priority control stage consists simply of two cathode follower triodes having a common cathode load. Priority control is exercised by the introduction of a positive square wave pulse onto the grid of V402A to return or hold the common cathode to a comparatively high potential regardless of the negative excursions of the grid of V402B. This prevents the sequence timing multivibrator from turning on the electronic switch through transmission of a negative pulse to the switching stages.

42. The sync multivibrator in the Radar Input Unit, V202 in Plate 11, is keyed by a positive pulse of about 15 volts from the radar to which the input unit is connected. The two stages of the multivibrator, V202A and V202B, are coupled through a low impedance cathode follower, V203B, to reduce the effect of radar repetition rate on the duration of the output switching pulse. Priority control over the sync multivibrator is exercised by V204, which holds the control grid of V202A sufficiently negative to prevent its being keyed for the duration of a priority pulse. C203 in connection with R205 forms a capacitative load on R206 and delays the positive swing of the control grid of V202A after the cutoff of the priority pulse. It is intended that this circuit shall delay any possible triggering of the radar sync multivibrator by four microseconds. This arrangement sets the minimum interval between successive output pulses by Radar or Own Ship's Course Input Units and assures that the clamping tubes in the modulated sweep generators will be allowed sufficient time to completely discharge the charging circuits.

43. The sweep gate pulses are the summation of all the priority pulses from the Radar and Own Ship's Course Input Units. Summation of the negative input sweep priority pulses with a negative pulse from a

[redacted]

Radar Input Unit is obtained through V204 and V205 in Plate 11. The negative sweep priority pulse is received on the grid of V204A. The plate of this tube is directly coupled to the grid of V205A, and maintains V205A at cutoff when there is no priority pulse and at zero grid bias when a priority pulse is received. The grid of V205B is resistance-coupled to the plate of V202B which, as the normally conducting triode of the sync multivibrator, maintains V205B at cutoff when the multivibrator is relaxed and at zero grid bias for the interval that it is triggered on. Since the sync multivibrator can be triggered only when there is no priority pulse and since the amplitude of the pulse inputs to V205A and V205B are effectively identical, the output pulses of the common plate load of V205 are always of the same amplitude. These pulses constitute the output priority control of the unit.

44. The timing circuits of the Own Ship's Course Input Unit are identical to those of the Radar Input Unit with the exception that no sync pulses are received. By placing a small condenser of about 0.001 microfarad between the plate of V201B and switch SW201 and by returning the plate of V201B to ground through an 8,200-ohm resistor, the sequence timing multivibrator may be made to key the sync multivibrator of this unit.

Electronic Switching and Blanking Circuits

45. The electronic switching circuits used in this system are required to switch dc centered high frequency signals at rapid rates and to introduce blanking into the video channel for the transition period of the switching. The switching is accomplished by connecting the grid of an output cathode follower to the plate of a triode amplifier switching tube which, when cut off, permits normal operation of the output cathode follower and which, when drawing current, biases the grid of the output tube below cut off. Blanking is obtained by delaying the opening of the video channel until the signals of the X and Y axes have reached their normal bias and by cutting the video signals of the Z axis off before the X and Y switching takes place.

46. The X and Y switching and output stages of the Resolved Sweep Generator and the Radar, Own Ship's Course, and Mark Input Units are self explanatory. The Z or video switching stages are somewhat more complicated because of the blanking and intensity controls required. In Plate 11, V207 and the associated components perform the video switching, blanking, and intensity control functions for the Radar Input Unit. V207A is the switching tube. R219, designated as the "Video Level" control, adjusts the voltage across V207A when it is cut off and thus controls the bias on the video signal at the grid of the output cathode follower. Condensers C209, C210, C211, and C212, which may be switched across V207A by the "Sweep Start Blanking" switch, delay the rise of the bias on the grid of V206B when the switching tube is cut off and thus prevent the presentation from being observed on the indicator for an interval after the stage has been switched on. In the Radar Input Unit several different values of condensers are used to permit blanking various proportions of the resolved

sweep in case it is desired to vary the minimum range at which the sweep may be observed. Blanking of the presentation during the switching off process is accomplished by means of V207B and its associated differentiating circuit. This tube is normally biased to cutoff by the voltage divider in its cathode circuit, and its grid receives the switching pulse through a short time constant differentiating circuit. When the switching pulse rises positively to cut off the switching tubes, its initial rise in potential is passed through the differentiating circuit and causes V207B to conduct and to drop the voltage on the grid of the video output tube, thereby blanking the presentation. The switching tubes do not conduct until the switching pulse has risen several volts because the negative potential of this pulse is considerably below the cut-off potential of these tubes, and the presentation is thus blanked before any change in the X and Y signals as a result of the switching has taken place. The video switching and blanking stages of the Mark and Own Ship's Course Input Units are essentially the same as those of the Radar Input Unit with the exception that no provision is made for variable blanking time.

Resolvers

47. Dc voltages which are accurately proportional to the sine and cosine of an input angle are required to modulate the sweep generators of the Resolved Sweep Generator and the Direct Acquisition Display Generator. The component dc voltages may be obtained either directly from a suitable potentiometer or by phase sensitive rectification of ac component voltages obtained from an ac resolver. By use of special transformer or resistance networks, ac component voltages may be obtained directly from three phase synchro stator voltages.

48. One method of utilizing the standard synchro transmission for generation of dc sine and cosine components of the synchro angle is shown in Plates 7 and 12. Ac component voltages are obtained from the rotors of two control transformers whose rotors are locked at zero degrees and 90 degrees. Dc component voltages of potential and polarity corresponding to the amplitude and phase of the ac output of the control transformers are obtained from the phase sensitive rectifier circuits.

49. The Y-axis phase sensitive rectifier of Plate 12 is composed of V311, T301, and the associated resistors and condensers. With no input from the control transformer, the cathode of V311A will be about + 100 volts, while the plate of V311B will be at -100 volts. The Y output tap of R333 is adjusted to be at zero volts under this condition. When voltage is applied to the center tap of the secondary winding of T301 by the control transformer, it adds a voltage of constant phase to all points of the winding, thereby adding to the induced voltage at one end of the winding and subtracting from the other. This unbalance causes the dc center of the phase sensitive rectifier, and thus the Y output voltage, to change either positively or negatively in proportion to the amplitude and phase of the control transformer output.

50. There are several limitations to this method of obtaining dc component voltages for controlling the resolved sweep generator. The most important of these are:

(1) The use of the phase sensitive rectifiers adds a stage in which both amplitude and center errors are likely to be incurred.
(2) The regulation of the voltages used by the various synchro systems aboard ship is not too good, and if components of this voltage are used to modulate the sweep generators, the length of the sweep will vary accordingly.
(3) The maximum rotation rates which can be accurately followed by the phase sensitive rectifiers are limited by the filters necessary to reduce the 60 cycle ripple voltage in the output to a maximum of about 0.5 per cent of the maximum dc output.

The X and Y outputs of the phase sensitive rectifiers of Plate 12 will lag the envelopes of the input ac voltages by one degree when the modulation on the 60 cycle carrier has a frequency of two cycles per minute. More complex filters could be designed to reduce this lag and might permit the circuit to follow rotation rates as high as 10 to 15 rpm with a maximum of one degree lag.

51. The inherent inaccuracy of the phase sensitive rectifiers constitutes the fundamental objection to all methods in which the component voltages are initially obtained as ac voltages. The poor regulation and slow maximum rotation rates of the circuit of Plate 12 are both due to the use of the standard synchro transmission voltages and will not adversely affect the control of the Own Ship's Course sweep since variation in ship's heading are slow. By utilizing resolvers operated on a regulated 1800 cps supply, for example, there would be no regulation problem, and simple filters in the phase sensitive rectifier circuit could pass one cps with a lag of less than one degree.

52. The use of special potentiometers wound to provide directly dc voltages corresponding to the sine and cosine of the rotor angle is considered the most accurate, simple, and reliable method of controlling the resolved sweep generators. The circuit for such a potentiometer is shown in Plate 11. No investigation has been made into the design details of such a potentiometer, but there should be nothing to prevent the design and manufacture of precision units of this type.

53. The potentiometer resolvers of the Director Acquisition Display Generator are required to cause the sweep generators to follow the antenna scanning of the director radar in addition to its angular position. This is accomplished as shown in Plate 9 by applying the antenna scanning voltages at right angles to the dc position voltages. Applying the scanning voltage in this manner adds it vectorially to the normal sweep

modulating voltage and the X and Y outputs of the resolved sweep generator will be

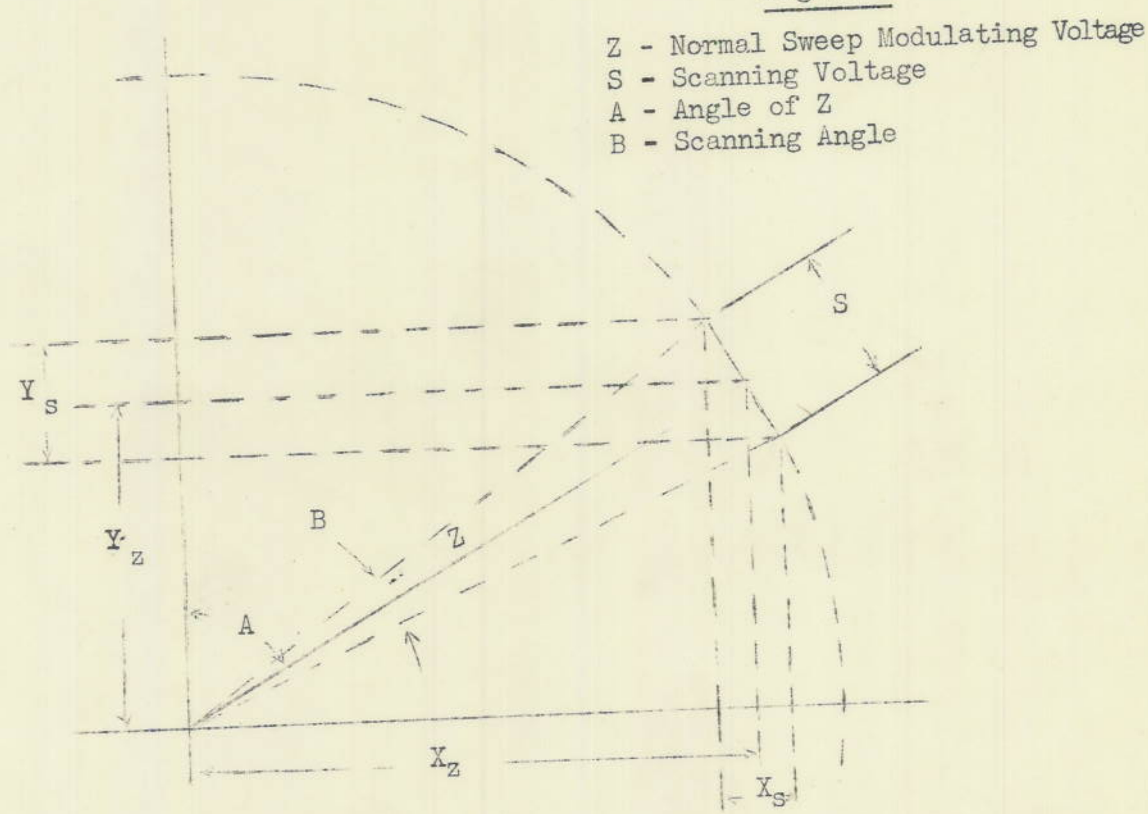
$$X = Z\sin A + S\cos A$$

$$Y = Z\cos A + S\sin A$$

where Z is the normal sweep modulating voltage, S the antenna scanning voltage in the plane of Z, and A the angle of Z.

54. Figure 1 shows diagrammatically the manner in which the scanning voltage S is added to the normal sweep modulating voltage Z. The method may be seen to be approximate rather than exact, for S is a straight line tangent to the circle traced by rotation of Z rather than a segment of it; however, for small scanning angles such as are normally used by fire control radars, there is very little error in the approximation.

Figure I



Mark Control Circuits

55. The circuits located in the Mark Input Unit generate and control voltages by which a video coded circle, line, ellipse, or spot may be presented on an electrostatic deflection cathode-ray tube. The mark itself is essentially a lissajou figure produced by applying

two phased voltages from the same source to the horizontal and vertical plates of a cathode-ray tube. The mark is positioned by dc voltages controlled by the Mark Control Unit and is intensity coded by the insertion of voltages which are integral frequency multiples of the mark producing voltages into the video channel of the system.

56. With reference to the schematic diagram of the Mark Input Unit shown on Plate 13, the Mark Generator is composed of V407B and its associated components. Voltages for producing and coding the mark are obtained from the Coding Oscillators. V407B splits the phase of the two kc mark voltage and transmits one phase to the X-axis and the other phase to the Y-axis circuits. The size of the mark is controlled by R423 which limits the input to V407B, and the shape of the mark is controlled by R429 which varies the phase angle of the voltages applied to the X and Y deflection axes. The position of the mark is set by dc bias voltages controlled by potentiometers in the Mark Control Unit.

57. The code selector switch in the Mark Control Unit can be set to ground the cathode resistor of either section of V403 or to leave the cathodes of both sections ungrounded. This permits either of the video codes supplied to the Mark Input Unit or no code to be used on the mark. The peak positive output of V403 is clamped to ground potential by V407A to maintain the peak mark intensity at the same level regardless of its code.

<u>Transmission Circuits</u>

58. The X, Y, and Z signals of the UETDS are transmitted to and through the various units of the system by series of cathode follower stages. The X and Y axes transmission elements are required to be exactly linear resistance-coupled dc stages with a maximum time constant of one microsecond. The Z axis transmission elements are required to pass frequencies from about 60 cycles per second to three megacycles.

59. The video inputs of all the output units and the X and Y outputs of the Mark Input Units are switched directly into the common output lines, and the X and Y outputs of the Radar and Own Ship's Course Input Units are switched first into the Resolved Sweep Generator and then into the common output lines. The terminating resistors of all the X, Y, and Z inter-unit lines are located in the Resolved Sweep Generator, Plate 10.

60. The maximum, minimum, and center voltages of the various X and Y stages of the Radar Input Unit, R esolved Sweep Generator, and Isolation Unit are shown on the schematic diagrams of these units. All of the X and Y stages should be precisely linear within these limits.

61. The most critical elements in the X and Y axis circuits are the two cathode followers of each axis in the Radar Input Unit. Any nonlinearity or change in the input-output voltage relationship of these cathode followers will cause range and angle errors in the sweep generated for this unit. The voltage centering controls are for the purpose of adjusting the output voltage of the two cathode follower stages to be equal to the clamping potential, about + 5 volts, of the clamping tubes

in the Resolved Sweep Generator when the input is at ground potential. No adjustments are provided in the present circuit for adjusting the input-output voltage characteristics of these cathode followers in each of the Radar Input Units to be identical. Tests of a few such stages have indicated that this is not necessary, but additional tests should be made for verification.

62. The X and Y stages in the Resolved Sweep Generator and all following units are not so critical with respect to drift, etc., since a change in these circuits will not affect the relative accuracy of the various radar sweeps although it may cause distortion of the indicator presentation. All of the circuits used, however, are linear by test and show very little tendency to drift.

63. To maintain a minimum time constant in all the X, Y, and Z inter-unit lines, it is of great importance that the capacity of these lines be a minimum. This effectively requires that the various units be designed and mounted specifically to facilitate inter-connection of the units by self-supporting unshielded lines of minimum length. To maintain a one microsecond time constant in the X and Y axis output signal lines connecting the Resolved Sweep Generator, six Mark Input Units, and six Isolation Units, the capacity of the lines must be less than 150 mmfd.

64. The Isolation Units, shown schematically in Plate 16, are designed to transmit the X, Y, and Z axis signals through coaxial lines to the indicator units. The Z axis stage of this unit transmits positive video signals of about three volts amplitude to a terminating resistance load at the indicator unit which may be chosen to match the coaxial cable used.

65. The X and Y axis stages of the Isolation Unit are required to transmit linear sweep and mark voltages at maximum amplitudes of $\pm$ 13 volts from a + 13 volt dc center. Because of these requirements, it is impossible even with four 6J6 driving tubes to terminate a low impedance coaxial cable in its characteristic impedance, and it is, therefore, necessary to consider the cable as a lumped capacitative load. The output impedance of the X and Y isolation stages is about 350 ohms to negative pulses, 250 ohms to dc potentials, and 25 ohms to positive pulses. Based on the dc output impedance, these stages will have a one microsecond time constant if they are connected to a 4000 mmfd. load. This corresponds to the capacity of about 400 feet of RG 63/U or 300 feet of low capacity RG 8/U coaxial cable. The terminating resistance for the X and Y lines should not be less than 1500 ohms unless the ground to cathode resistance is increased in the X and Y cathode followers of the isolation unit.

Indicator Units

66. An indicator unit amplifies the X, Y, and Z signals received from an Isolation Unit and applies them to the deflection and intensity axes of an electrostatic cathode-ray tube. The complete indicator unit

includes the cathode-ray tube, high voltage power supply, deflection and video signal amplifiers, and low voltage power supply. The circuits shown in Plates 17 and 18 do not include the high voltage power supply. It is recommended that a compact audio or radio frequency high voltage power supply be used in the indicator units to keep the space requirements of the circuit to a minimum.

67. The amplifier circuits are those developed for the original Laboratory model of the UETDS and will probably require some modification before they will be adequately matched to the output of the redesigned system. The indicator amplifiers were not redesigned along with the rest of the equipment, as it was felt that redesign should await the final decision on the types of indicator cathode-ray tubes to be used in the system. The 5CP type cathode-ray tubes, for example, for which the Five-inch Indicator Unit was designed have already been outmoded for this application by the 7GP type tubes which have been announced recently.

68. The deflection and video amplifiers are subject to the same frequency and linearity requirements as the respective X, Y, and Z transmission stages. The video amplifiers of the Z axis are standard and require no adjustment. The deflection amplifiers are dc cathode-coupled push-pull stages. The circuits for the Five-inch and Twelve-Inch Indicator Units are similar.

69. The deflection amplifiers of the Five-Inch Indicator Unit are designed to develop maximum deflection voltages with an input equal to about one-quarter of the voltage transmitted to the unit from the Isolation Unit. An amplification switch is provided on this unit by which an operator may reduce the area shown on the cathode-ray tube to one-half or one-fourth of that for which information is generated by the input units. This is accomplished without altering the dc center of the presentation by the use of similarly coupled potentiometers for both the centering and signal grids of the deflection amplifiers. The amplification control is also coupled to taps on rheostats in the cathode circuits of the deflection amplifiers to maintain correct operating voltages on the stages when the dc level of the input signals is shifted. The gain of the two tubes making up a deflection amplifier is adjusted to be equal by means of the output balance control which adjusts the relative screen potential of the two tubes.

70. It is intended that a 5CP7A or 5CP14 cathode-ray tube be used for the Five-Inch Indicator. Under operating conditions of approximately + 2000 volts on the second anode and + 4000 volts on the intensifier anode, the maximum voltage required on each deflection plate to move the beam to any part of the tube face is about ± 150 volts. The deflection amplifiers are designed to supply slightly more than ± 150 volts to the deflecting electrodes so that saturation of the amplifiers will not occur until after the beam has been deflected beyond the face of the tube. When the amplification control is set to have the indicator show an area less than that for which the video and deflection voltages have been generated by the input units, the X and Y axis signal

voltage fed to the deflection amplifiers will be of such magnitude as to saturate the amplifiers at either or both extremities of the input signal potentials. The area presented on the indicator under this condition is selected by the vertical and horizontal center controls, and is shown in true plan position regardless of its location with respect to the center of the resolved sweep rotation.

71. The Twelve-inch Indicator Unit was designed to present the complete information of the designation system on a 12GP7 cathode-ray tube. No amplification control is provided in this unit, since the full amplitude of the X and Y axis input signals is required by the deflection amplifiers to develop maximum deflection voltages. The deflection factor of the 12GP7 when operated at approximately $+$ 6000 volts on the intensifier anode and $+$ 4000 volts on the second anode is about 110 volts per inch. Deflection of the electron beam to any part of the twelve-inch diameter viewing screen of the cathode-ray tube thus requires maximum deflecting potentials of about $\pm$ 350 volts on each deflecting plate.

72. The deflection amplifiers shown on Plates 17 and 18 were designed to operate on X and Y input signals of about $+ 30 \pm 12$ volts, while the output of the redesigned system is $+ 13 \pm 13$ volts. Reduction of the signals to this level will require reduction of the common cathode resistor of the push-pull amplifier stages to the point where distortion will probably result. To remedy this it is suggested that the resistor be connected to - 150 volts, which can be supplied from the power supply for the Isolation Units.

Coding Oscillators

73. The coding oscillators of Plate 14 provide the voltages for producing and intensity-coding the marks used to point out targets on the indicating scopes. The marks are produced by applying an ac voltage through circuits to both deflection axes of the indicator cathode-ray tube and are coded by intensity modulating the beam of the scope at a rate which is an integral multiple of the frequency of the voltage producing the mark. The coding oscillators provide an 1850 cps voltage for the generation of the mark, and voltages whose frequencies are 2, 3, 4, and 12 times the frequency of the mark voltage. These coding voltages divide up the lissajous figures of the marks into 2, 3, 4, and 12 separate segments. This coding of marks may be seen in the photograph of the presentation of the UETDS, Plate 2.

74. The coding oscillators consist of a series of harmonic oscillators. The oscillators are all of the same type and utilize a resistance-capacitance network to apply positive feedback at a single frequency to a high gain triode amplifier. The oscillators are harmonically locked by inserting a small harmonic voltage into the cathode of the oscillator triode. It has been found that oscillators of this type may be harmonically locked without difficulty to voltages with frequencies of approximately 1, 2, 3, or 4 times the natural frequency of the oscillator, and by careful adjustment such oscillators may be harmonically locked to voltages with frequencies ranging

from one-half to ten times the natural frequency of the oscillator.

75. Coding voltages for the marks may be generated by several circuits other than harmonic oscillators. Free running multivibrators which are cut off for short intervals at the frequency of the mark voltage offer one means for obtaining a given number of coding pulses for each cycle of the mark voltage. Another method would be the use of a special cathode-ray tube which has a number of spaced metallic plates as the target for the electron beam. By deflecting the beam of such a tube by the mark voltage, the current drawn by the target would be a definite series of pulses occurring within each cycle of the mark voltage. A single cathode-ray tube could have a large number of separate targets of this type each representing a different code. The tube could be designed to deliver all of the codes simultaneously by the use of a fan beam electron gun, or by the use of a normal pencil beam electron gun it could be made to deliver any one of the various codes simply by varying the deflection bias in the axis perpendicular to the alignment of the target plates. It is believed that generation of mark coding by such a tube would be desirable if a large number of codes are desired or if it is required that a Mark Control Unit provide selection of any code for the particular mark which it controls.

Range Calibrator

76. The function of the Range Calibrator is to inject ranged video pulses into all of the sweeps of the UETDS to permit range matching of the different sweeps and estimation of target range. The unit has not been designed since many such equipments have been previously designed and manufactured. The Range Calibrator may be keyed by the positive "Mark Priority Control" pulse, as shown on Plate 4, or by the negative "Sweep Gate" pulse.

Acquisition Display Generator

77. The Acquisition Display Generator develops range-correlated height position and plan position displays for a particular radar and transmits the video and sync of the radar to a Radar Input Unit after inserting an intensity code into the video of the radar. The block diagram of Plate 4 shows the interconnection of the unit with the rest of the UETDS, while Plate 9 shows its general circuit arrangement.

78. The circuits for the Acquisition Display Generator consist of two resolved sweep generators and potentiometer resolvers with antenna scanning voltage inputs, a video coding circuit, and a sweep timing circuit. The sweep generators may be identical to those of Plate 11 or may have the linearizing feed-back arrangement described in Paragraph 35 on Page 11, providing the antenna scanning is not faster than about 30 cycles per second. The timing circuit may consist of a simple one-kick multivibrator feeding a positive sweep gate pulse into an amplifier and sharpener circuit similar to that of V102 and V103A in Plate 11.

[redacted]

79. The sweep coding circuit of the Acquisition Display Generator is the only component of the unit not previously discussed in connection with some other unit. Its purpose is to intensify the video output of this unit for 2000-yard intervals starting at the initial range of the precision sweep of the radar and by this means to provide range correlation and identification of the different displays of the sweep. To accomplish this a multivibrator keyed by the precision sweep sync pulse is caused to release a ringing 81.995 kc oscillator for a number of cycles corresponding to the desired code. By keying a second multivibrator with the output of the ringing oscillator, a predetermined number of square wave pulses having exactly 2000 yards per half cycle may be obtained. Mixing these square waves with the radar video signal gives the desired intensity coding of the video output of this unit.

80. The Acquisition Display Generator has not been built as such, but all of its components, with the exception of the potentiometer resolvers, are similar to others which have been designed and tested. Once the specifications for the unit have been decided, its design should be a comparatively minor problem.

DC Power Requirements

81. All of the units of the UETDS with the exception of the indicator units require accurately regulated dc power at + 150 and - 150 volts. The circuit diagram for the Coding and Sequence Timing Generator indicates ground and + 300 volts as the dc power potentials; however, the circuit can and should be modified to operate between - 150 and + 150 volts. The Indicator Units have individual power supplies for the cathode-ray tube and deflection amplifiers, but require + 150 volts as a centering potential and, in the case of the Five-inch Indicator Units, for powering the video amplifier stage. If, as suggested in paragraph 1 on page 34, it is found desirable to connect the common cathode resistor of the deflection amplifier to - 150 volts, the indicator units will also require power at this potential. The approximate power requirements of the various units are as follows:

	Current at + 150 V (ma)	Current at - 150 V (ma)
Resolved Sweep Generator----------------	105	115
Radar Input Unit------------------------	95	70
Own Ship's Course Input Unit------------	95	70
Mark Input Unit-------------------------	80	60
Coding and Sequence Timing Generator----	55	55
Isolation Unit		
Maximum Load------------------	270	100
Average Load------------------	190	90
Minimum Load------------------	110	80
Five-inch Indicator Unit (Under Proposed Conditions)	30	80
Twelve-inch Indicator Unit (Under Proposed Conditions)	30	160

 [redacted]

82. The regulation on the 150 volt dc power potentials must be precise over a comparatively large range of loads. Any change in these potentials will cause a corresponding change in the center position of the displays on the indicator cathode-ray tubes. Since a complete UETDS may consist of a Resolved Sweep Generator, a Coding and Sequence Timing Generator, six Radar Input Units, eight Mark Input Units, one Own Ship's Course Input Unit, six isolation Units, six Five-inch Indicator Units, and two Twelve-inch Indicator Units, the dc power requirements of the system will obviously be considerable. Special consideration should be given to the size, weight, reliability, adaptation to systems of different sizes, and maintenance of the power supplies.

CONCLUSIONS

83. The circuits and operational capabilities of the UETDS have been developed and investigated. The accuracy of the system display is sufficient for target acquisition, and the reliability of the system under the proposed operating conditions should be good. The system provides a practical means for the presentation of the most valuable information from each available search radar together with target designation marks and repeat-back indications of director tracking positions on a single plan position indicator.

RECOMMENDATIONS

84. It is recommended that further development of the system should follow issuance of operational specifications for the system by the Bureau of Ordnance. It is also recommended that a complete model of the system be commercially constructed to the Bureau of Ordnance specifications and subsequently installed on a fleet unit for operational tests.

85. Several of the recommendations included in the discussion are also summarized here:

(1) That circular marks of two distinct sizes and four different codes be used to point out "bogie" targets and that either a dot or a dotted circular mark be used to identify friendly targets.

(2) That a storage tube be developed to televise internally a potential image traced by an electron gun on a suitable target. Multiple scanning without alteration of the potential image is desired.

(3) That the time sharing of the UETDS be effectively extended by development of a method for storing radar information for periods up to about 20,000 microseconds and removing it from the storage medium in a single rapid sweep of about 100 microseconds.

[redacted]

(4) That the use of color to indicate target elevation be investigated.

ACKNOWLEDGEMENTS

86. The author wishes to express his appreciation of the able assistance of Mr. Robert Curtis in the construction of the Laboratory Model of the UETDS, the assistance of Mr. H. L. Gerwin in correcting and proof-reading the report, and the encouragement and backing of Mr. J. J. Fleming, Capt. D. P. Tucker, and Dr. R. M. Page.

REFERENCES

1. NRL Registered Notebooks No. 4311, No. 4988, No. 6014.

2. Memorandum to Dr. R. M. Page, Section Head, Fire Control Section, dated 5 January 1945, "Proposed Electronic Plan Position Indicator and Target Designation System, Preliminary Description of".

3. BuOrd ltr S67(Re4f) to Director, NRL, dated 9 July 1945, "Request for Assignment of Problem O-168R-C, Universal Electronic Target Designation System".

4. NRL conf report R-2826, "A System for Obtaining Two Color Presentations on Cathode-Ray Tubes Having P-7 or P-14 Screens".

[redacted]

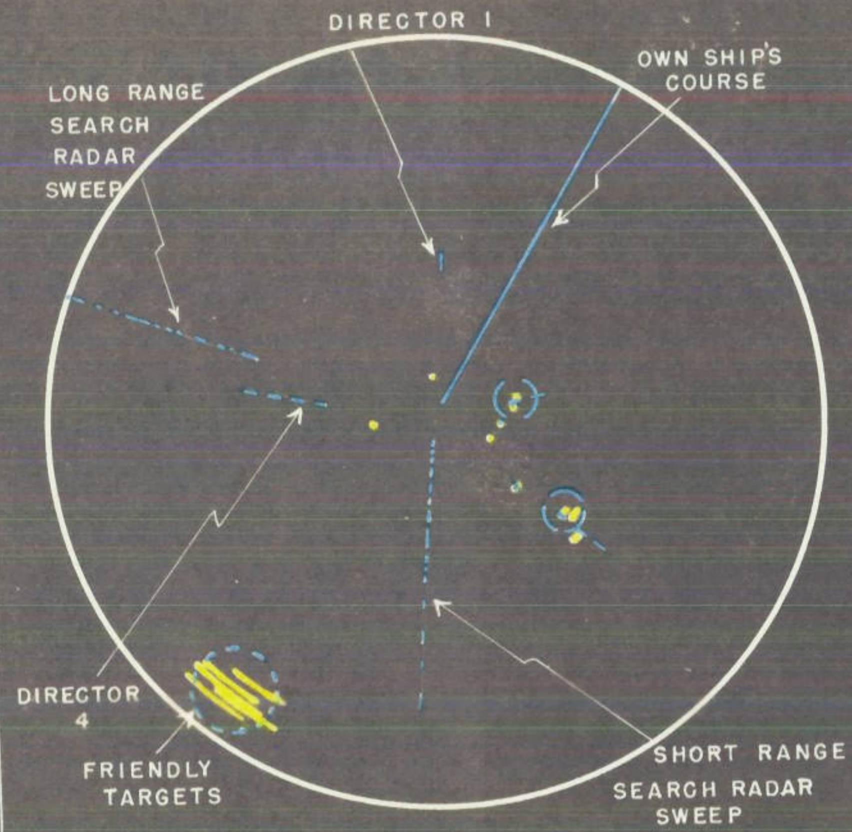


FIGURE 1.

TOTAL PLAN POSITION PRESENTATION

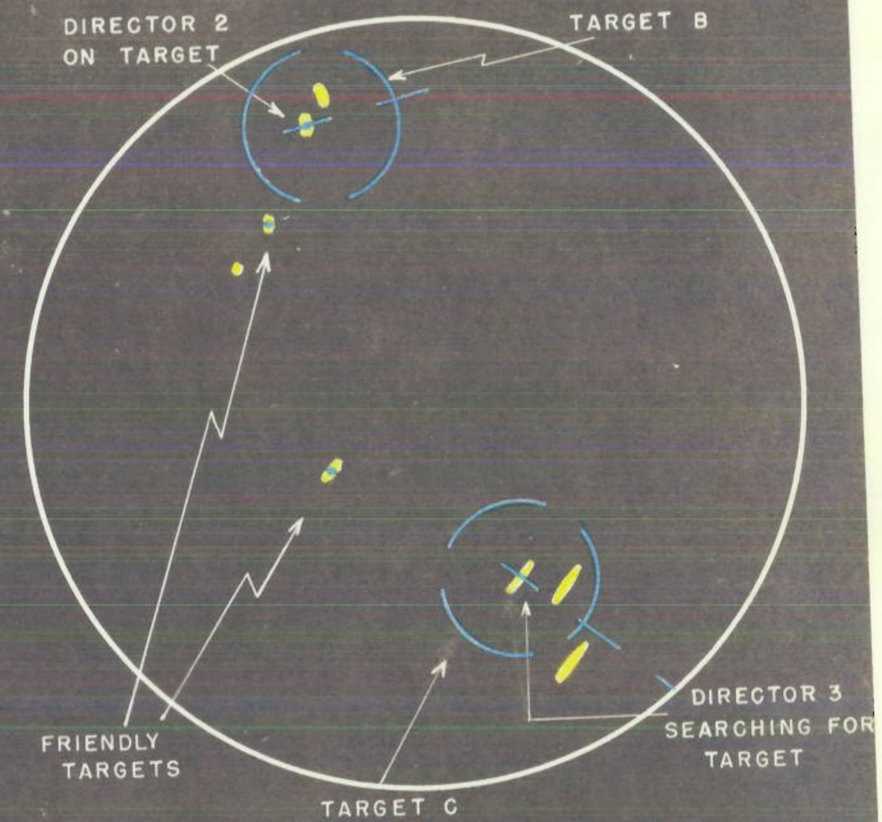
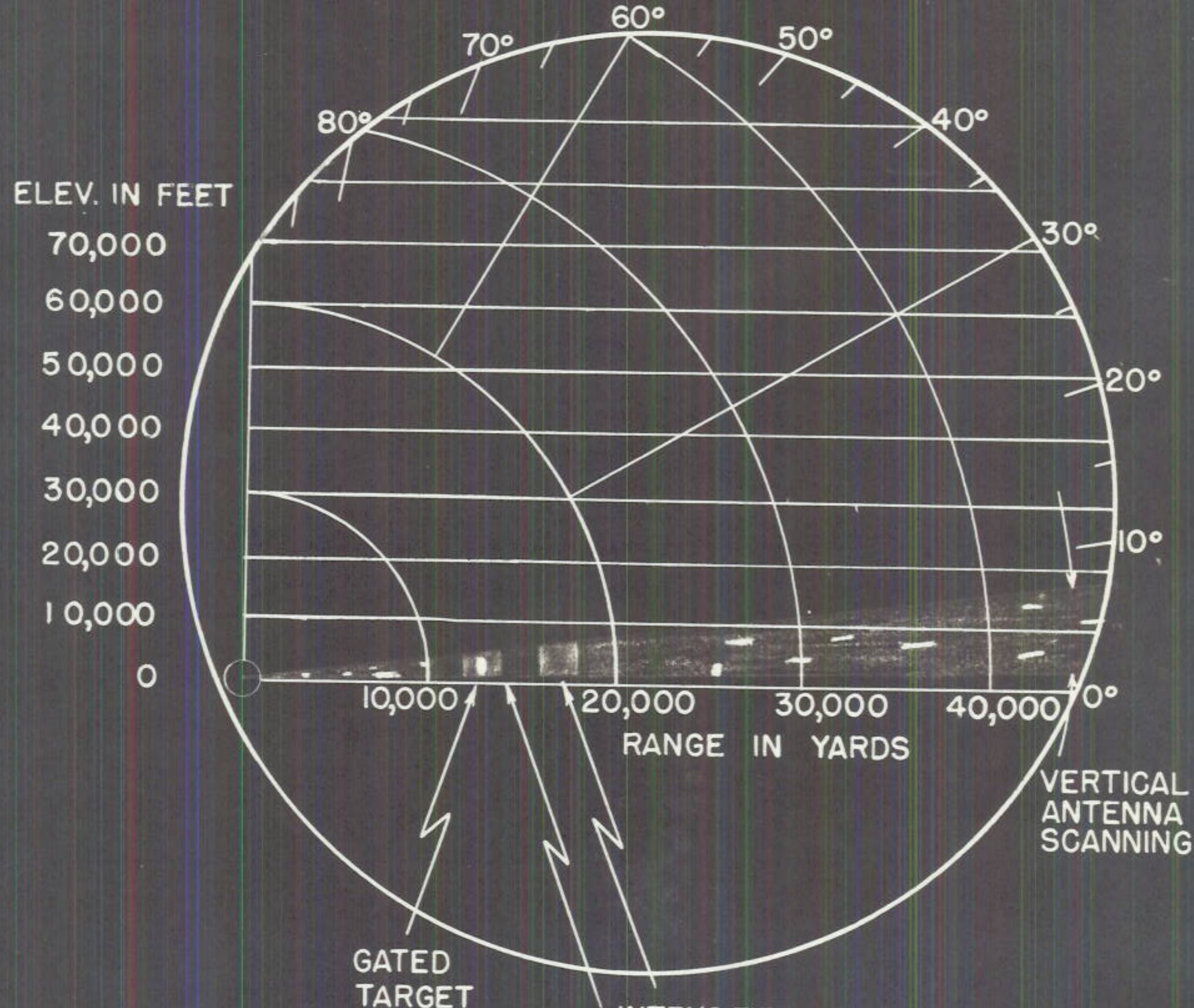


FIGURE 2.

AMPLIFIED OFF CENTER SECTION OF TOTAL PRESENTATION

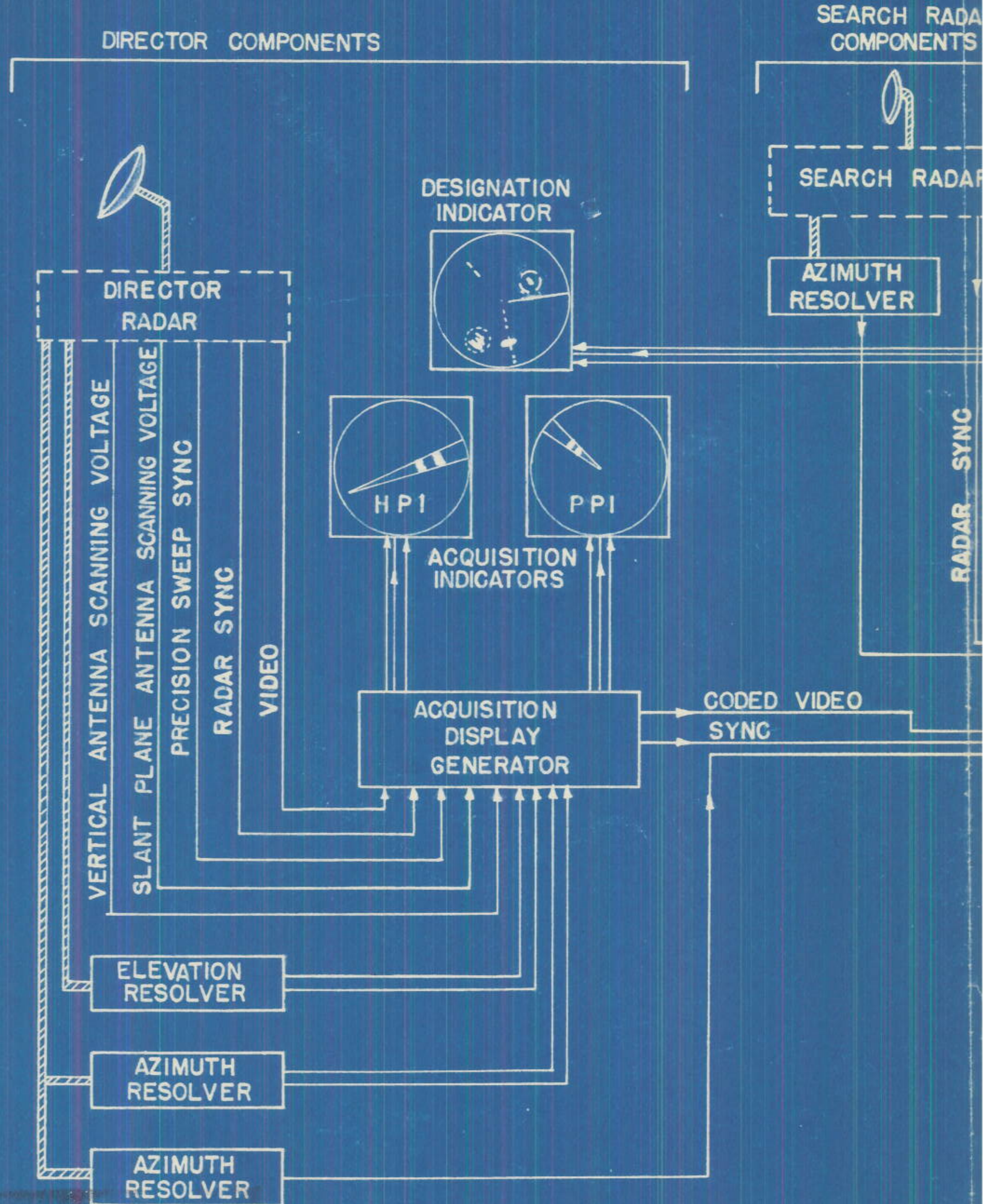
PROPOSED TARGET PLOTS OF THE UNIVERSAL ELECTRONIC TARGET DESIGNATION SYSTEM

[redacted]	NRL MISSILE CONTROL DIVISION	PLATE I
	P.C.S. 23 MAY 1946 R2772	



PROPOSED HEIGHT POSITION INDICATOR

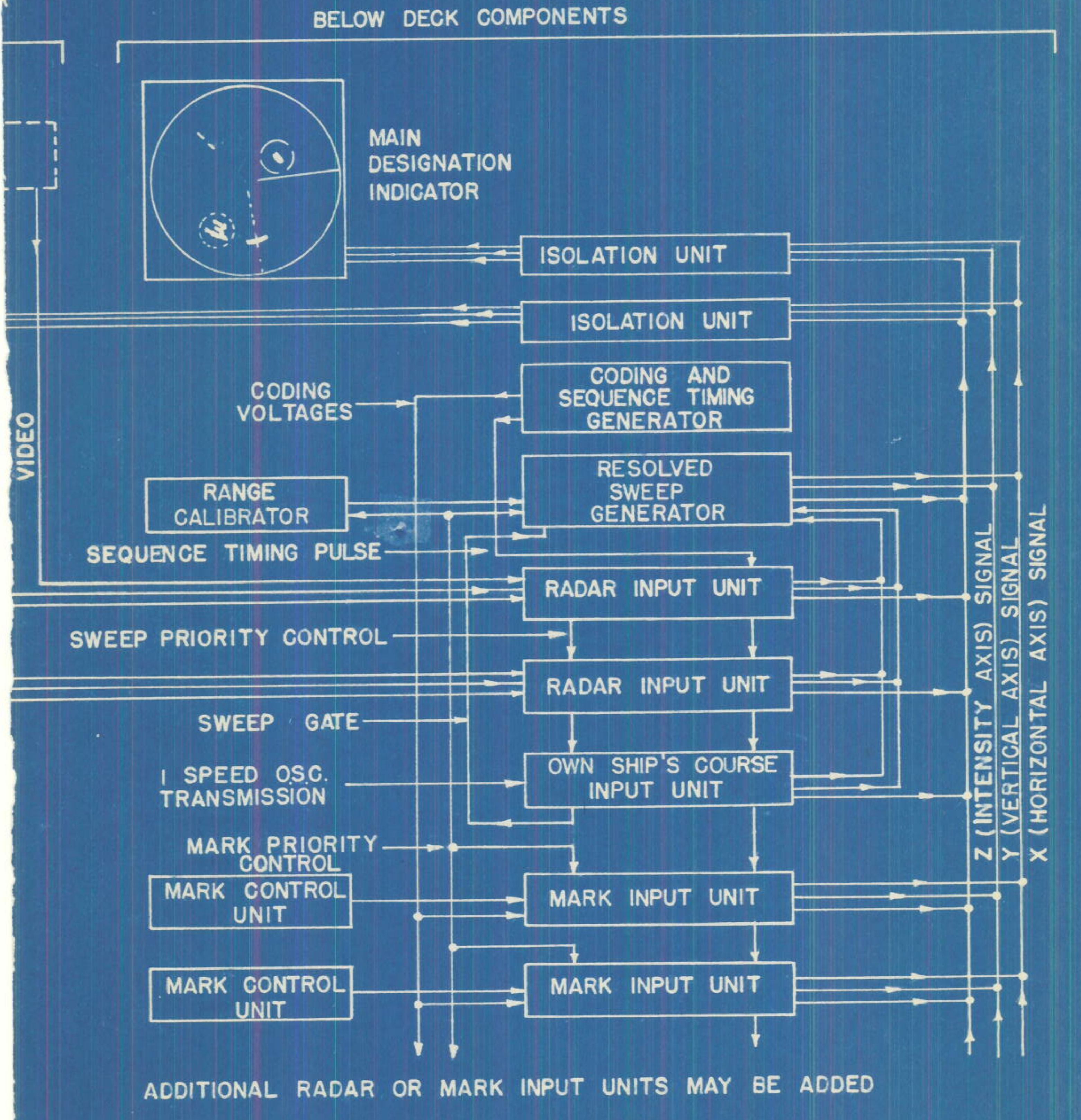
CONFIDENTIAL	NRL MISSILE CONTROL DIVISION	PLATE 3
	P. C. S. 28 MAY 1946 R-2772	



BLOCK DIAGRAM OF THE UNIVERSA

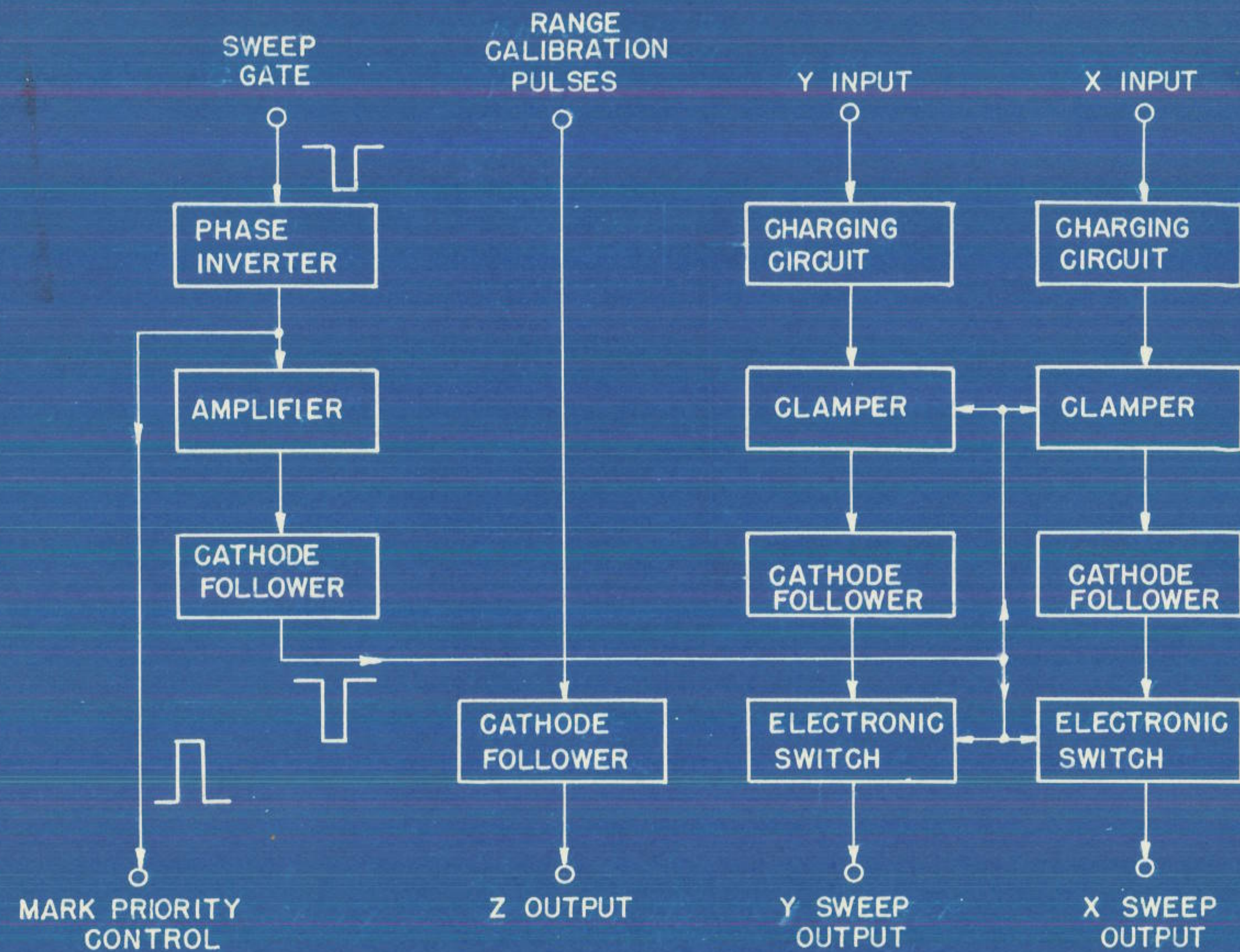
DECLASSIFIED

CONFIDENTIAL	NRL MISSILE CONTROL DIVISION	PLATE 4
	P. C. S 26 JUNE 46 R 2772	



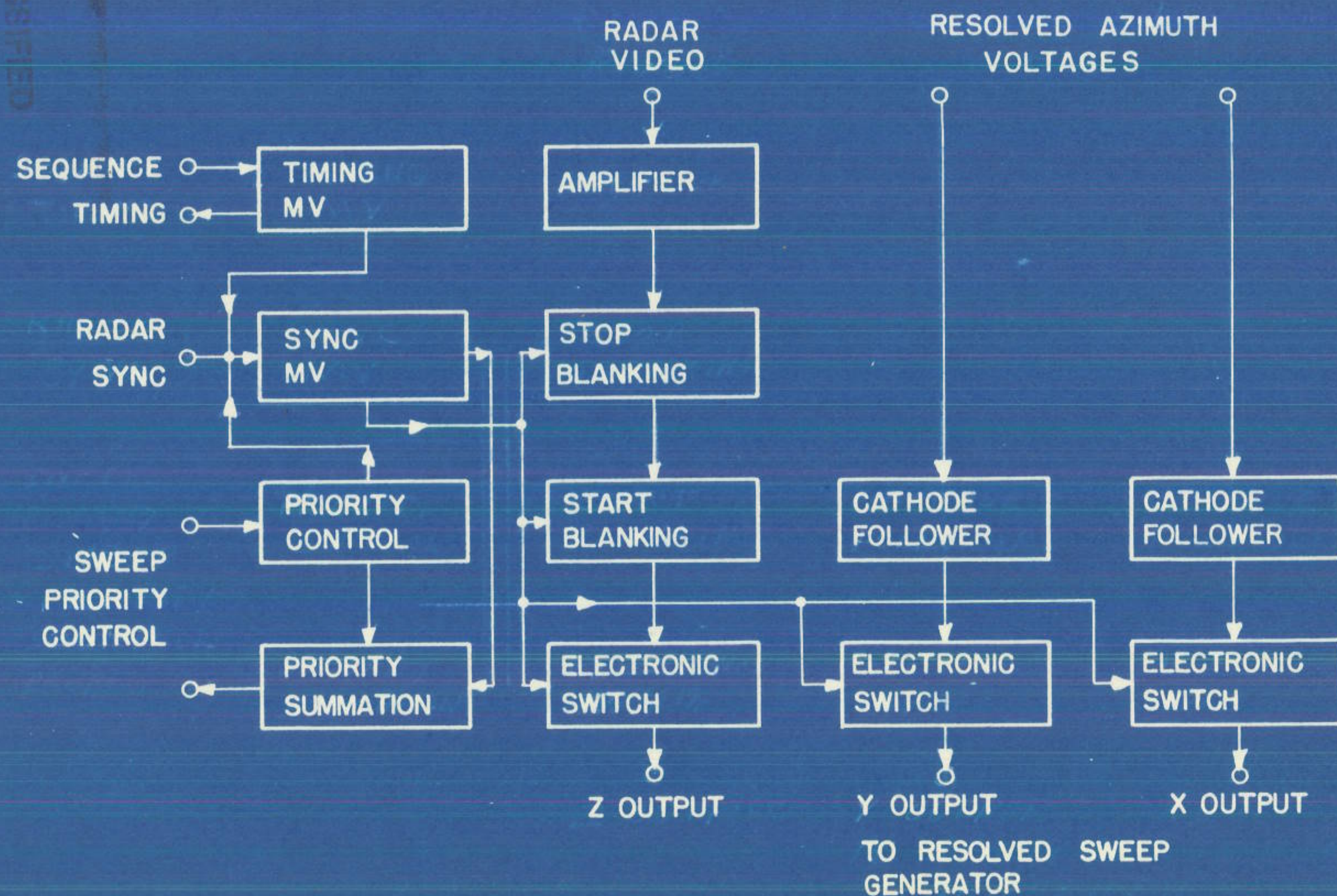
L ELECTRONIC TARGET DESIGNATION SYSTEM

RESOLVED SWEEP GENERATOR - BLOCK DIAGRAM - UNIVERSAL ELECTRONIC TARGET DESIGNATION SYSTEM



[redacted]	NRL MISSILE CONTROL DIVISION P.C.S. 27 JUNE 46 R-2772	PLATE 5

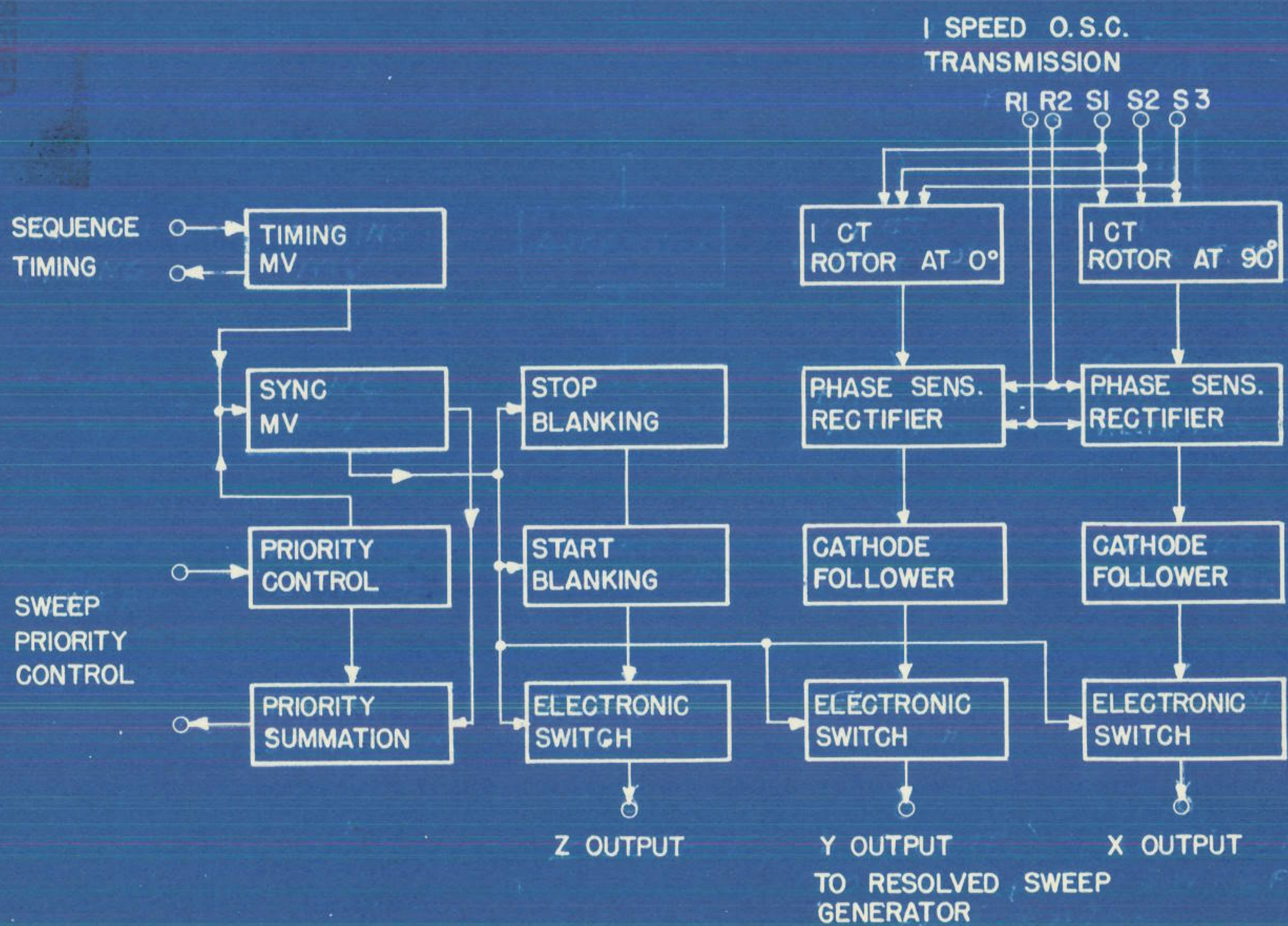
RADAR INPUT UNIT — BLOCK DIAGRAM
UNIVERSAL ELECTRONIC TARGET DESIGNATION SYSTEM



DECLASSIFIED

C[redacted]	NRL MISSILE CONTROL DIVISION P.G.S. 27 JUNE 46 R-2772	PLATE 6

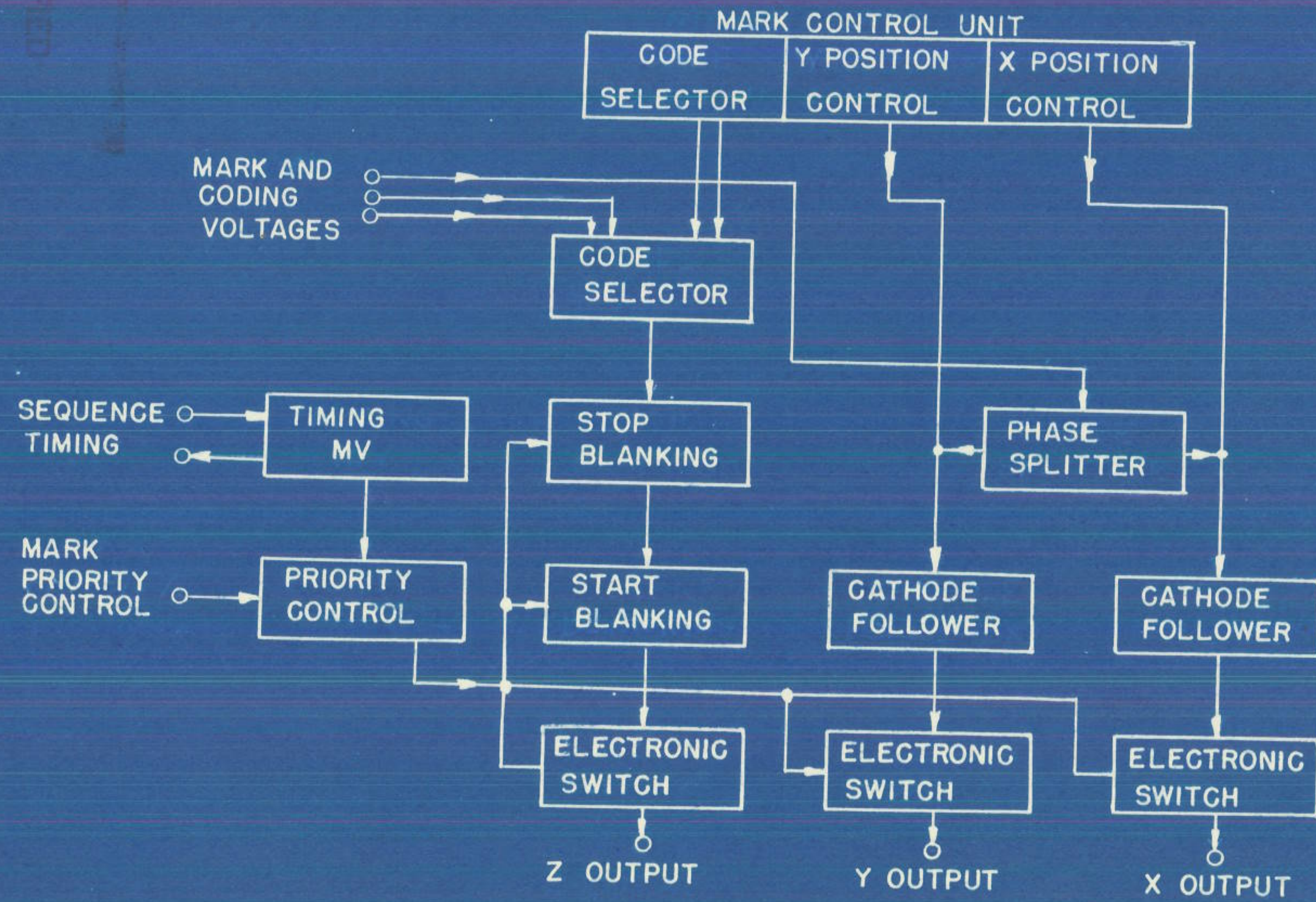
OWN SHIP'S COURSE INPUT UNIT - BLOCK DIAGRAM
UNIVERSAL ELECTRONIC TARGET DESIGNATION SYSTEM



DECLASSIFIED

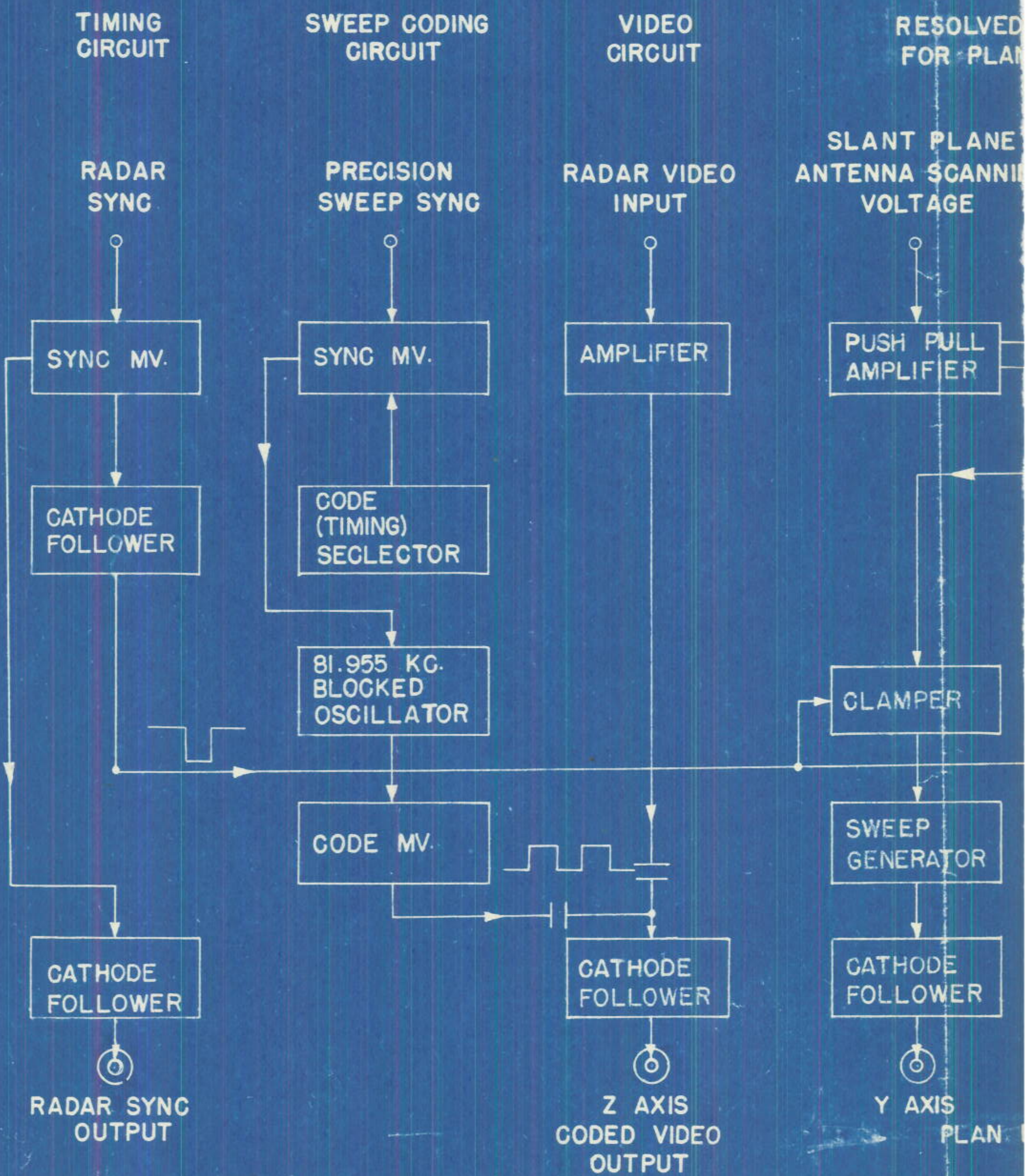
[redacted]	NRL MISSILE CONTROL DIVISION	PLATE 7
	P.C.S. 27 JUNE 46 R-2772	

MARK INPUT AND CONTROL UNITS- BLOCK DIAGRAM
UNIVERSAL ELECTRONIC TARGET DESIGNATION SYSTEM



[redacted]	NRL MISSILE CONTROL DIVISION P.C.S. 27 JUNE 46 R-2772	PLATE 8

BLOCK DIAGRAM OF DIRECTOR ACQUI



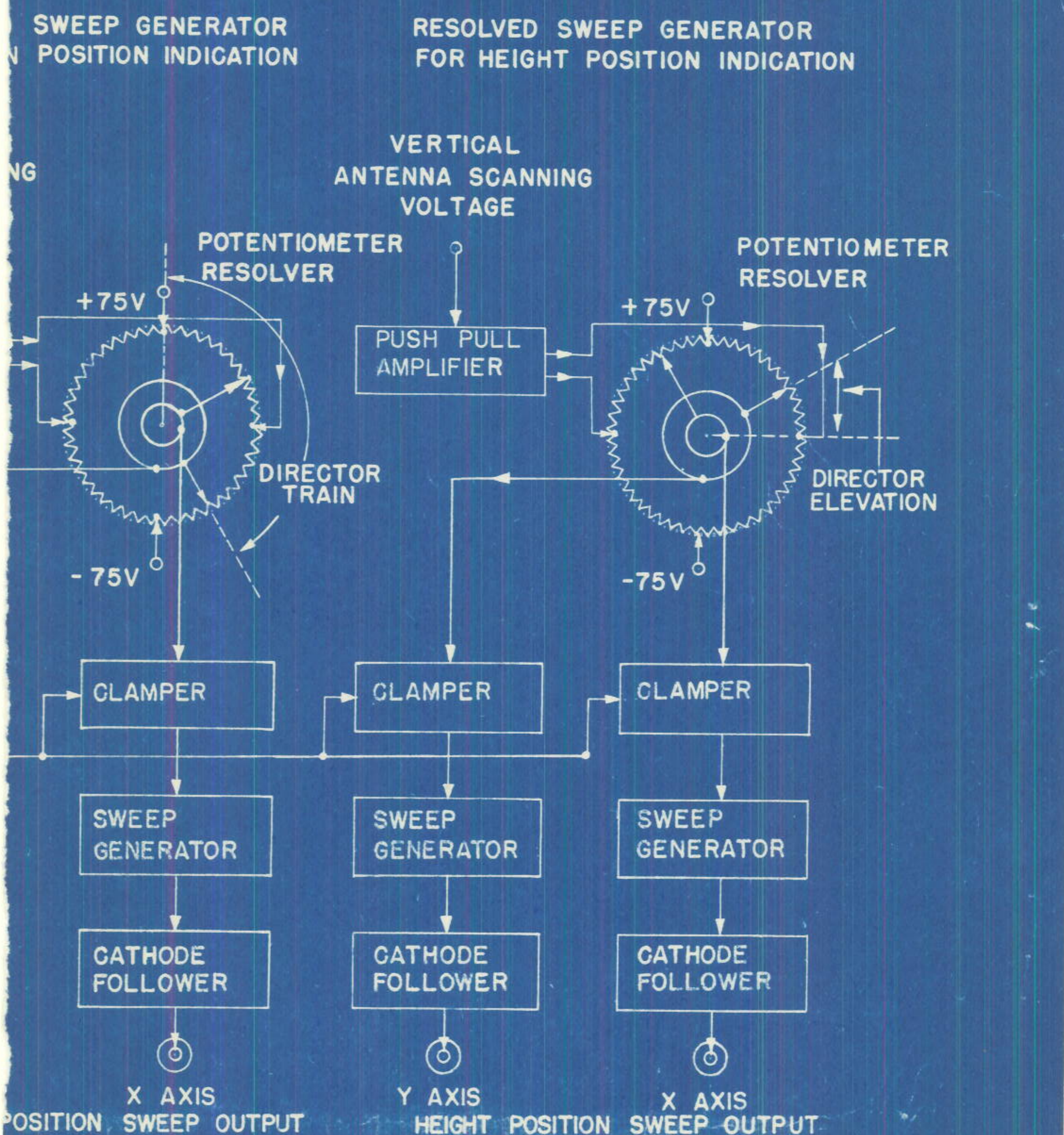
[redacted]

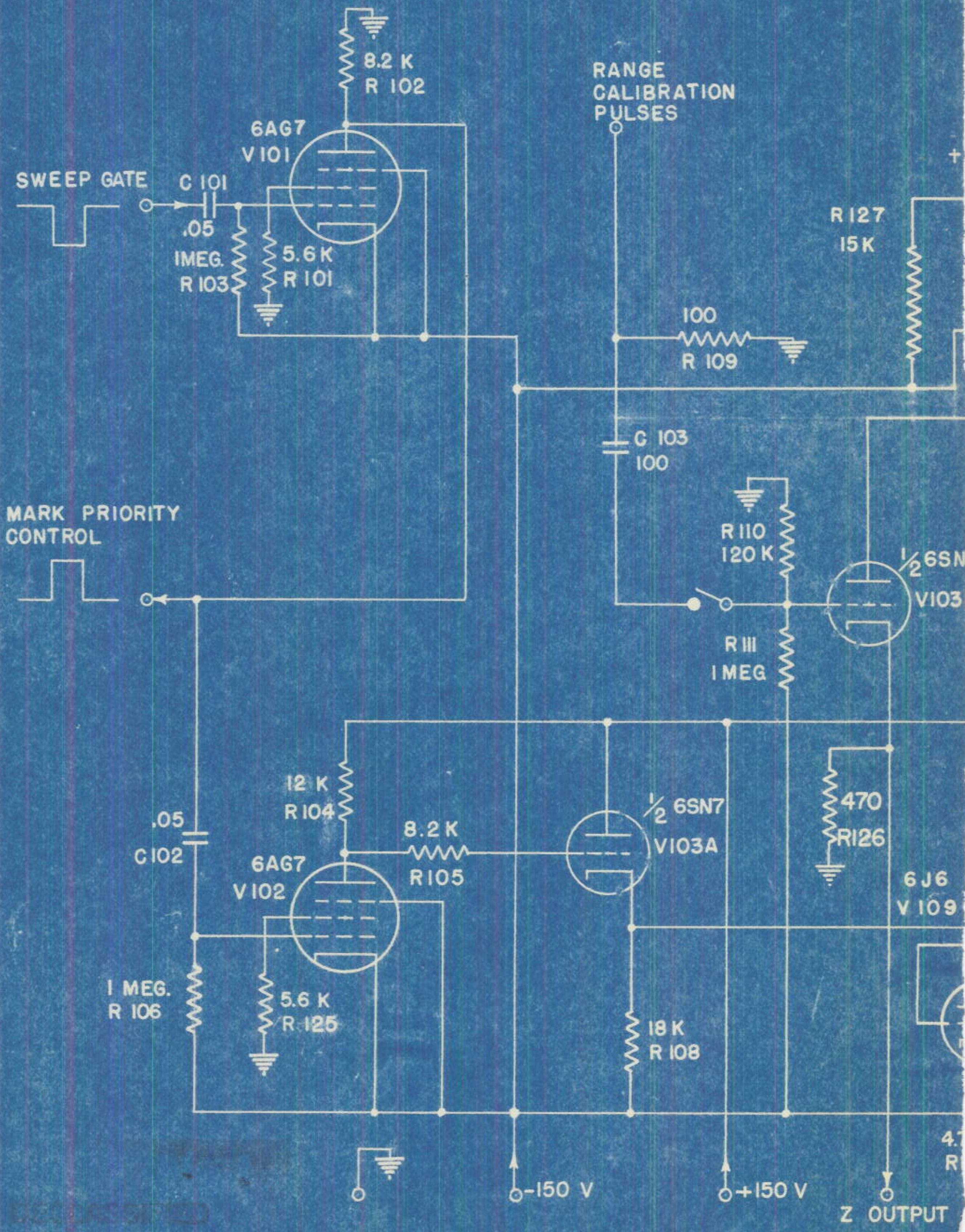
NRL MISSILE CONTROL DIVISION

PCS 27 MAY 1946 R2772

PLATE 9

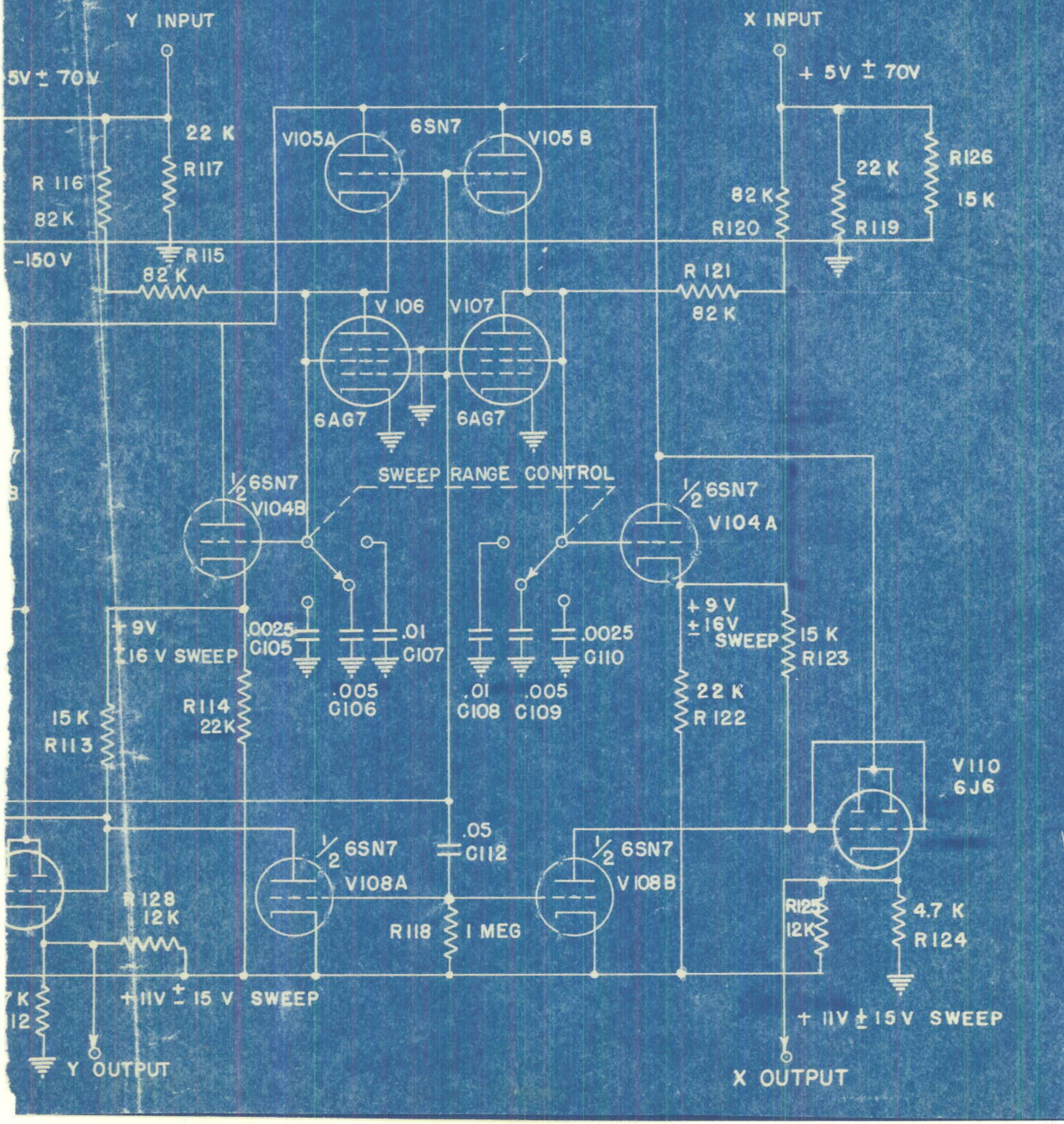
SITION DISPLAY GENERATOR



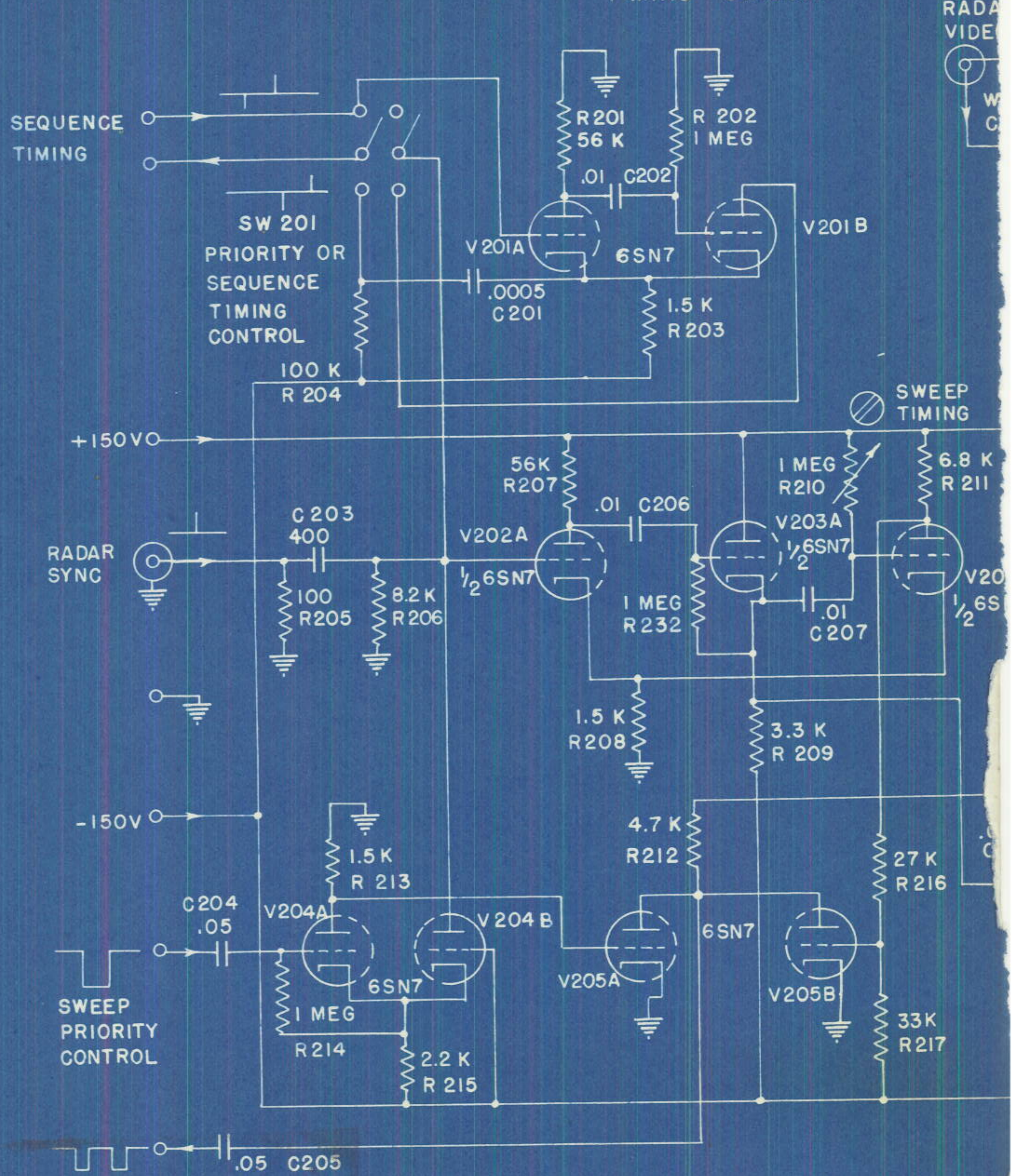


[redacted]	NRL MISSILE CONTROL DIVISION	PLATE 10
	P.C.S. 1 JULY 46 R2772	

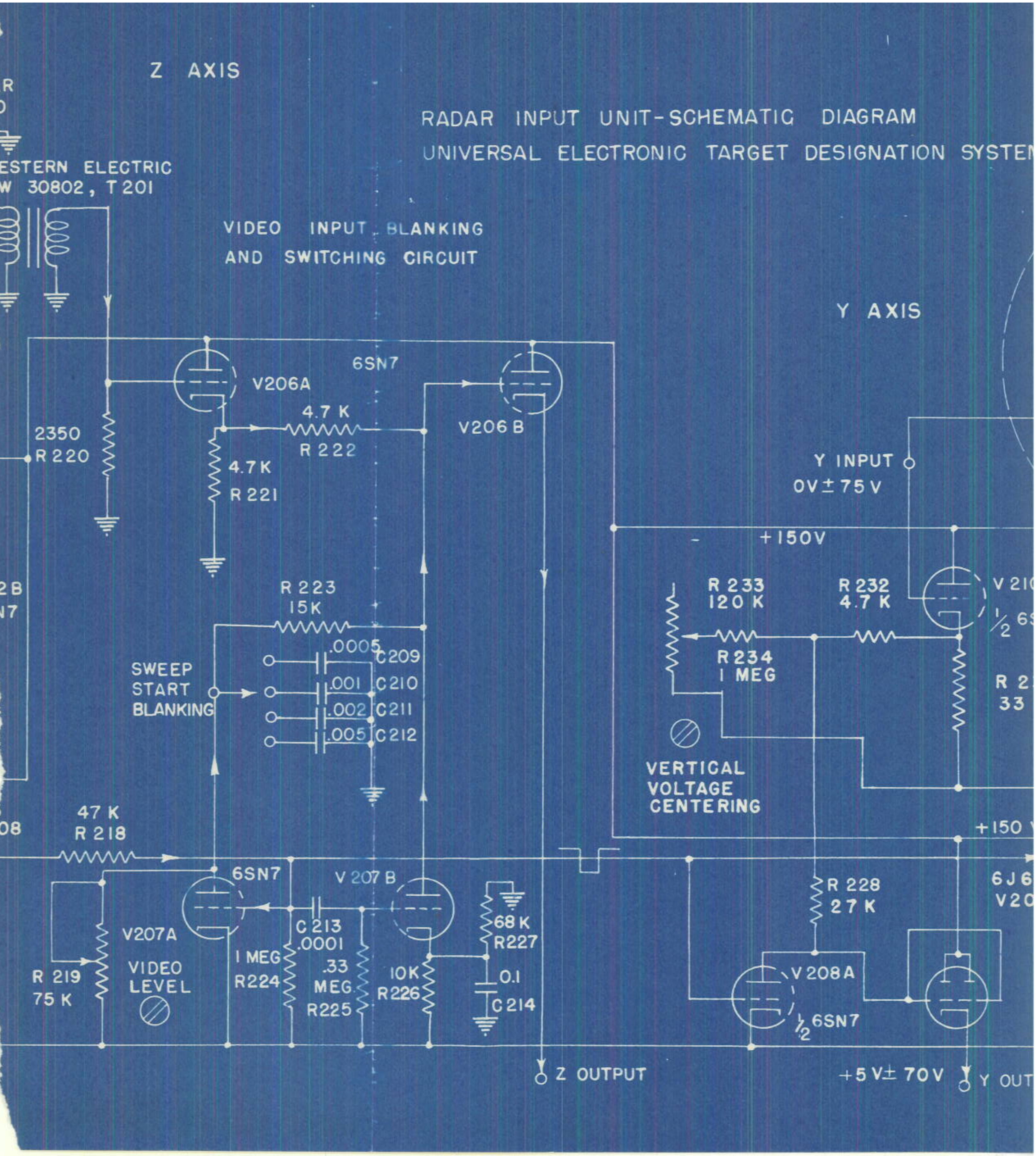
RESOLVED SWEEP GENERATOR-SCHEMATIC DIAGRAM
UNIVERSAL ELECTRONIC TARGET DESIGNATION SYSTEM



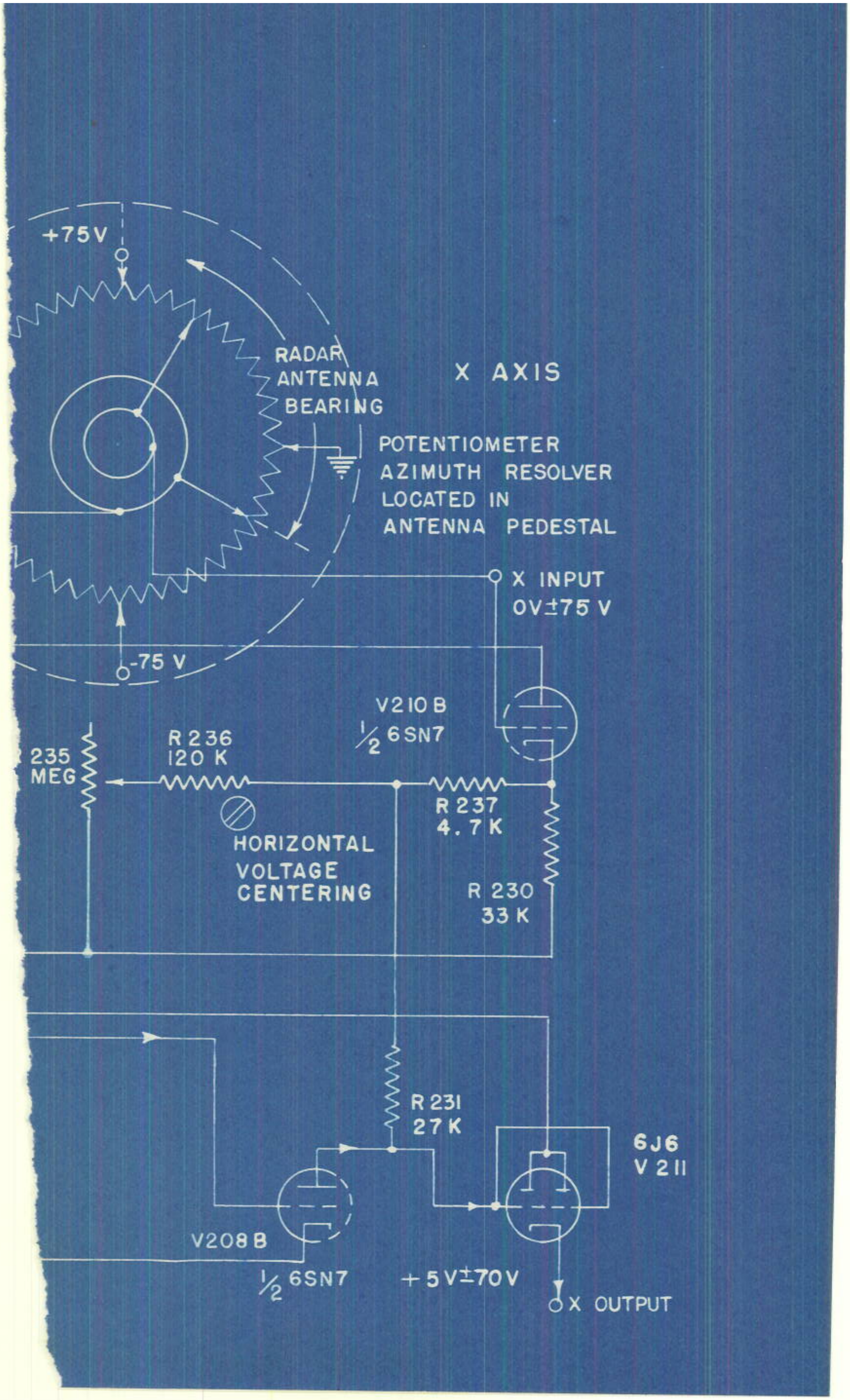
TIMING CIRCUIT



[redacted]	NRL MISSILE CONTROL DIVISION P.C.S. 1 JULY 46 R 2772	PLATE II

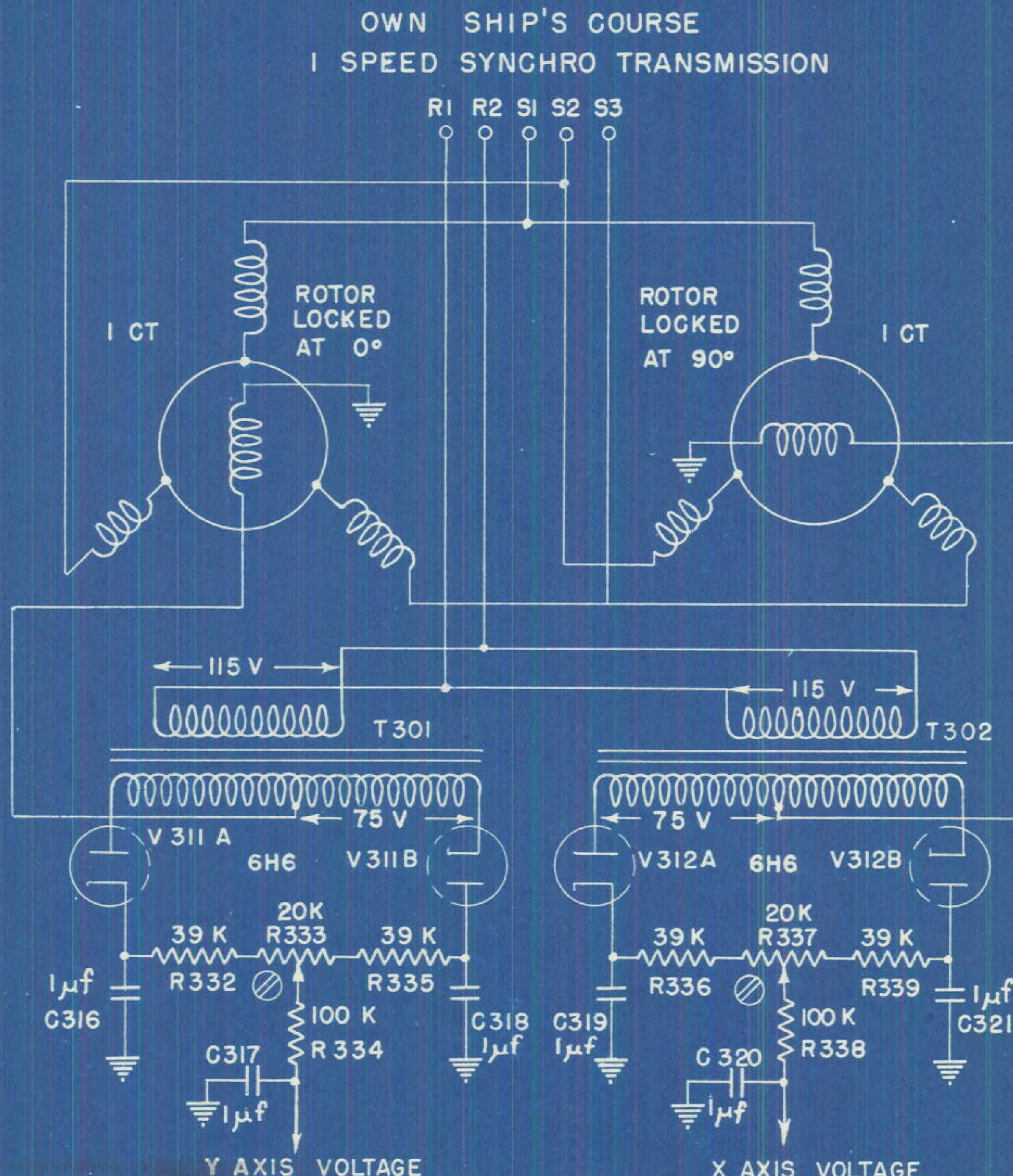


RADAR INPUT UNIT-SCHEMATIC DIAGRAM
UNIVERSAL ELECTRONIC TARGET DESIGNATION SYSTEM
Z AXIS
Y AXIS
ESTERN ELECTRIC
W 30802, T 201
VIDEO INPUT BLANKING
AND SWITCHING CIRCUIT
6SN7
V206A
V206 B
4.7 K
R 222
2350
R 220
4.7K
R 221
R 223
15K
.0005 C209
.001 C210
.002 C211
.005 C212
SWEEP
START
BLANKING
47 K
R 218
6SN7
V207A
V 207 B
R 219
75 K
VIDEO
LEVEL
C 213
.0001
I MEG
R224
.33
MEG
R225
10K
R226
68 K
R227
0.1
C 214
Z OUTPUT
Y INPUT
0V ± 75 V
+150V
R 233
120 K
R 232
4.7 K
R 234
I MEG
VERTICAL
VOLTAGE
CENTERING
R 228
27 K
V 208A
1/2 6SN7
+150
+5 V ± 70V
Y OUT



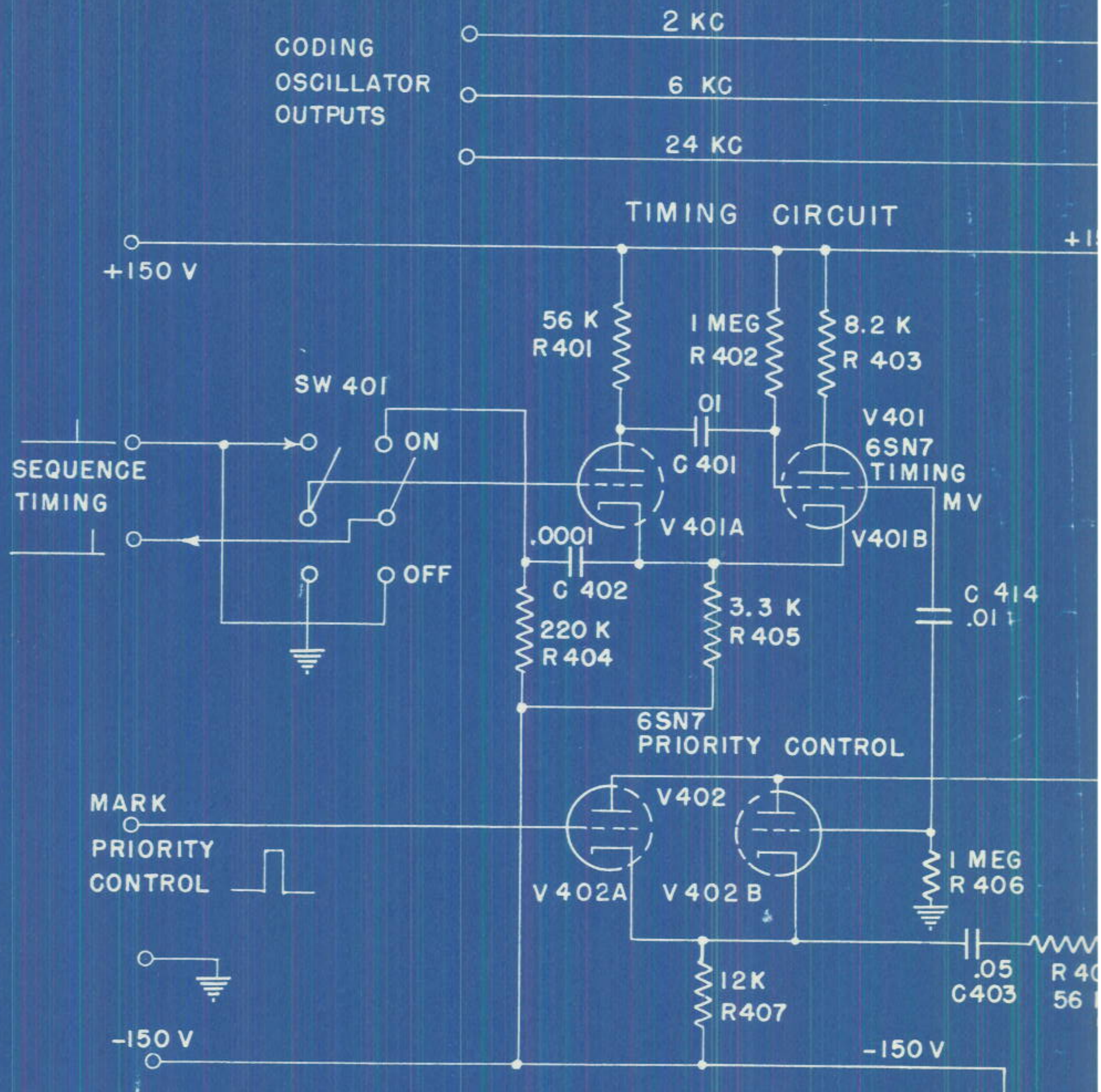
+75 V
RADAR
ANTENNA
BEARING
X AXIS
POTENTIOMETER
AZIMUTH RESOLVER
LOCATED IN
ANTENNA PEDESTAL
X INPUT
0V±75 V
-75 V
V210 B
1/2 6SN7
R 236
120 K
235
MEG
R 237
4.7 K
HORIZONTAL
VOLTAGE
CENTERING
R 230
33 K
R 231
27 K
6J6
V 211
V208 B
1/2 6SN7
+5 V±70 V
X OUTPUT

AZIMUTH RESOLVER CIRCUIT – SCHEMATIC DIAGRAM
OWN SHIP'S COURSE INPUT UNIT
UNIVERSAL ELECTRONIC TARGET DESIGNATION SYSTEM



DECLASSIFIED

CONFIDENTIAL	NRL MISSILE CONTROL DIVISION	PLATE 12
	P.C.S. 1 JULY 46 R 2772	

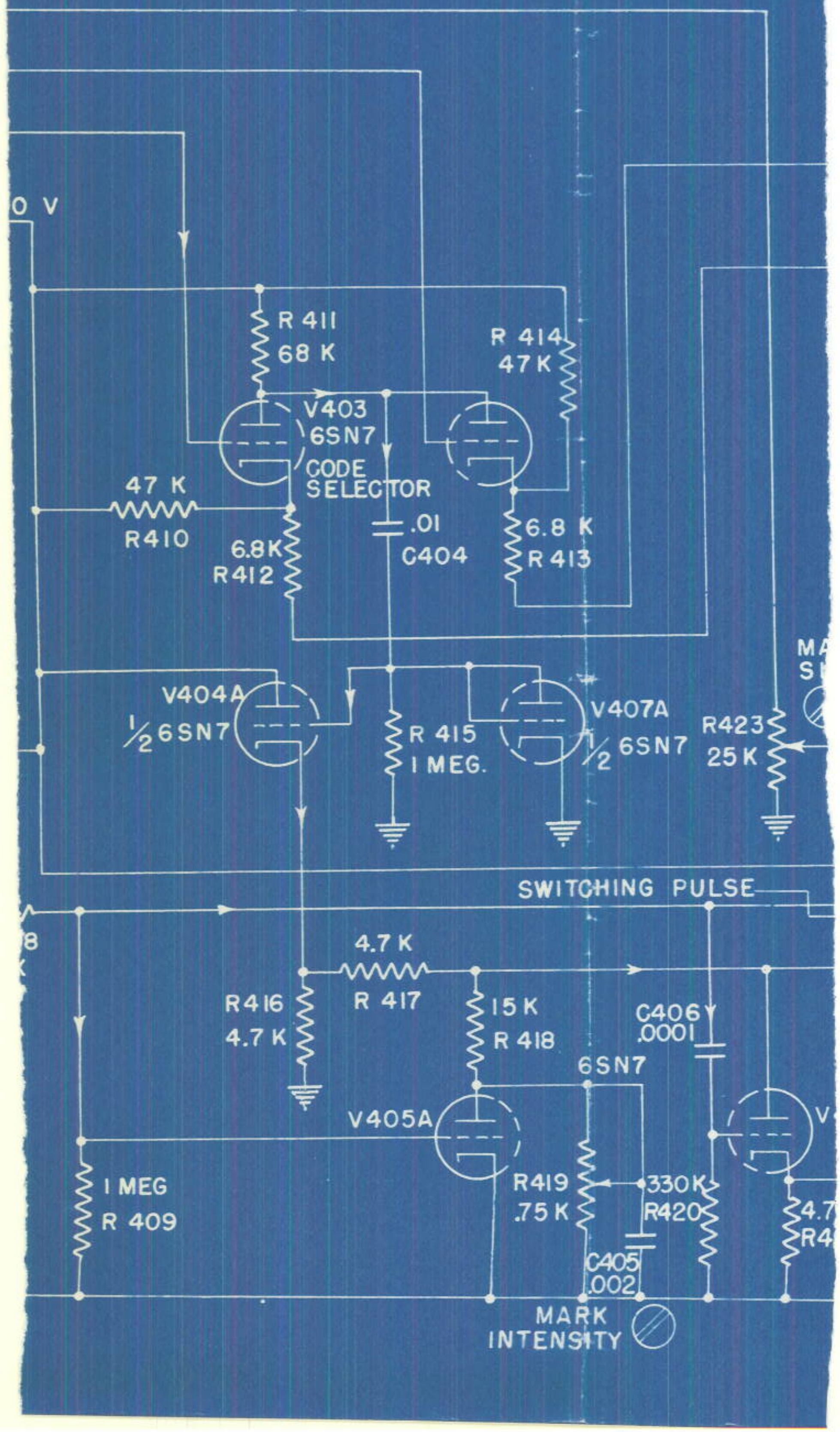


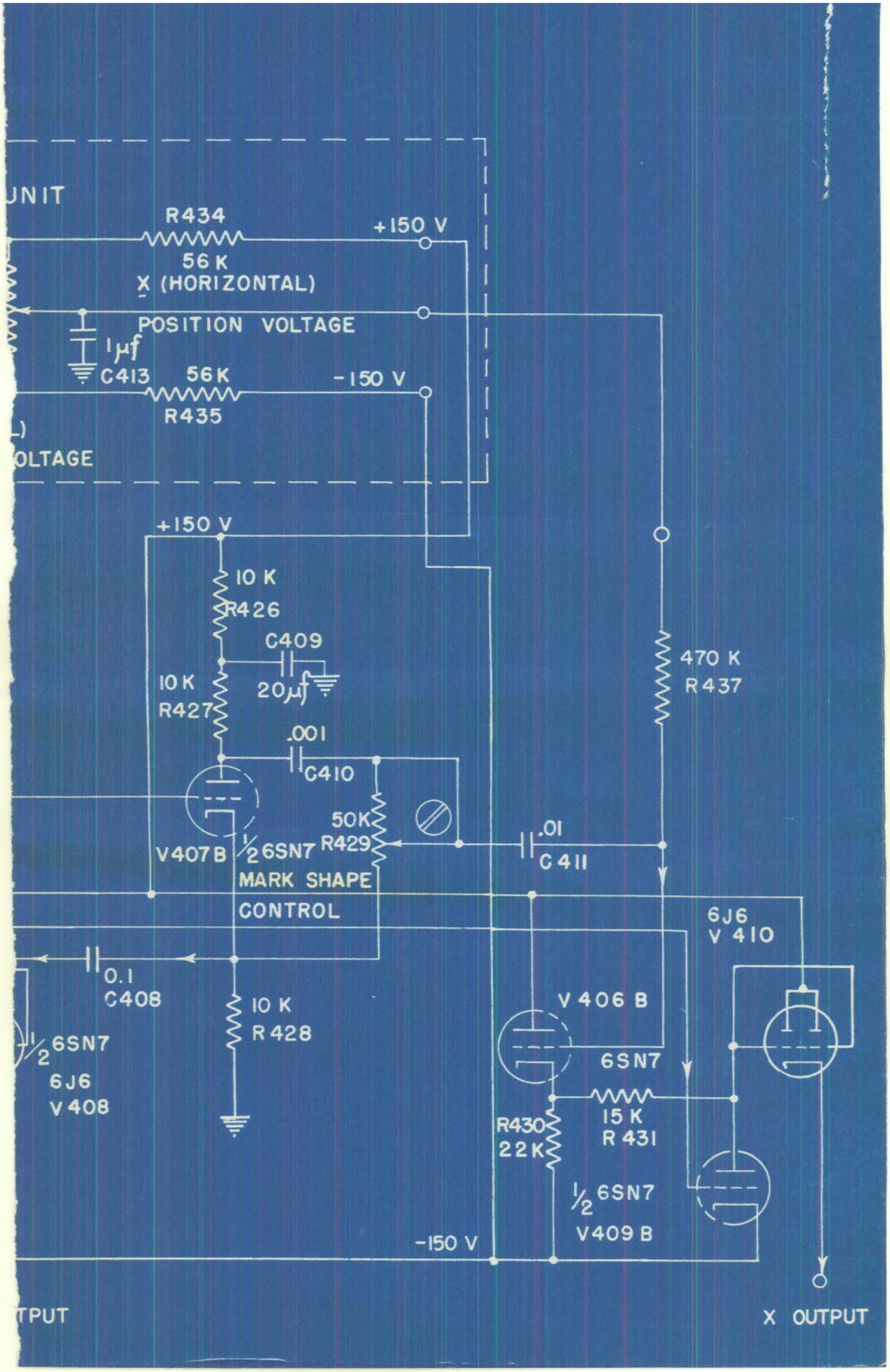
MARK INPUT UNIT-SCHEMATIC DIAGRAM
UNIVERSAL ELECTRONIC TARGET DESIGNATION SYSTEM

DECLASSIFIED

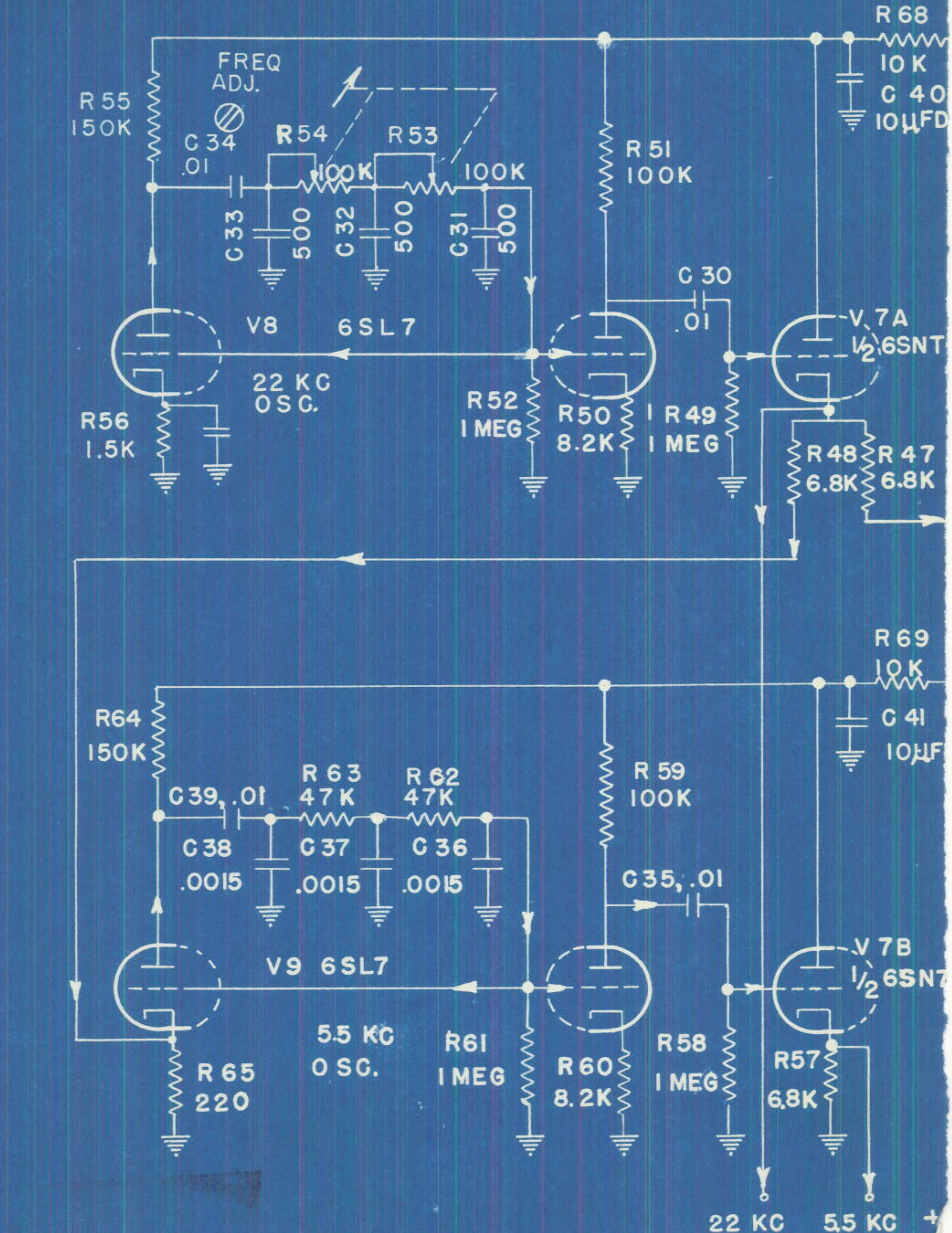
[redacted]	NRL MISSILE CONTROL DIVISION	PLATE 13
	P.C.S. I FEB. 46 R 2772	

Z AXIS
VIDEO CODING, BLANKING & SWITCHING CI



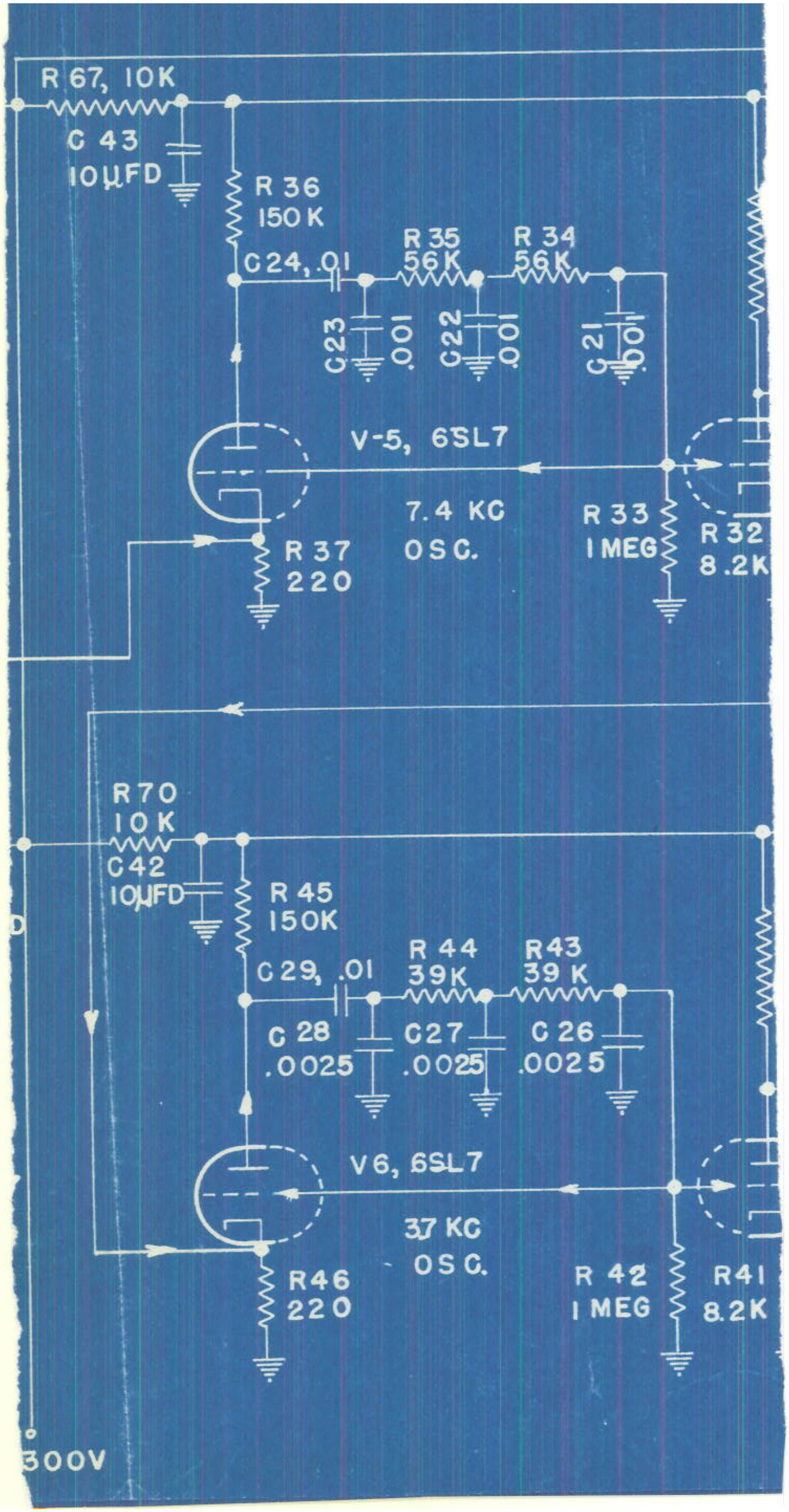


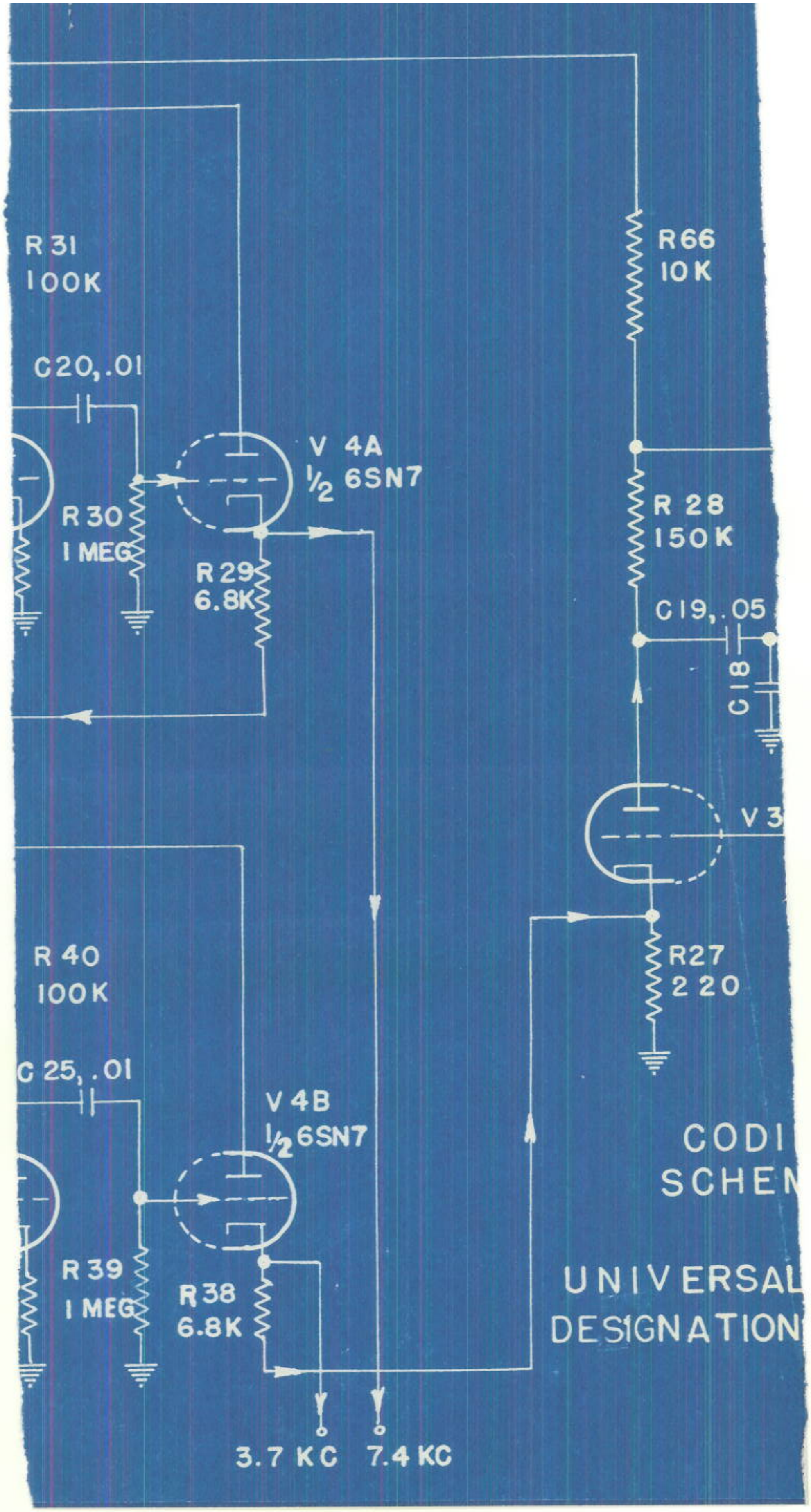
UNIT
R434
56 K
+150 V
X (HORIZONTAL)
POSITION VOLTAGE
1μf
C413
56K
R435
-150 V
L)
OLTAGE
+150 V
10 K
R426
C409
20μf
10 K
R427
.001
C410
470 K
R437
50K
R429
.01
C411
V407B
½ 6SN7
MARK SHAPE
CONTROL
6J6
V 410
0.1
C408
10 K
R428
V 406 B
6SN7
½ 6SN7
6J6
V 408
R430
22K
15 K
R 431
½ 6SN7
V409 B
-150 V
TPUT
X OUTPUT

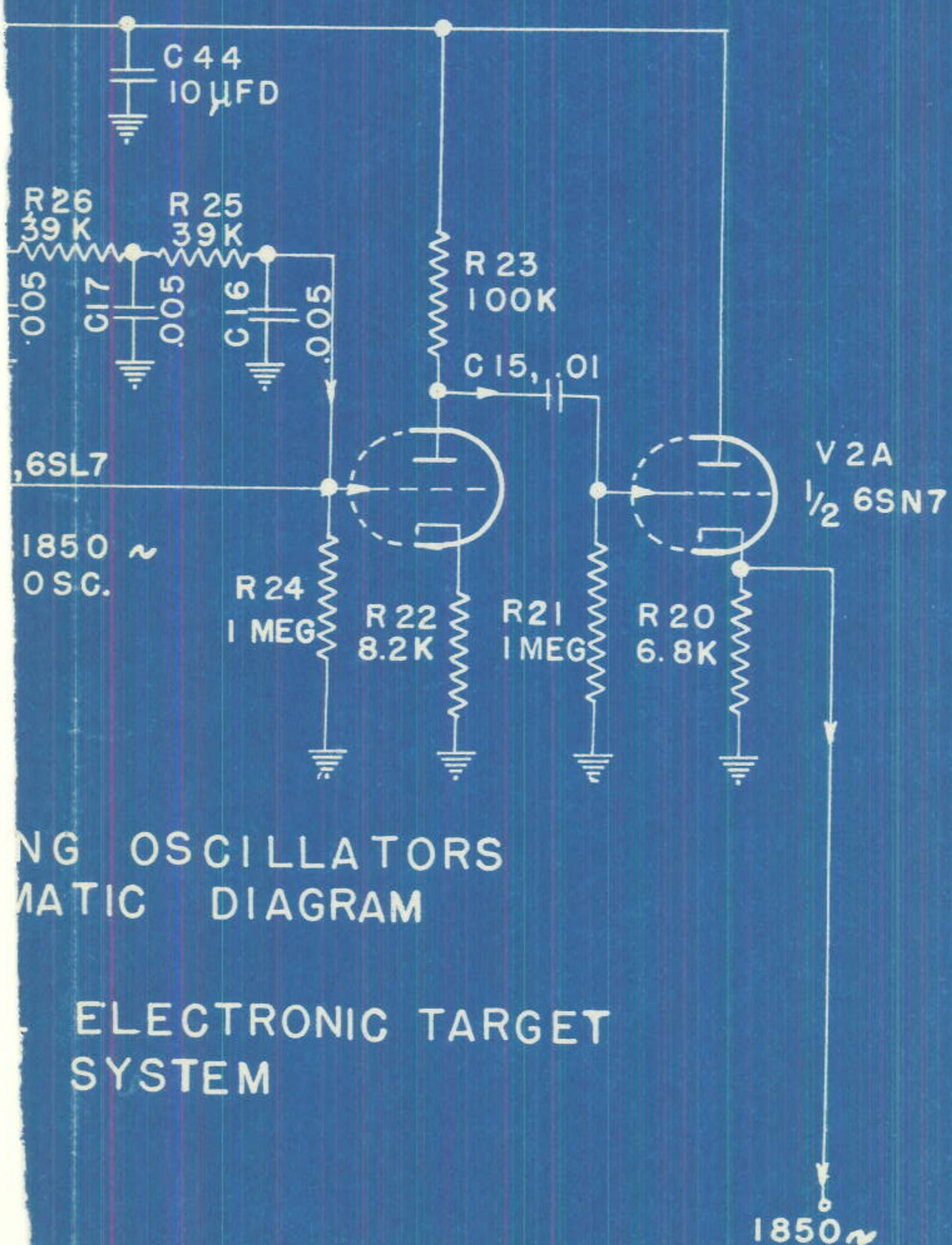


DECLASSIFIED

[redacted]	NRL MISSILE CONTROL DIV. P.C.S. 5 MARCH 46 R2772	PLATE 14


R 67, 10K
C 43
10µFD
R 36
150 K
C24, .01
R 35
56K
R 34
56K
C23
.001
C22
.001
C21
.001
V-5, 6SL7
7.4 KC
OSC.
R 33
1 MEG
R 32
8.2K
R 37
220
R70
10 K
C42
10µFD
R 45
150K
C29, .01
R 44
39K
R43
39 K
C 28
.0025
C27
.0025
C 26
.0025
V6, 6SL7
37 KC
OSC.
R 42
1 MEG
R41
8.2K
R46
220
300V


R 31
100K
C20, .01
V 4A
1/2 6SN7
R 30
1 MEG
R 29
6.8K
R66
10K
R 28
150K
C19, .05
C18
V3
R27
220
R 40
100K
C 25, .01
V 4B
1/2 6SN7
R 39
1 MEG
R 38
6.8K
3.7 KC
7.4 KC
CODI
SCHEM
UNIVERSAL
DESIGNATION

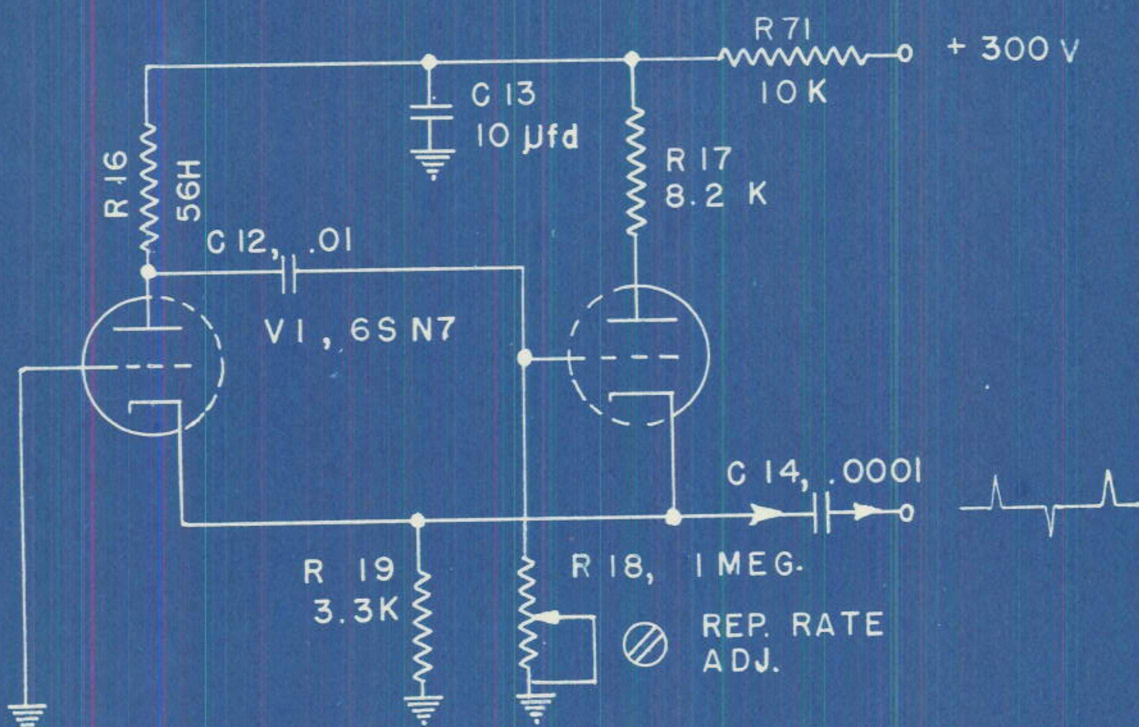


NG OSCILLATORS
MATIC DIAGRAM

L ELECTRONIC TARGET
SYSTEM

TIMING SEQUENCE INITIATOR
SCHEMATIC DIAGRAM

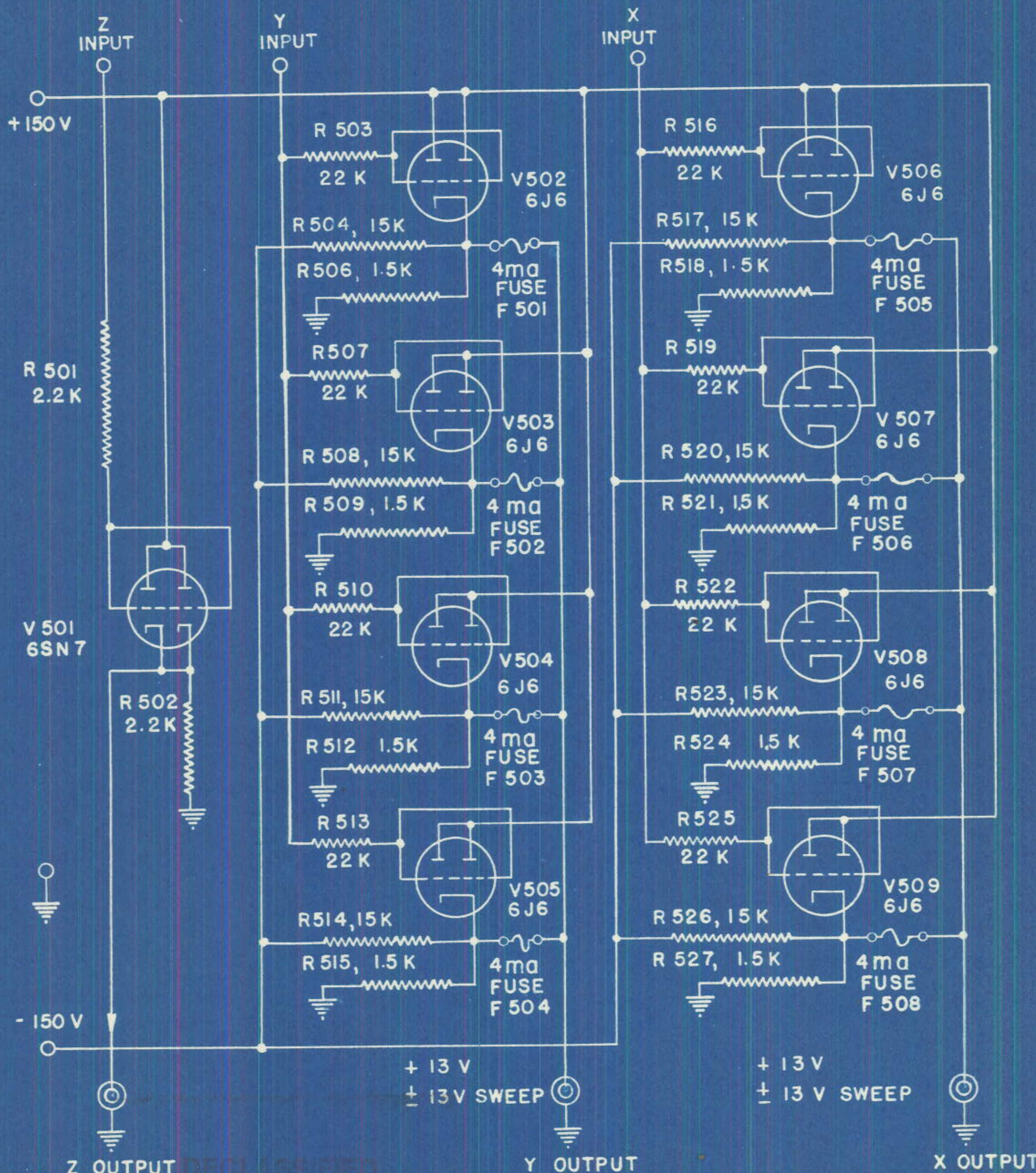
UNIVERSAL ELECTRONIC TARGET DESIGNATION SYSTEM



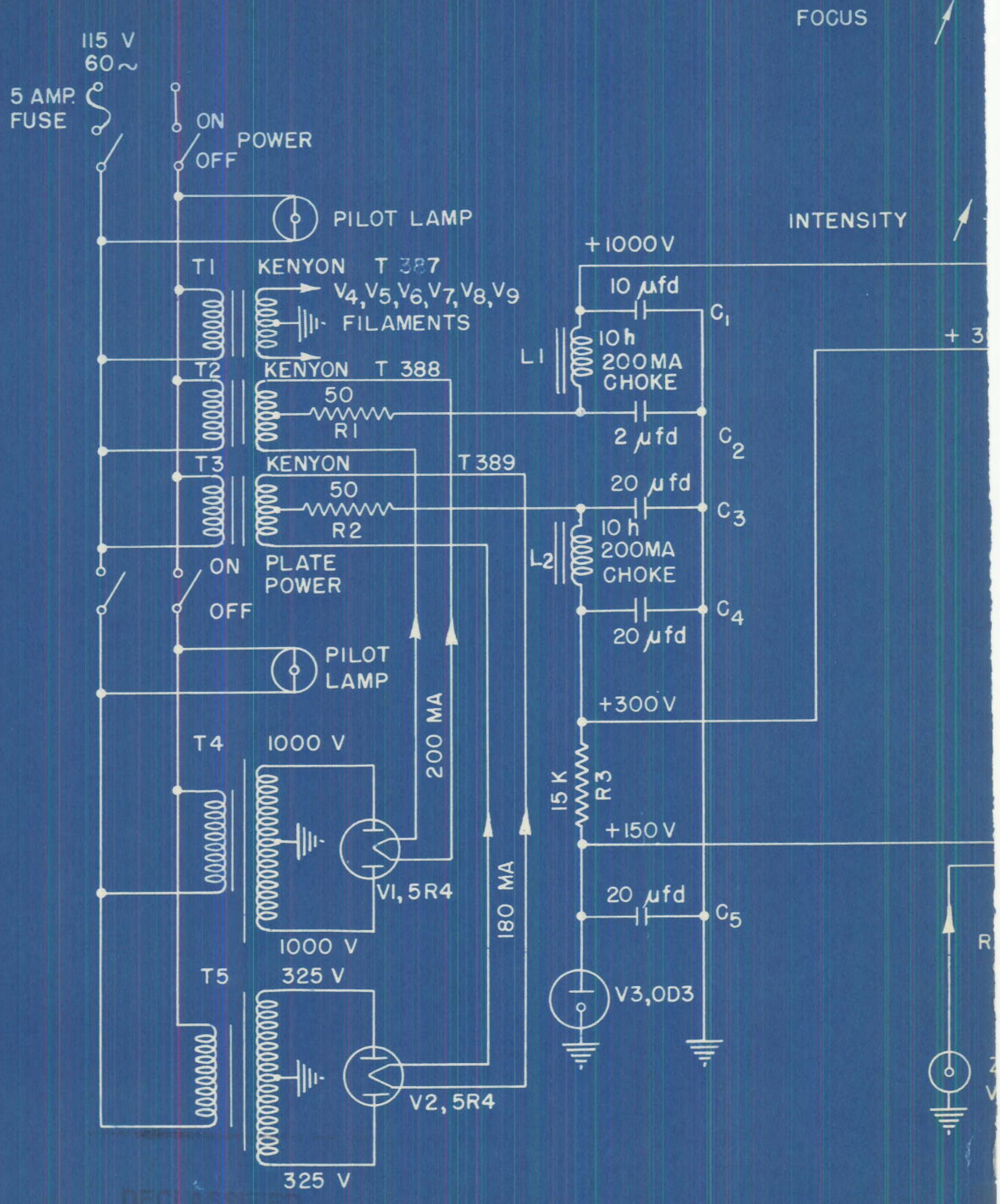
CONFIDENTIAL	NRL MISSILE CONTROL DIV.	PLATE 15
	P.C.S. 5 MARCH 46 R 2772	

DECLASSIFIED

ISOLATION UNIT - SCHEMATIC DIAGRAM
UNIVERSAL ELECTRONIC TARGET DESIGNATION SYSTEM

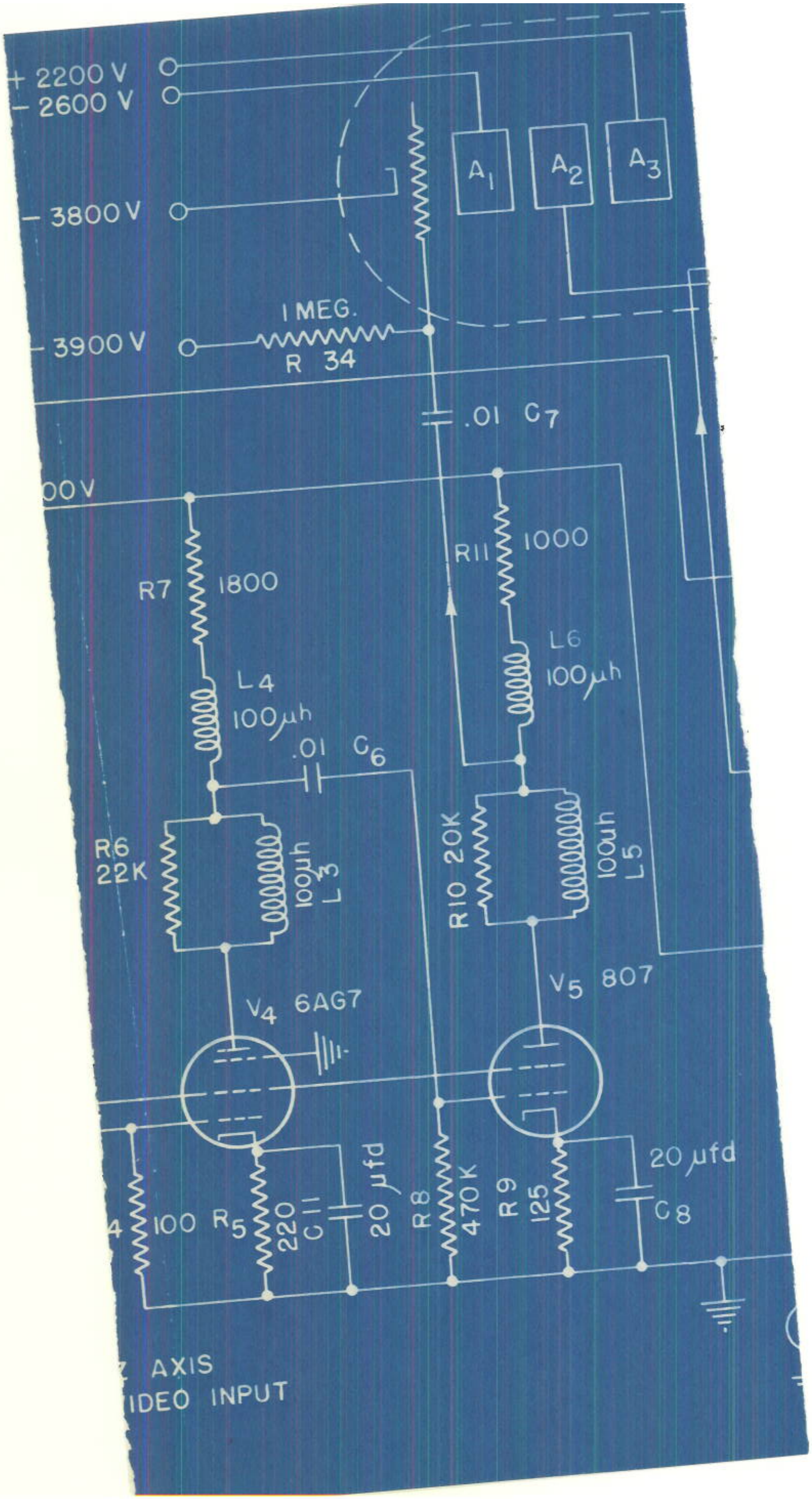


[redacted]	NRL MISSILE CONTROL DIVISION	PLATE 16
	P.C.S. 26 JULY 46 R 2772	

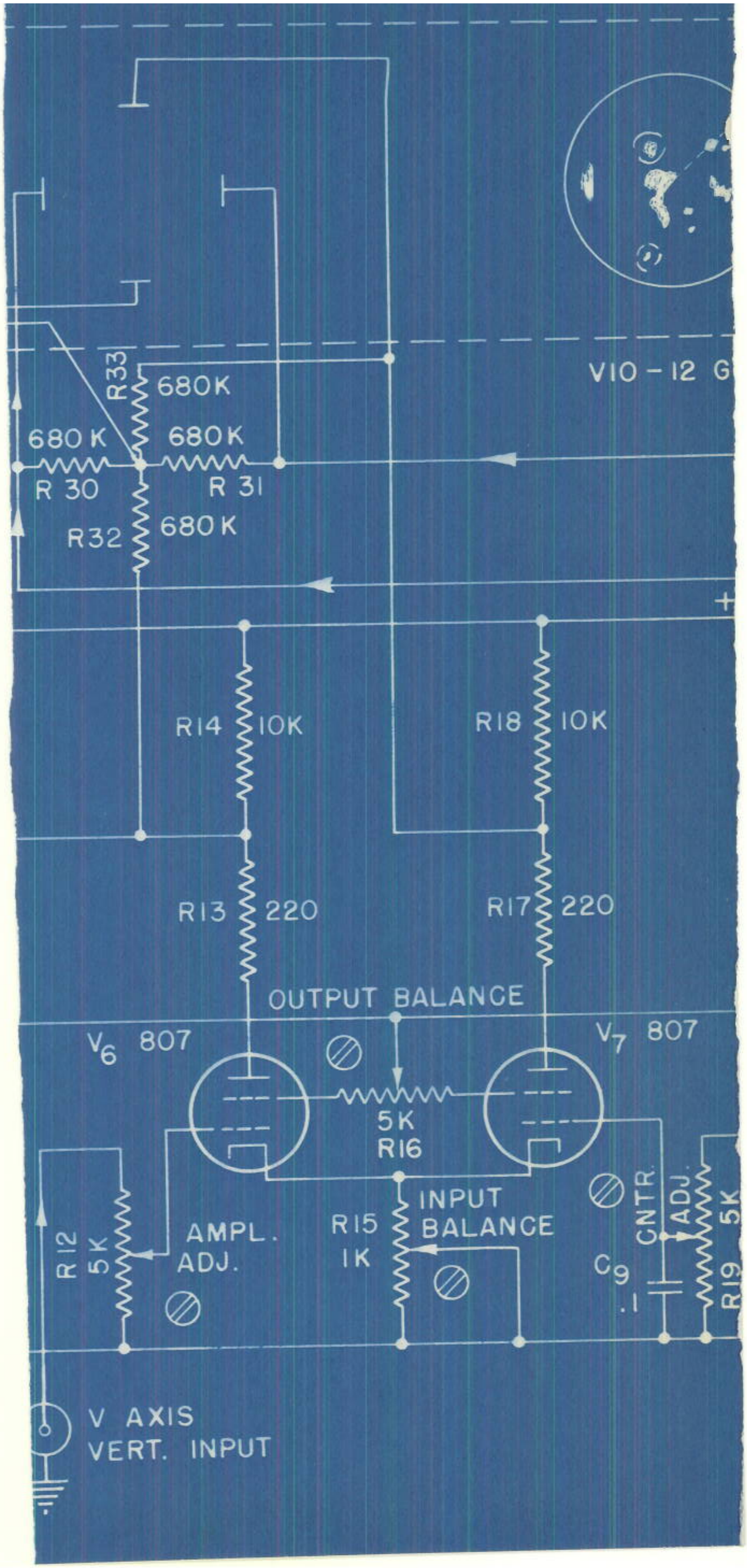


DECLASSIFIED

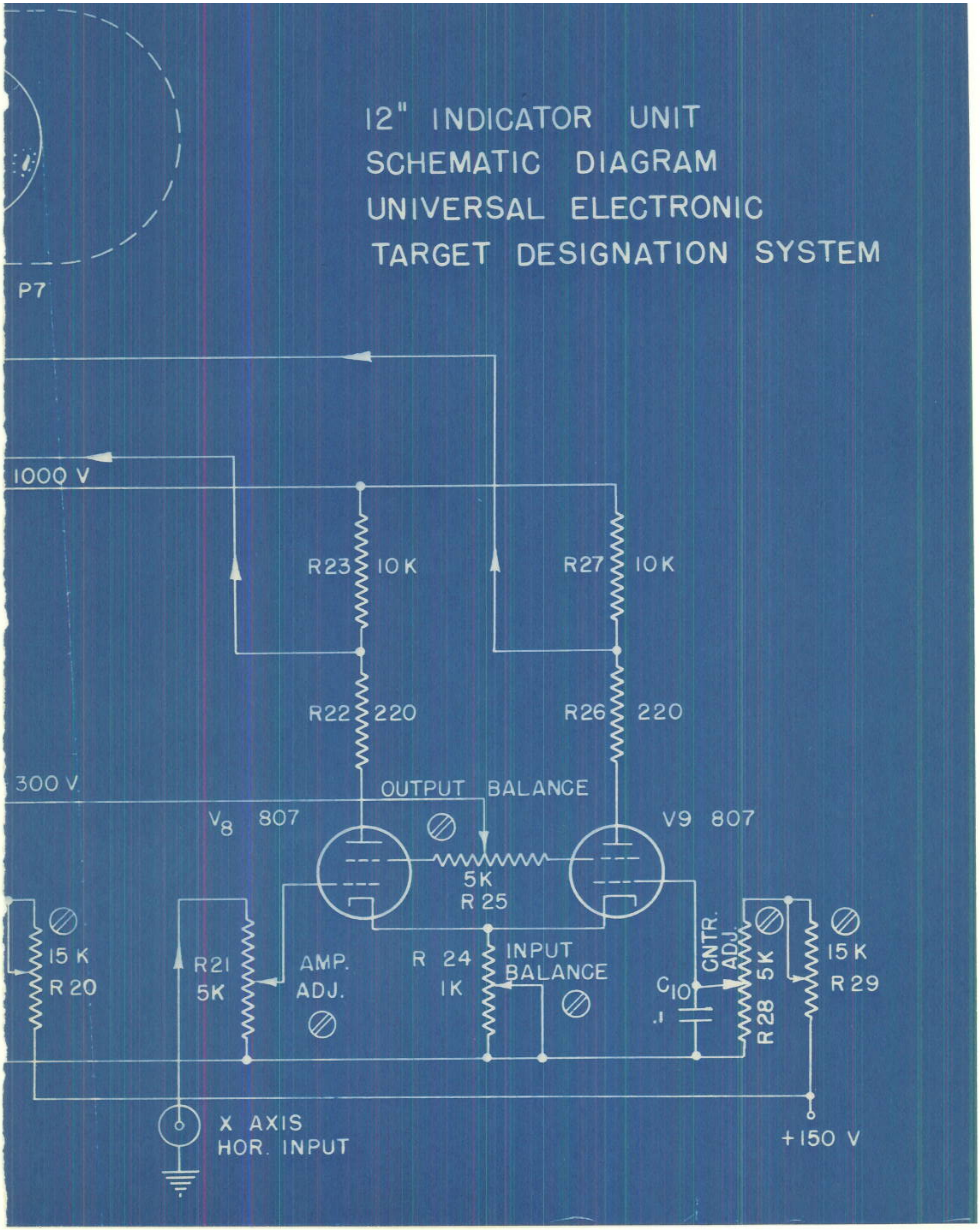
[redacted]	NRL MISSILE CONTROL DIVISION	PLATE 17
	P.C.S. 8 FEB. 46 R 2772	

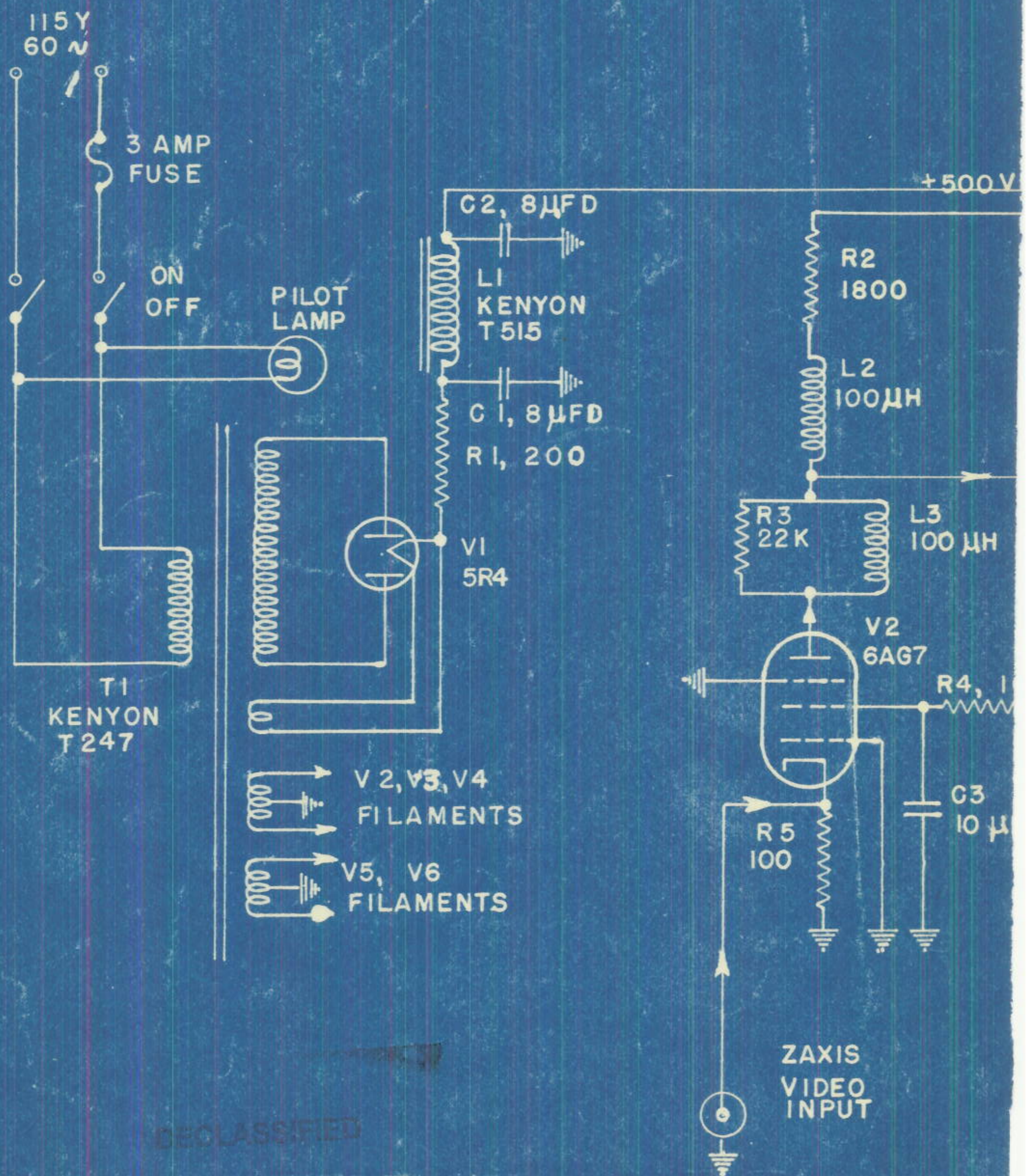


+ 2200 V
- 2600 V
- 3800 V
- 3900 V
A1
A2
A3
1 MEG.
R 34
.01 C7
00 V
R7 1800
L4 100μh
.01 C6
R11 1000
L6 100μh
R6 22K
100μh L3
R10 20K
100μh L5
V4 6AG7
V5 807
4 100
R5 220 C11 20 μfd
R8 470K
R9 125
20 μfd C8
Z AXIS
IDEO INPUT


VIO - 12 G
R33
680K
680 K
680K
R 30
R 31
R32
680 K
R14
IOK
R18
IOK
R13
220
R17
220
OUTPUT BALANCE
V6 807
V7 807
5K
R16
INPUT
BALANCE
R15
IK
CNTR.
ADJ.
5K
R19
R12
5K
AMPL.
ADJ.
C9
.1
V AXIS
VERT. INPUT

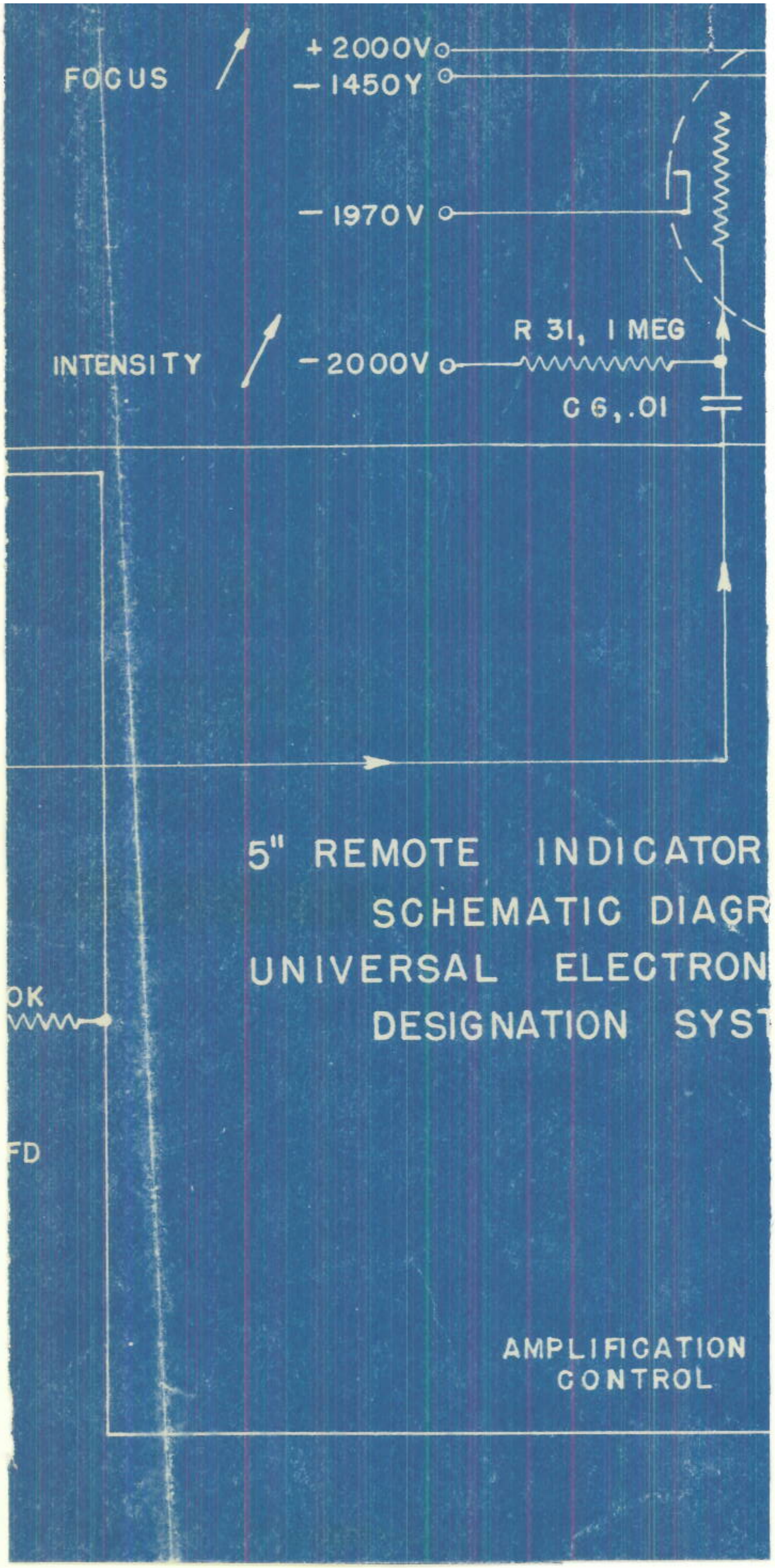
12" INDICATOR UNIT SCHEMATIC DIAGRAM UNIVERSAL ELECTRONIC TARGET DESIGNATION SYSTEM

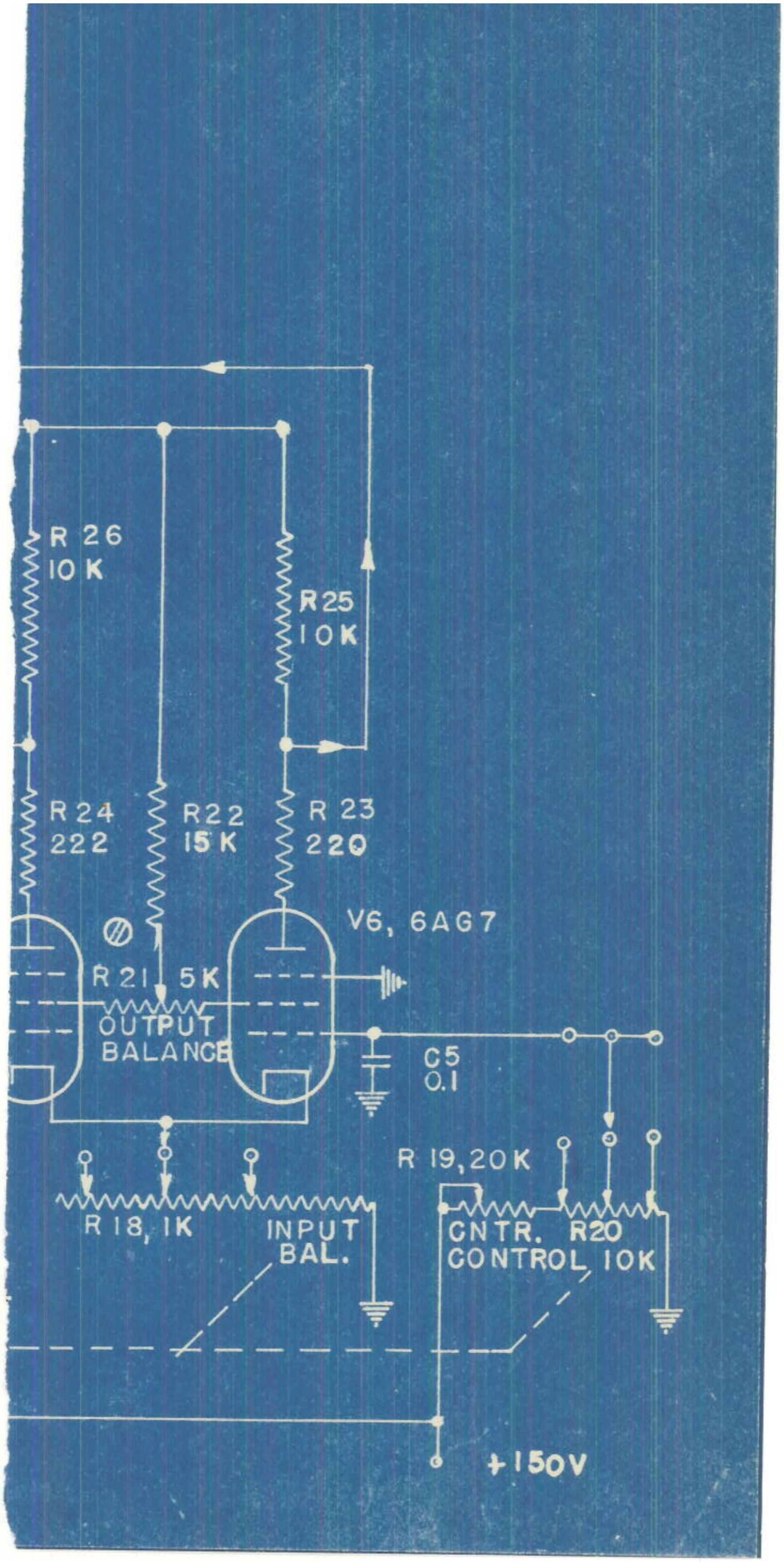




DECLASSIFIED

[redacted]	NRL MISSILE CONTROL DIV.	PLATE 18
	PCS 28 FEB. 46 R2772	


FOCUS
+2000V
—1450Y
—1970V
INTENSITY
—2000V
R 31, 1 MEG
C 6, .01
0K
FD
5" REMOTE INDICATOR
SCHEMATIC DIAGR
UNIVERSAL ELECTRON
DESIGNATION SYST
AMPLIFICATION
CONTROL


R 26
10 K
R25
10K
R 24
222
R22
15 K
R 23
220
V6, 6AG7
R 21 5K
OUTPUT
BALANCE
C5
0.1
R 19, 20K
R 18, 1K
INPUT
BAL.
CNTR. R20
CONTROL 10K
+150V