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THIRD IN-SERVICE SURVEILLANCE EXAMINATION OF THE INDIAN POINT NO. 3 STEAM GENERATOR CHANNEL HEAD CLADDING

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Prepared by Westinghouse for the Power Authority State of New York

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SUMMARY

This report describes the tests conducted and the results obtained in the third in-service clad cracking surveillance examination of the channel heads, steam generators 31, 32 and 34 at the Power Authority State of New York (PASNY) Indian Point Unit 3 power plant. The ultrasonic examination of the areas to be monitored in the three (3) channel heads was performed in accordance with PASNY and NRC approved Westinghouse Procedures NPT 81 and NPT 61 to criteria setforth in Westinghouse Tampa Report TD-MET-77-127. A comparison of the results obtained with the data recorded from the pre-service, first and second in-service examinations shows no significant changes indicative of crack growth during service. No evidence of new cracking is indicated in the recorded data.

A recommendation to discontinue the ultrasonic surveillance program, per the NRC corrective action plan issued prior to start-up, is included in this report.

INTRODUCTION

In April 1982, the third ultrasonic in-service surveillance examination of the weld deposited stainless steel clad cracking in the 31, 32, and 34 steam generator channel heads at the Indian Point 3 power plant was performed. The primary objective of the examination was to determine if clad cracks in the 5 x 12 inch areas previously examined in the pre-service, first and second in-service surveillance examinations have grown in depth or length. The techniques utilized were in accordance with process specifications and criteria set forth in Westinghouse Tampa Plant Report #TD-MET-77-127, "Proposed In-Service Ultrasonic Examination and Structural Appraisal of Clad Steam Generator Channel Heads, Consolidated Edison Indian Point #3.".

Specific details concerning test techniques, methods for evaluating test results, and criteria for determining the need for repair are provided in Westinghouse Process Specification NPT 81, "Procedure for Ultrasonic In-Service Inspection and Evaluation of Channel Head Cladding Flaws" (Appendix A). Westinghouse Process Specification NPT 61, "Method for Shear Wave Ultrasonic Cladding Surveillance" (Appendix B) referred to in specification NPT 81 details the procedure to be followed when conducting the comparative surveillance examinations. Process Specifications NPT 81 and NPT 61 were previously reviewed and approved by PASNY.

The NPT 61 ultrasonic examination procedures for estimating clad crack depth were developed in two test programs conducted on in-production channel head castings and artificially-defected sections of a clad channel head casting. The results of the two programs are documented in Westinghouse Report TD-MET-77-110 (Revised) "Development of Improved Ultrasonic Testing Technique for In-Service Examination of Cladding Flaws in Steam Generator Channel Heads" (Appendix C). The process specifications NPT 81 and 61 and the aforementioned report, identified as Appendices A, B and C in this report, were previously reviewed and approved by the Nuclear Regulatory Commission (NRC) when Consolidated Edison (now PASNY) was seeking permission to monitor the Indian Point #3 steam generator channel head cladding condition. The NRC approval

included the recommendation that the "Utility" conduct the approved ultrasonic surveillance examination during the first three refueling operations and, if no changes in the cladding condition are indicated by the three (3) surveillance examinations, the "Utility" may discontinue the ultrasonic surveillance.

EXAMINATION

The location of the channel head areas selected for monitoring in the surveillance program are shown in Figures 1 and 2. Prior to performing the ultrasonic examination, the insulation around the areas of interest was removed, the exact locations of the test areas identified and the sound beam entry surfaces were wire-brushed to remove dirt and rust.

The ultrasonic test system was calibrated using selected ELOX calibration notches in the Indian Point Unit 3 reference/calibration block shown in Figure 3. The 1/8 inch, 3/16 inch, 1/4 inch, 3/8 and 0.45 inch deep notches in the block were utilized to calibrate the test system. Calibration for the testing was established in accordance with the requirements set forth in NPT 61, Part II. A summary of the personnel certs., the equipment used during the surveillance testing and, the key calibration parameters are given in Table I. Personnel and equipment documentation and certifications are provided in Appendix D.

To obtain the required calibration, the 1.0 MHz search unit was mounted in the Westinghouse 20° incident angle "immersion" test fixture and the fixture adjusted, per NPT 61 Part II, to provide the proper surface contact. The entire search unit assembly was then mounted in the scanning frame on the IPP-3 reference/calibration block. The maximized Cathode Ray Tube (CRT) response amplitude from the 3/8 inch deep notch was set to 85-90% of full screen height (FSH) by adjusting the "5N Weld" pulser/receiver gain and pulse controls. At that calibration setting, a 60-65% FSH response was obtained from the 1/4 inch deep notch, a 50% FSH indication from the 3/16 inch deep notch and a 30% FSH indication from the 1/8 inch deep notch. Recalibration after the surveillance tests were completed produced very similar data, see "Final Calibration Amplitudes" data in Table I. The output from the X-Y recorder obtained during the initial calibration is shown in Figure 4. The data from the notches in the calibration/reference block was used to develop the amplitude versus notch depth plots shown in Figure 5. Note, in Figure 5, the non-linearity (compressed) in the recorded response amplitude above the 65% FSH (1/4 inch notch) level. Below the 65% FSH level, the recorded calibration data "tracks" the CRT calibration data exactly; 25% FSH to 65% FSH is the zone of concern in the test. Automation Industries later reported, based on a laboratory calibration, that the recorder operated linearly up to 75% FSH during the surveillance examination of the IPP 3 channel head cladding.

TABLE I

CHANNEL HEAD CLADDING ULTRASONIC SURVEILLANCE
INDIAN POINT UNIT 3 (PASNY)
STEAM GENERATORS 31, 32 & 34

PROCEDURES

Westinghouse Tampa NPT 81 9/24/77 Appendix A

Westinghouse Tampa NPT 61 6/28/78 Revision Appendix B

PERSONNEL

E. T. Hughes, Level III UT	Westinghouse Ser. No. 013 9/15/80 Records on file W NDE Technical Institute, Pittsburgh, PA Appendix D
Robert Lucas, Level II UT	Nuclear Energy Services, Inc. 9/30/80 Danbury, CT (certs attached) Appendix D

EQUIPMENT

Reflectoscope	UM 771	S/N 28 Cert. (attached) 3/7/82 Appendix D
Pulser/Receiver	5N Weld	S/N 2853-9 Cert. (attached) 3/7/82 Appendix D
Alarm/Recording Mod	AG 1 FM	S/N 85066-4 Cert. (attached) 3/7/82 Appendix D
Search Unit 1.0 MHz	57A3453	S/N C82575 Cert. (attached) 4/23/82 Appendix D
Search Unit Fixture	20°	W Immersion/Contact
Recorder, X-Y	7046A	Hewlett Packard Calibration 4/30/82
Reference Block	SA216WCC	IPP-3, Clad Channel Head Section - Elox Notches 1/8" x 3/4", 3/16" x 3/4", 1/4" x 3/4", 3/8" x 3/4", 0.45" x 3/4", 1/2" x 3/4", 5/8" x 3/4", 3/4" x 3/4".
Couplant	Chem Pure	Glycerine

CALIBRATION (Figure 5)

Notch	CRT (Initial)*	Recorder	CRT (Final)*	Gain	Freq.	Sweep.	Tuning
1/8" x 3/4"	30% FSH	30% FSH	35% FSH**	28 db	1.0 MHz	0.5	2"
3/16" x 3/4"	50% FSH	-	-	28 db	1.0 MHz	0.5	2"
1/4" x 3/4"	60-65% FSH	60% FSH	65% FSH**	28 db	1.0 MHz	0.5	2"
3/8" x 3/4"	85-90% FSH	75% FSH	90% FSH**	28 db	1.0 MHz	0.5	2"
0.45" x 3/4"	95% FSH	-	-	28 db	1.0 MHz	0.5	2"

*Observed Cathode Ray Tube Amplitudes.
**About 1 db hot.

The designated areas on the three channel heads were examined at the calibration sensitivity along 5 inch vertical scan paths at 3/4 inch increments around the channel heads. In each case, the search unit was scanned up and down along the same path at least twice to ensure that the data were repeatable. After scanning was completed along one scan path, the search unit was indexed the pre-set 3/4 inch interval and the process repeated.

On steam generators 31 and 34, no recordable indications were found in the scanning of the designated areas. Recordable indications are defined as relevant indications of amplitude equal to or exceeding the 1/8 inch deep notch amplitude minus 5% FSH. Based on the calibration data shown in Figures 4 and 5, 25% FSH was the minimum recording level set for the test.

The results of the surveillance scanning on the six (6) designated areas on steam generator 32 were documented, as in the pre-service, first and second in-service surveillance examinations, by a series of X-Y strip chart recordings. The X-Y recordings are shown in Figures 6 through 11. To expedite the UT examination (to make way for eddy current testing of steam generator 32 tubes), the cladding condition in the designated areas were evaluated based on Cathode Ray Tube (CRT) observations and X-Y recordings made of the scans showing indications of and near recordable levels; the X-Y recording is time consuming.

DISCUSSION

For comparison purposes, the X-Y plots from the pre-service examination, the first and second in-service examinations of the six areas in the steam generator 32 channel head are attached to this report as Appendix E. The X-Y recordings for the current examination and the previous in-service examinations were made, as noted earlier, while traversing the selected areas in both directions to provide a confirming trace. The pre-service X-Y recordings were made in only one scanning direction. To facilitate comparison, the X-Y recordings from all four, the pre-service and the three in-service, examinations were reviewed and the recordable data excerpted for listing in tabular form. The recordable data from all of the examinations are shown in Table II. It should be pointed out that only those indications that equal or exceed the 1/8 inch notch calibration amplitude minus 5% FSH are (in all four examinations) considered relevant and recordable.

Comparison of the data from the second in-service and the current (third) surveillance data indicates that no significant changes in the clad cracking condition have occurred in the period of operation between examinations. Comparison and evaluation of all of the data shown in Table II indicates no significant differences between the results of the pre-service and the three in-service surveillance scans. Comparison of the surveillance examination(s) results shows no evidence of new cracking or the propagation of minor cracking into the "recordable" category. In addition to the above observations, it should be noted that 5% FSH variations in indication amplitudes from test to test are well within the expected 2 db instrument, reading, recording, etc. error. The generally lower indication amplitudes, i.e., 5-10% FSH compared to pre-, 1st and 3rd examinations, obtained in the second in-service examination are due to the higher - compared to the calibration (block) - channel head temperatures encountered in that test cycle; specifically, channel head temperatures of 120-125°F versus calibration block temperatures of 90-95°F.

TABLE II

ULTRASONIC TEST RESULTS STEAM GENERATOR #32 PRE- AND IN-SERVICE SURVEILLANCE EXAMINATIONS

Area	Scan	Pre-Service Recorded Ampl.	Scan	First In-Service Recorded Ampl.	Scan	Second In-Service Recorded Ampl.	Scan	Third In-Service Recorded Ampl.
#1	13	20%	13	20%	13	20%	13	25%
	14	40%	14	35%	14	30%	14	35%
	15	30%	15	25%	15	25%	15	25%
#2	12	30%	12	20%	12	15%	12	20%
	14	30%	14	30%	14	30%	14	35%
	17	60%	17	50%	17	45%	17	50%
#3	2	70%	2	60%	2	50%	2	55%
	4	40%	4	45%	4	40%	4	40%
	5	30%	5	25%	5	20%	5	25%
	14	30%	14	25%	14	25%	14	30%
#4	2	35%	2	30%	2	25%	2	30%
	14	30%	14	25%	14	25%	14	25%
#5	2	40%	2	30%	2	20%	2	25%
	3	25%	3	35%	3	30%	3	35%
	5	30%	5	20-25%	5		5	25%
	7	25%	7	25%	7	20%	7	25%
	16	35%	15	40%	15	30%	15	35%
#6	1	45%	1	30-35%	1	25%	1	30%
	2	45%	2		2		2	35%
	5	40%	5	30%	5	20%	5	25%
	6	35%	6	25%	6	20%	6	25%
	7	40%	7	30%	7	20%	7	25%
	8	50%	8	40%	8	30%	8	35%
	12	35%	12	35%	12	25%	12	35%
	17	30%	17	25%	17	20%	17	30%

CONCLUSIONS AND RECOMMENDATIONS

Comparison of the second in-service surveillance results with those obtained in this current or third in-service monitoring shows no changes indicative of increasing crack depth or length due to service and no new indications of cracking, specifically, no indications approaching the recordable level.

Comparison of the in-service (3 surveillance examinations) test results with the pre-service results, all obtained using the prescribed and approved UT procedures, indicates that there has been no change in the cladding condition in the designated scan areas of the three affected steam generator channel heads.

Based on the UT indicated conclusion that the cladding condition has not changed, i.e., the cracking has not propagated and no new cracks have been indicated over the first three cycles of operation, it is recommended that the UT surveillance of the channel head cladding, Indian Point 3 steam generators 31, 32 and 34 be discontinued. As pointed out earlier, the NRC approval of the ultrasonic surveillance procedure included the recommendation that the "utility" conduct the approved ultrasonic surveillance examination during the first three refueling operations and, if no changes in the cladding condition are indicated, the utility may discontinue the ultrasonic surveillance.

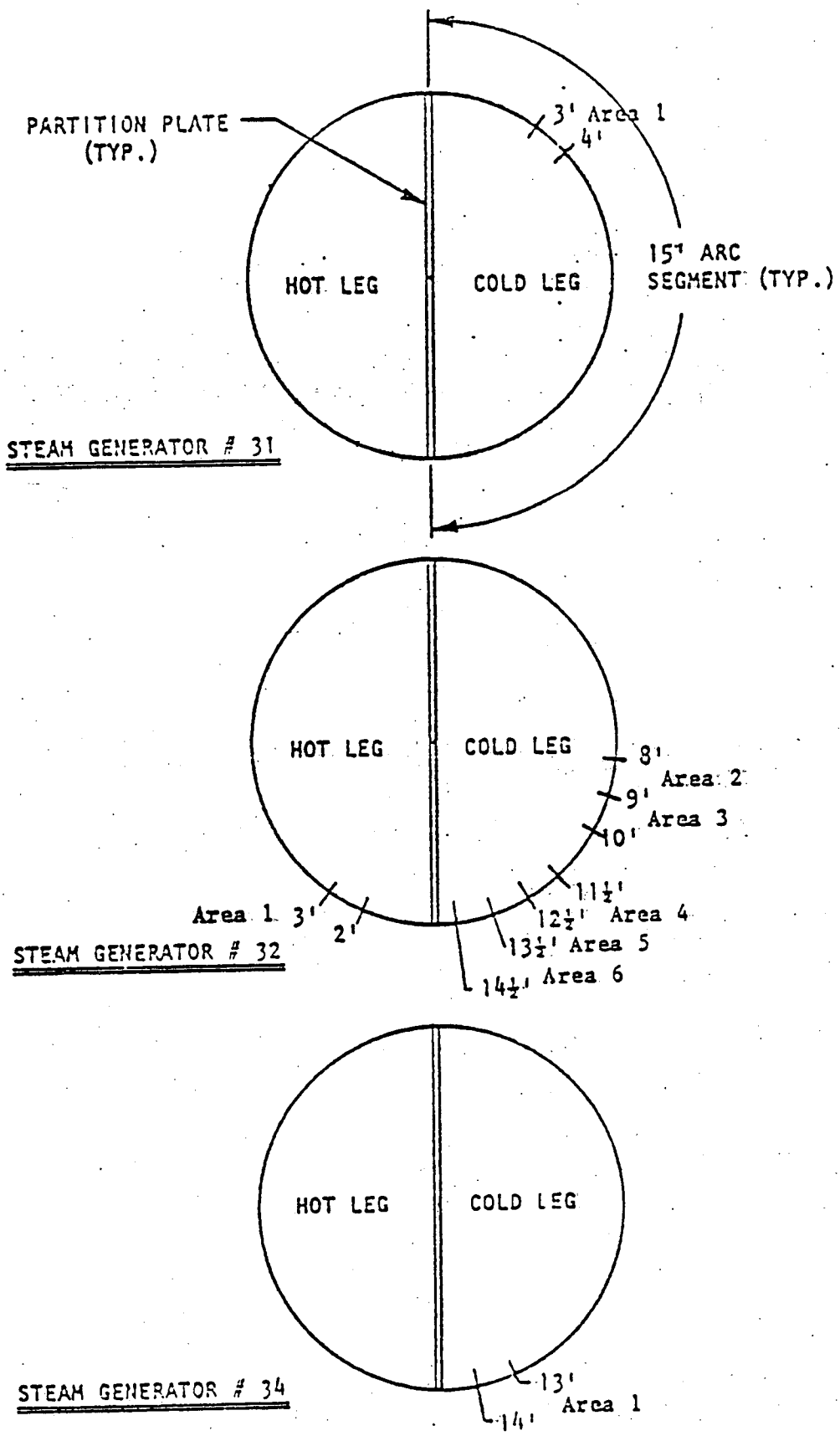

FIGURE 1 SURVEILLANCE AREA LOCATIONS

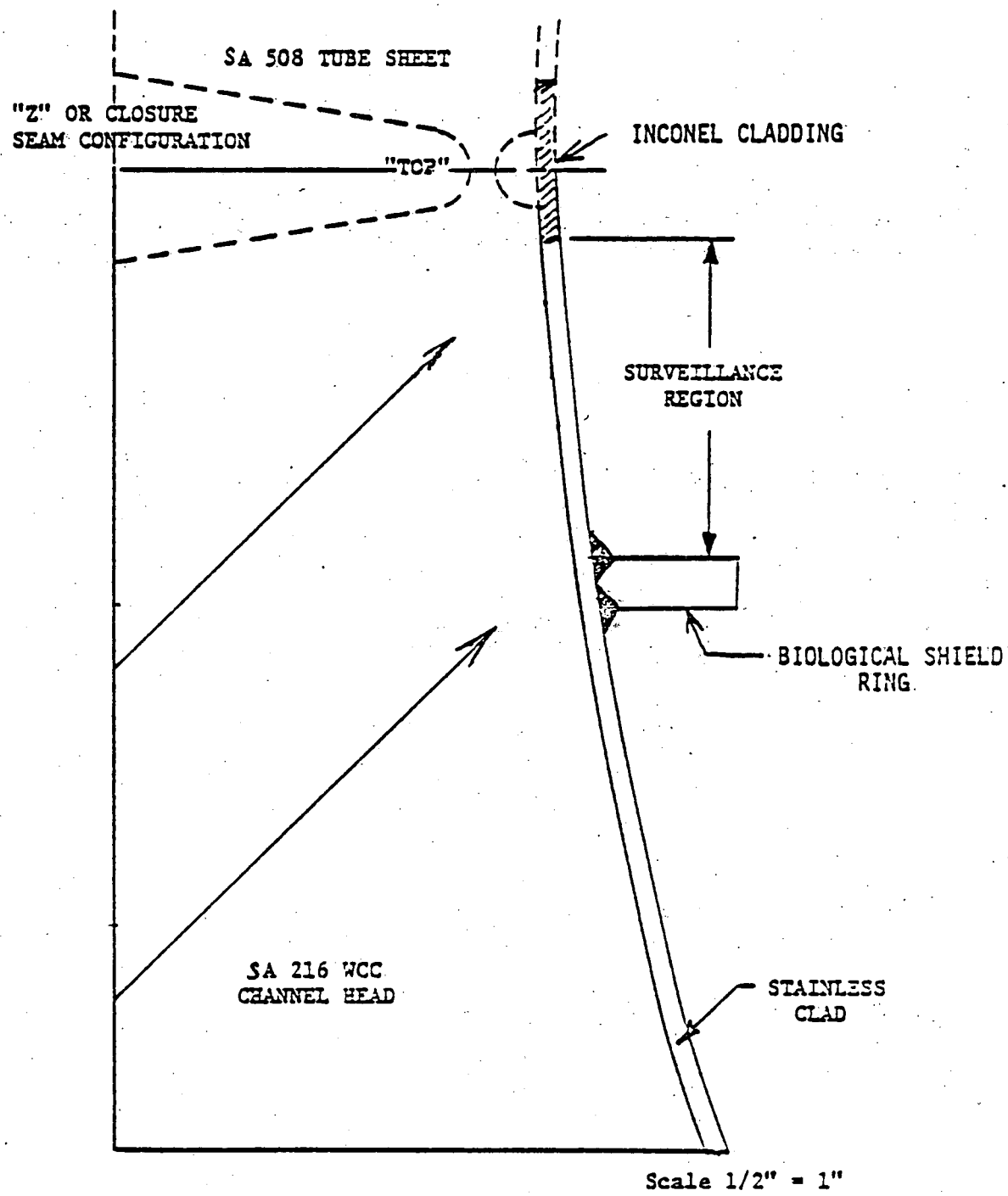

FIGURE 2: SURVEILLANCE REGION IN CHANNEL HEAD

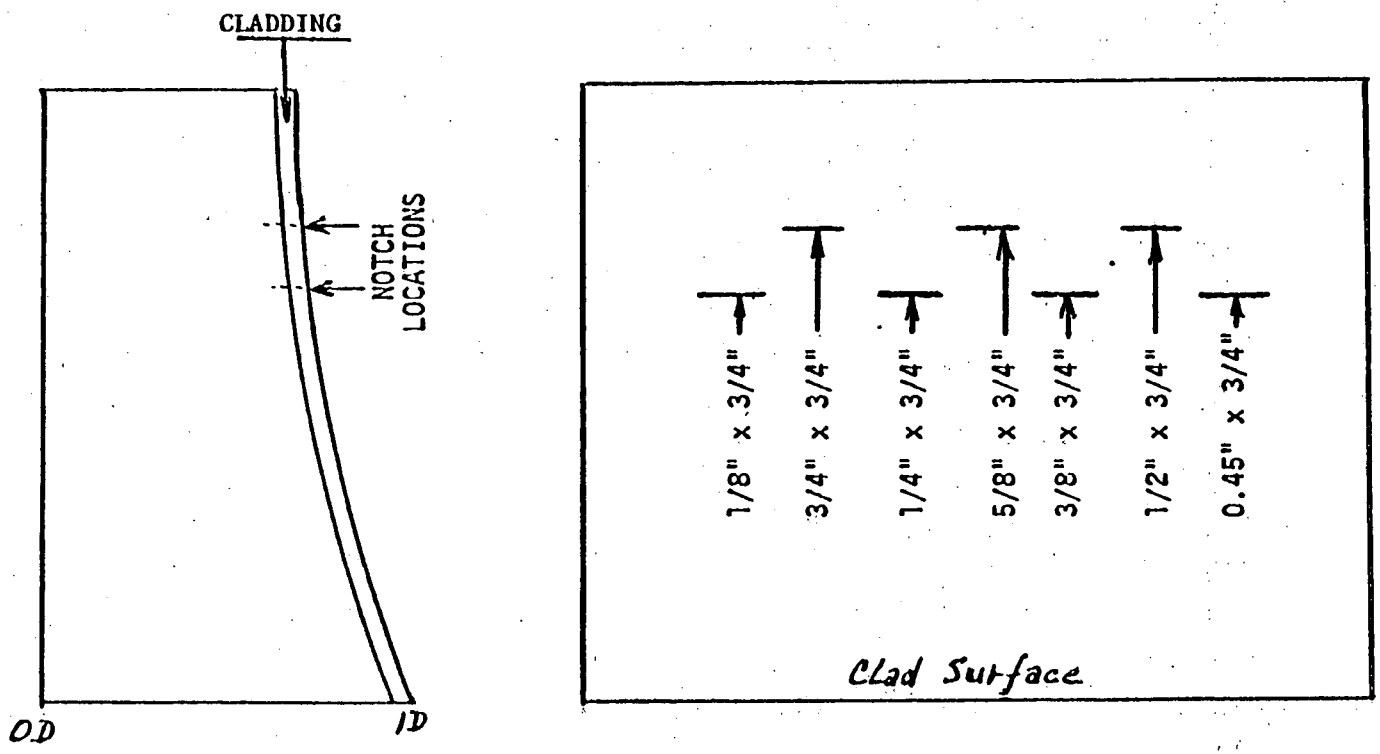

FIGURE 3: CALIBRATION BLOCK CONFIGURATION

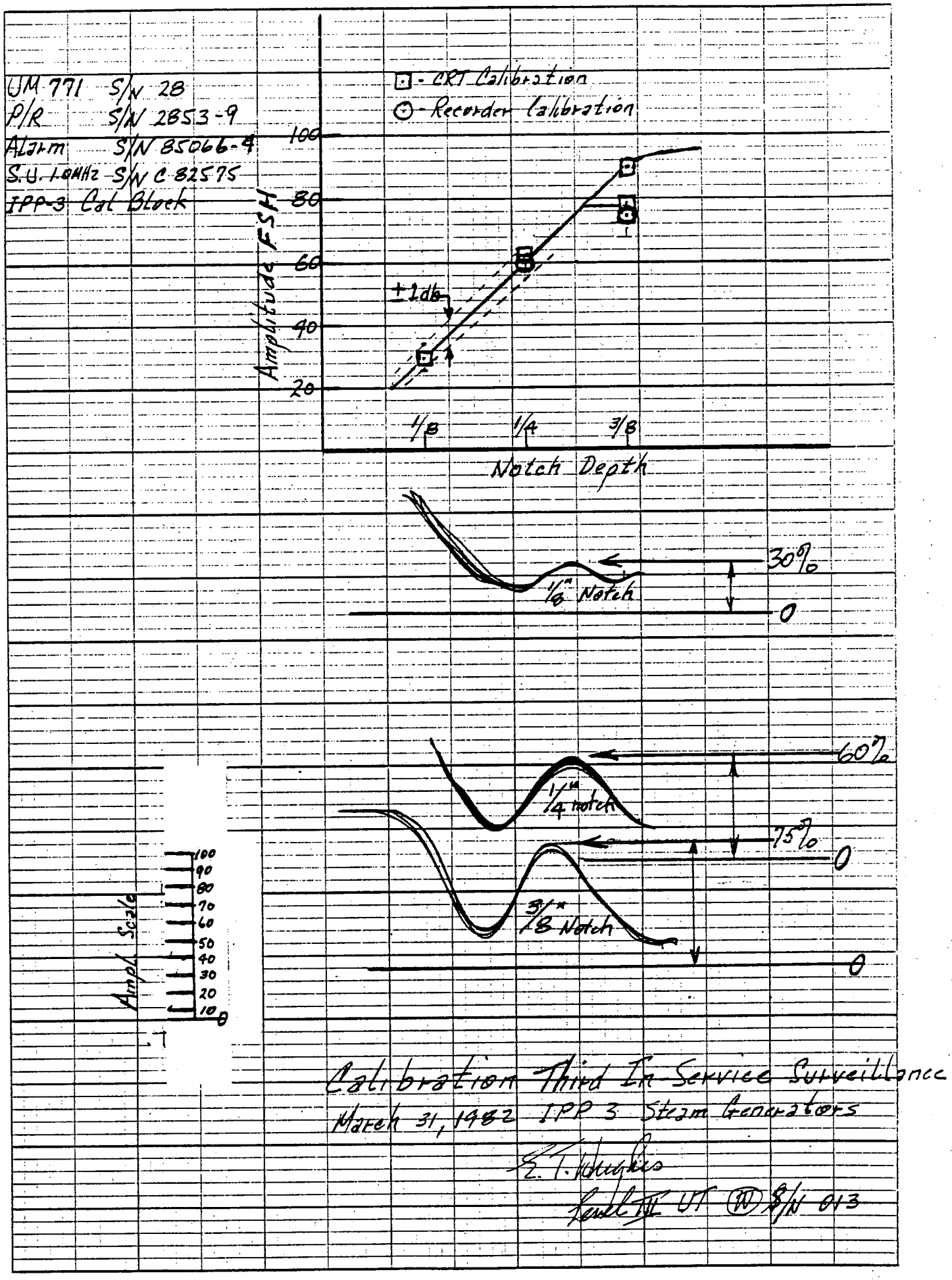

Figure 4. Recorder Calibration, Third In-Service Surveillance IPP 3 Steam Generators

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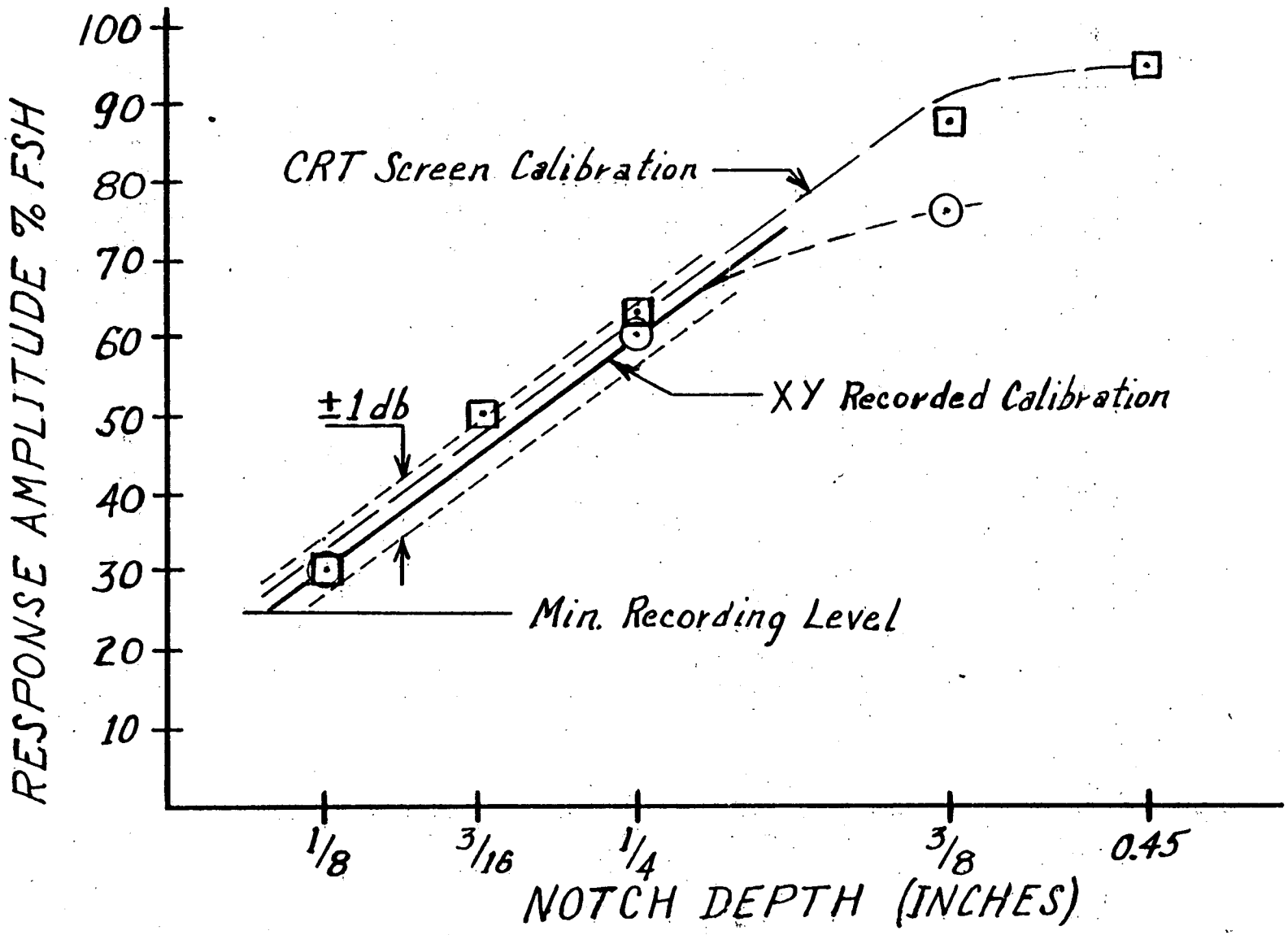

FIGURE 5 - CALIBRATION, SURVEILLANCE NO. 3

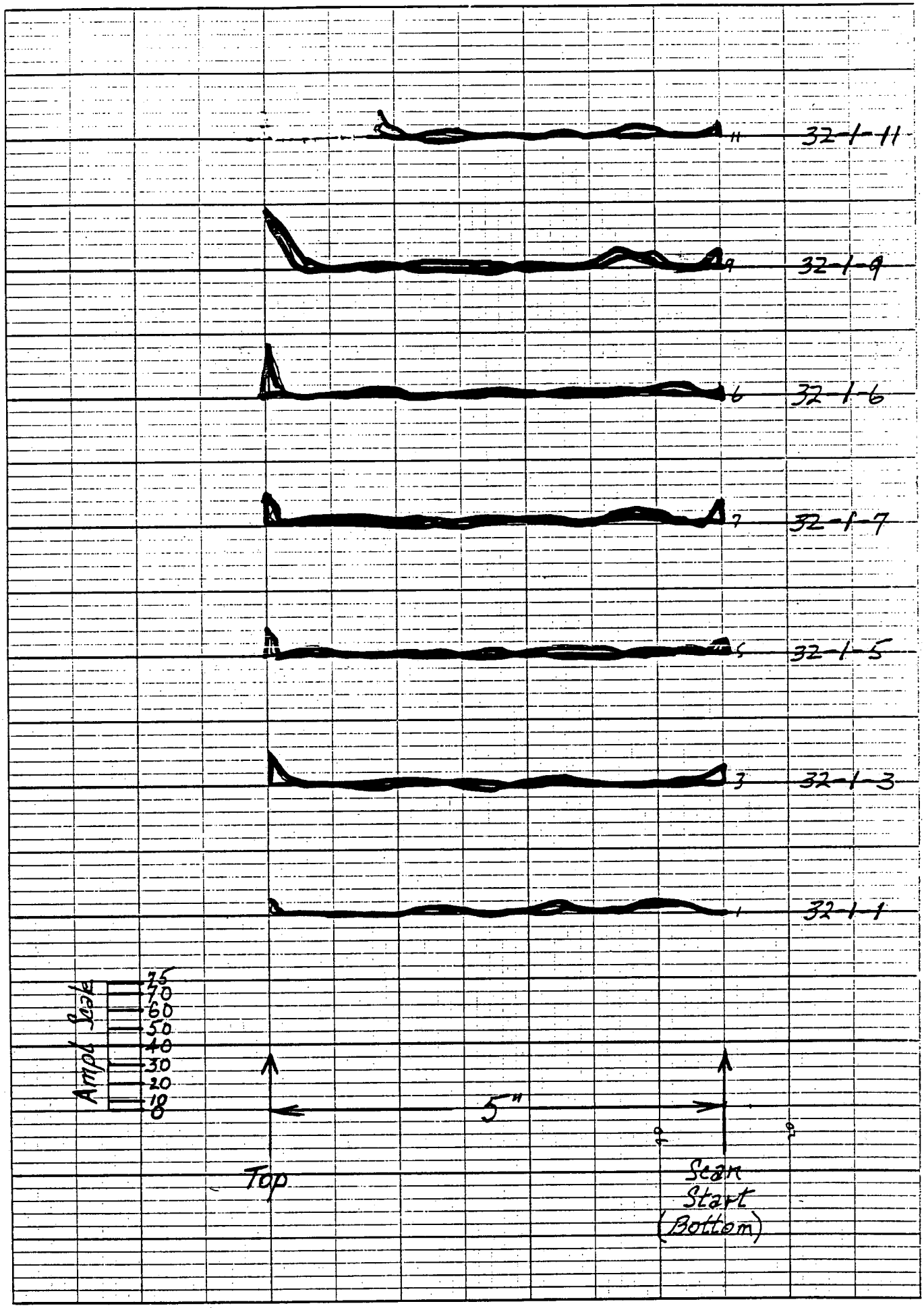

Figure 6a. X-Y Recordings Steam Generator 32 Area 1

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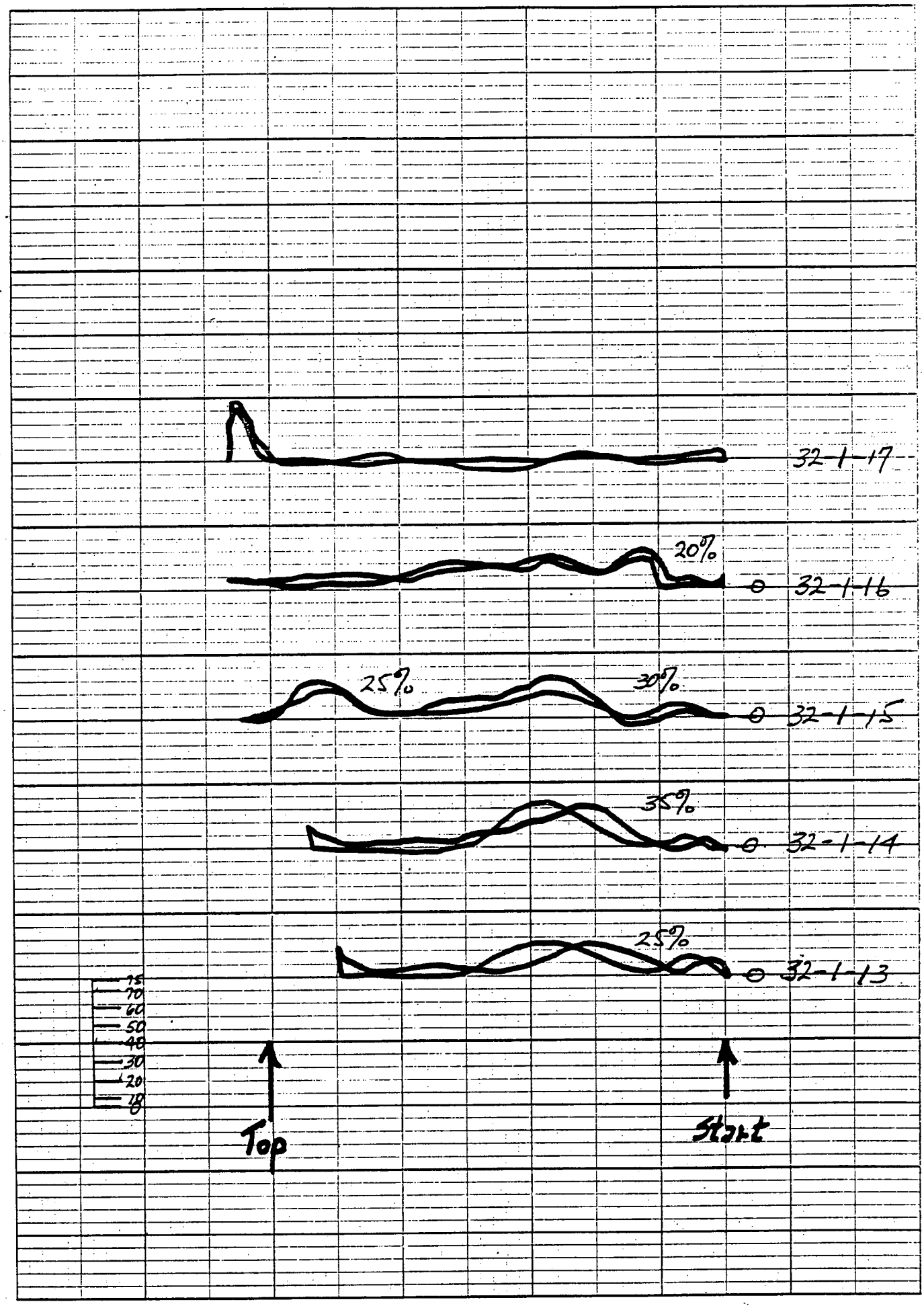

Figure 6b. X-Y Recordings Steam Generator 32 Area 1

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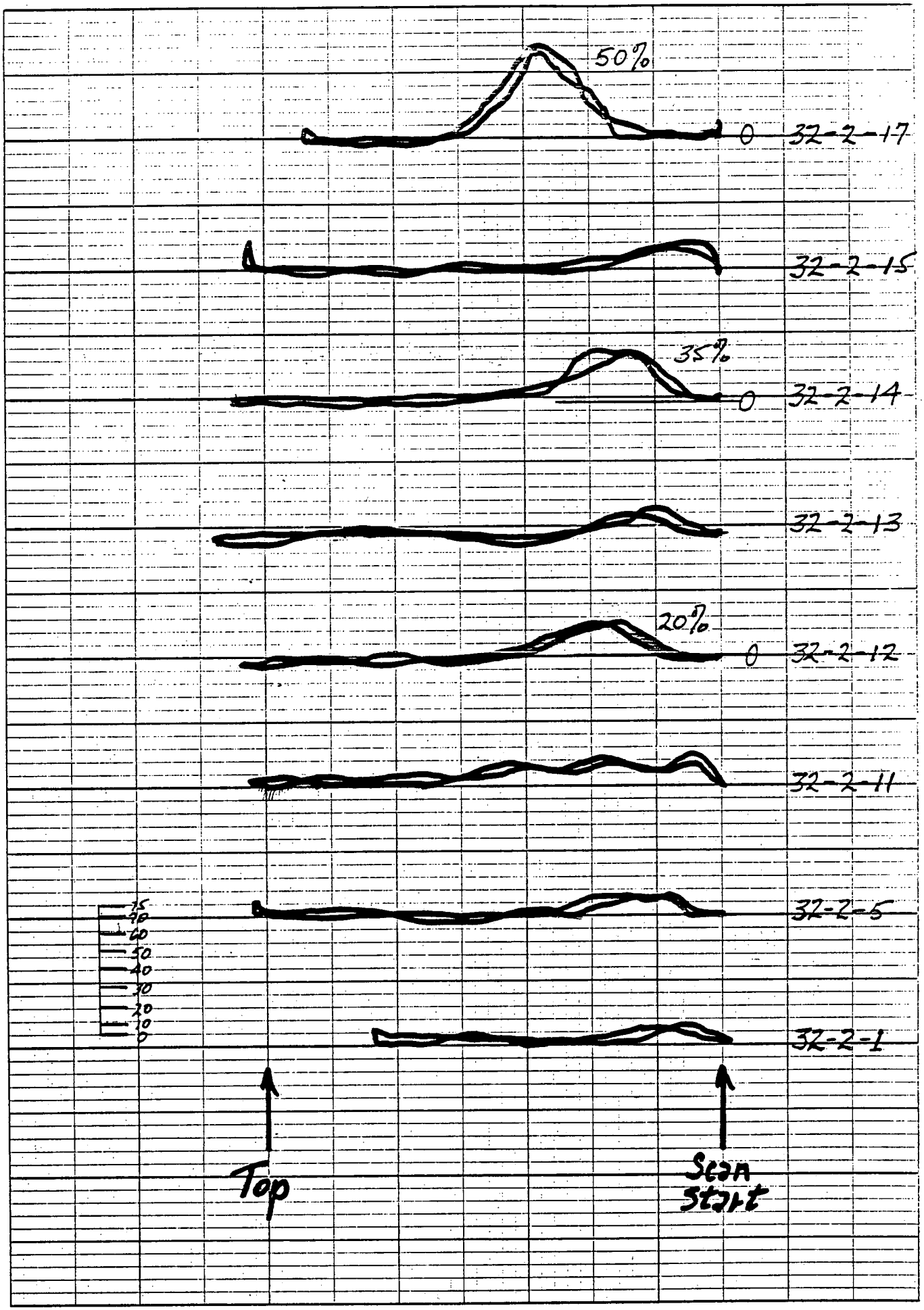

Figure 7. X-Y Recordings Steam Generator 32 Area 2

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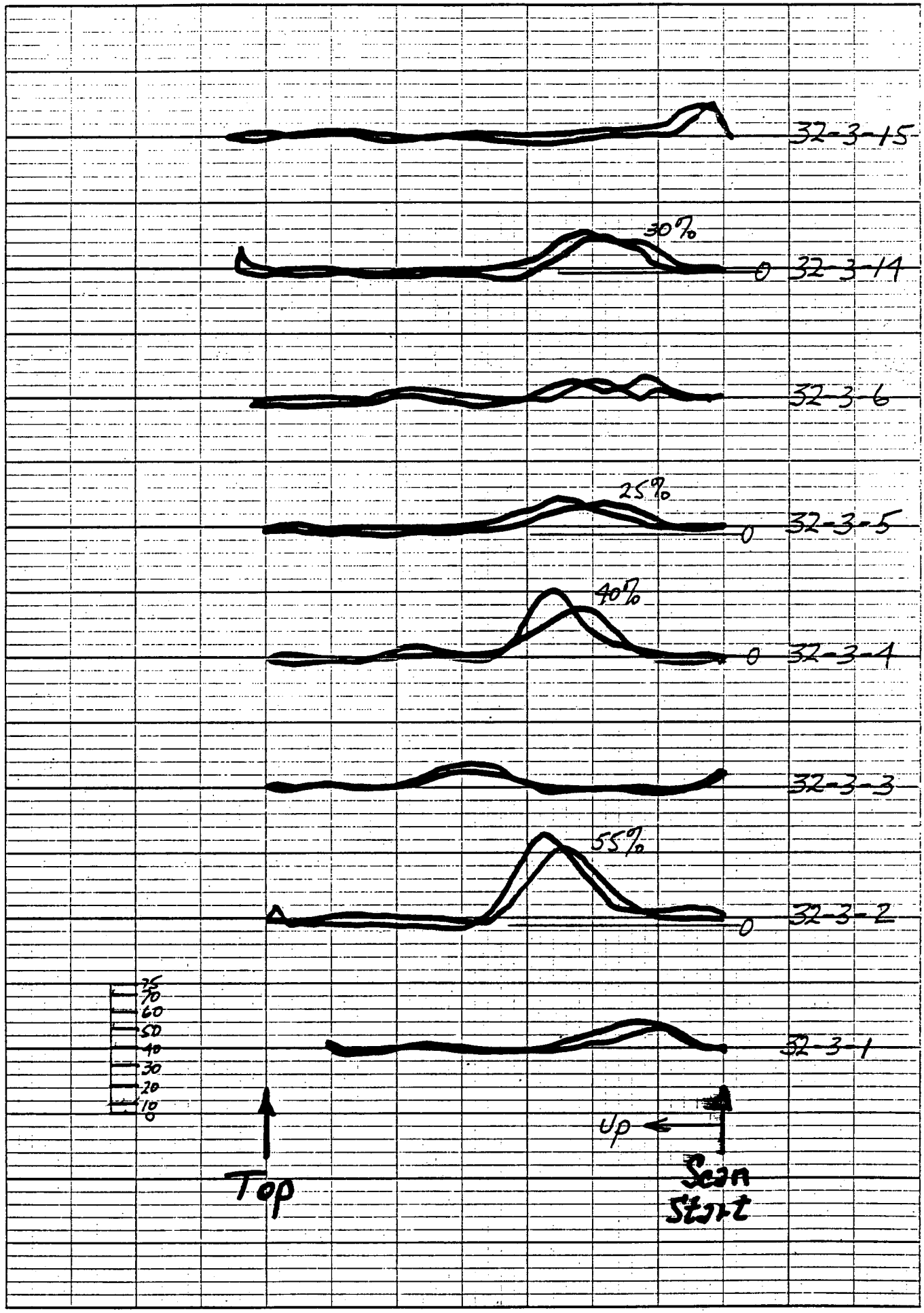

Figure 8. X-Y Recordings Steam Generator 32 Area 3

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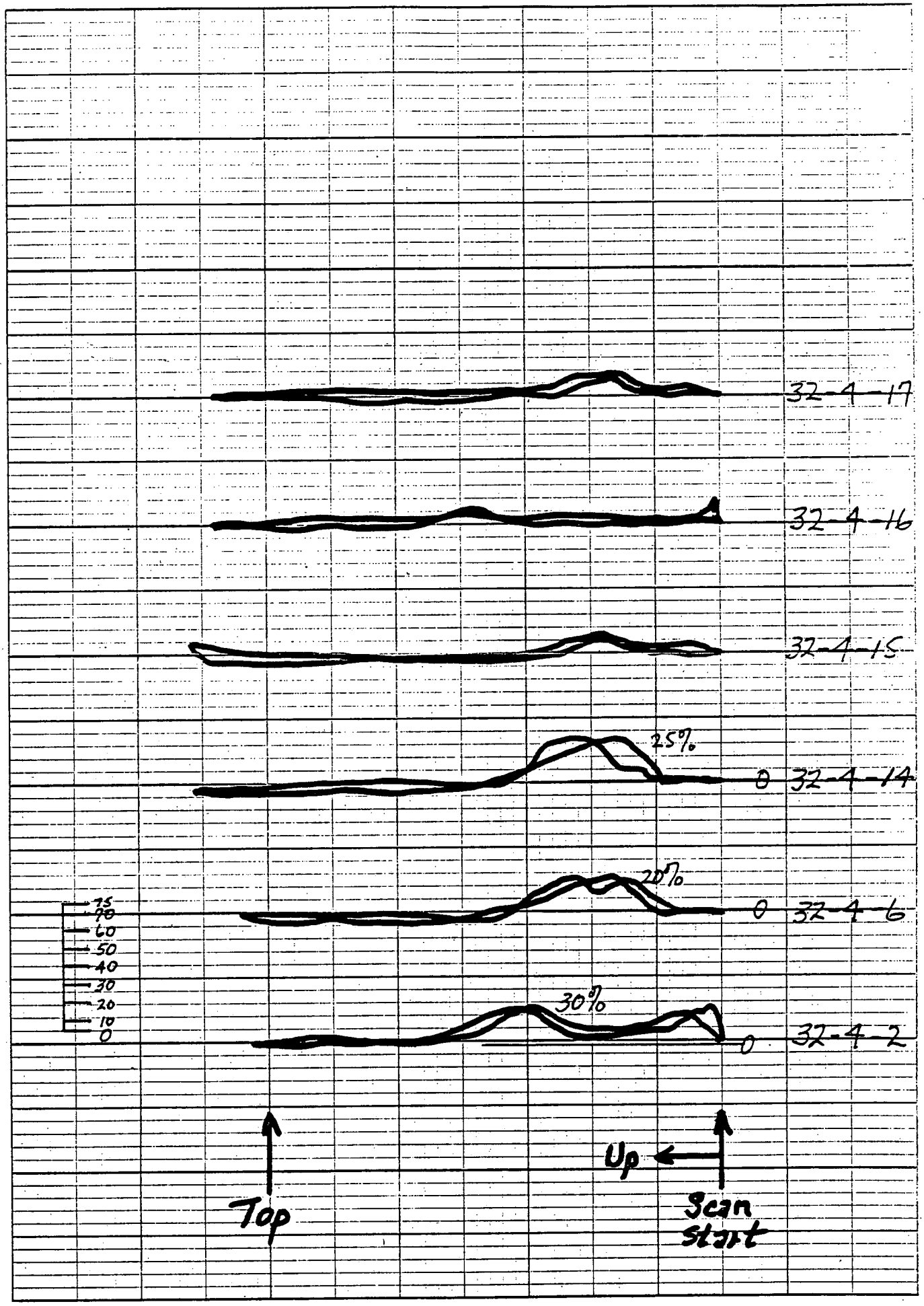

Figure 9. X-Y Recordings Steam Generator 32 Area 4

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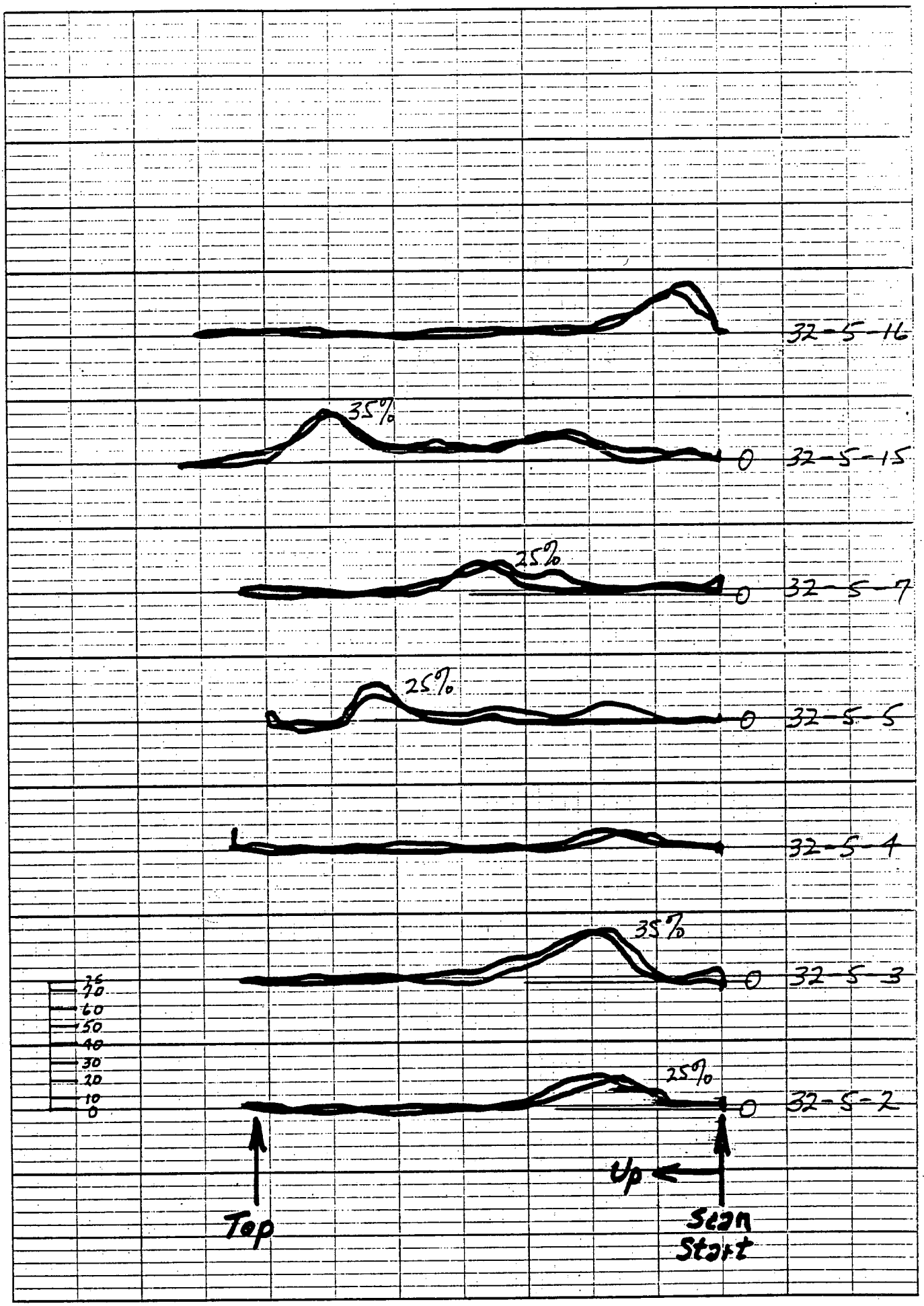

Figure 10. X-Y Recordings Steam Generator 32 Area 5

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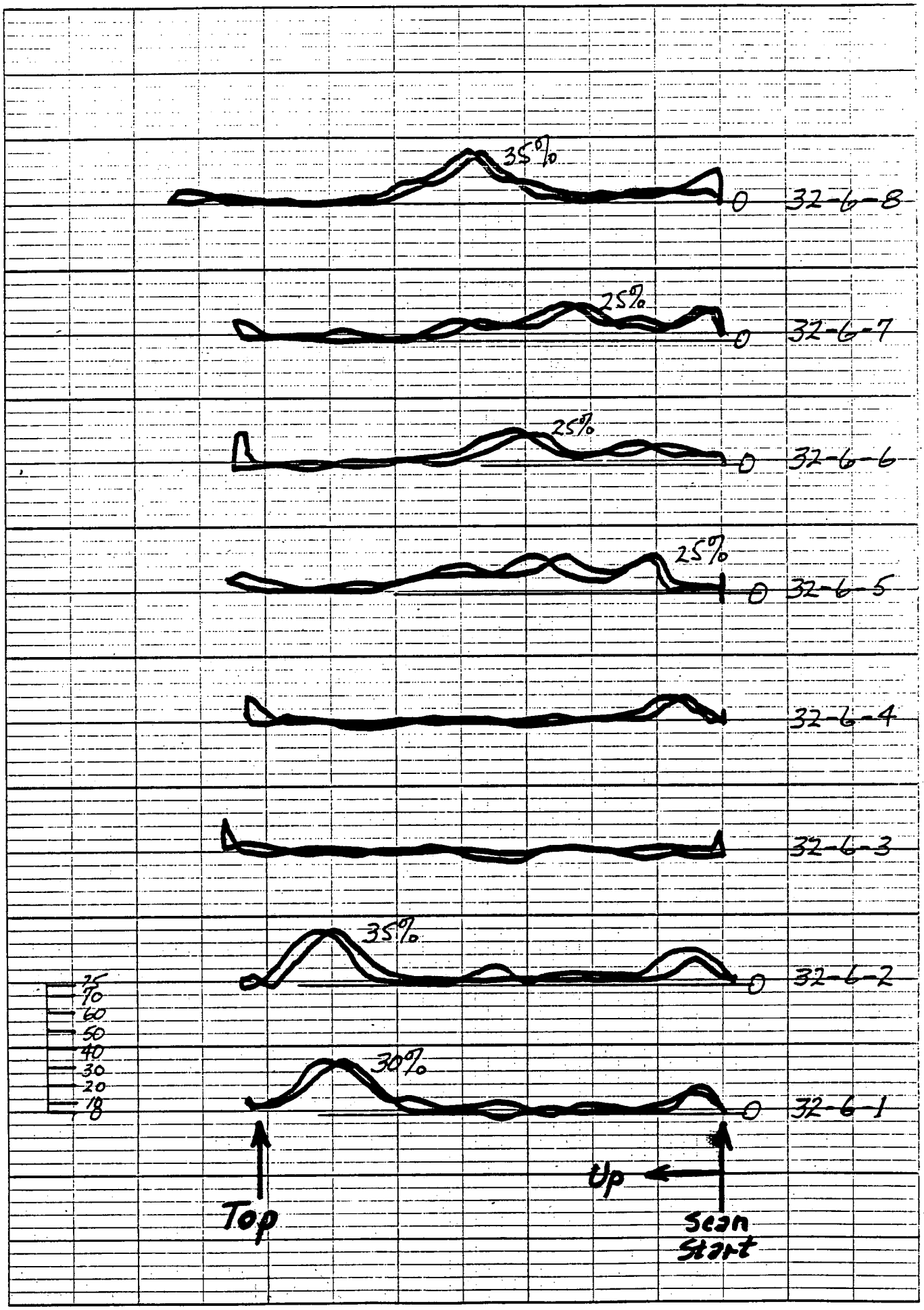

Figure 11a. X-Y Recording Steam Generator 32 Area 6

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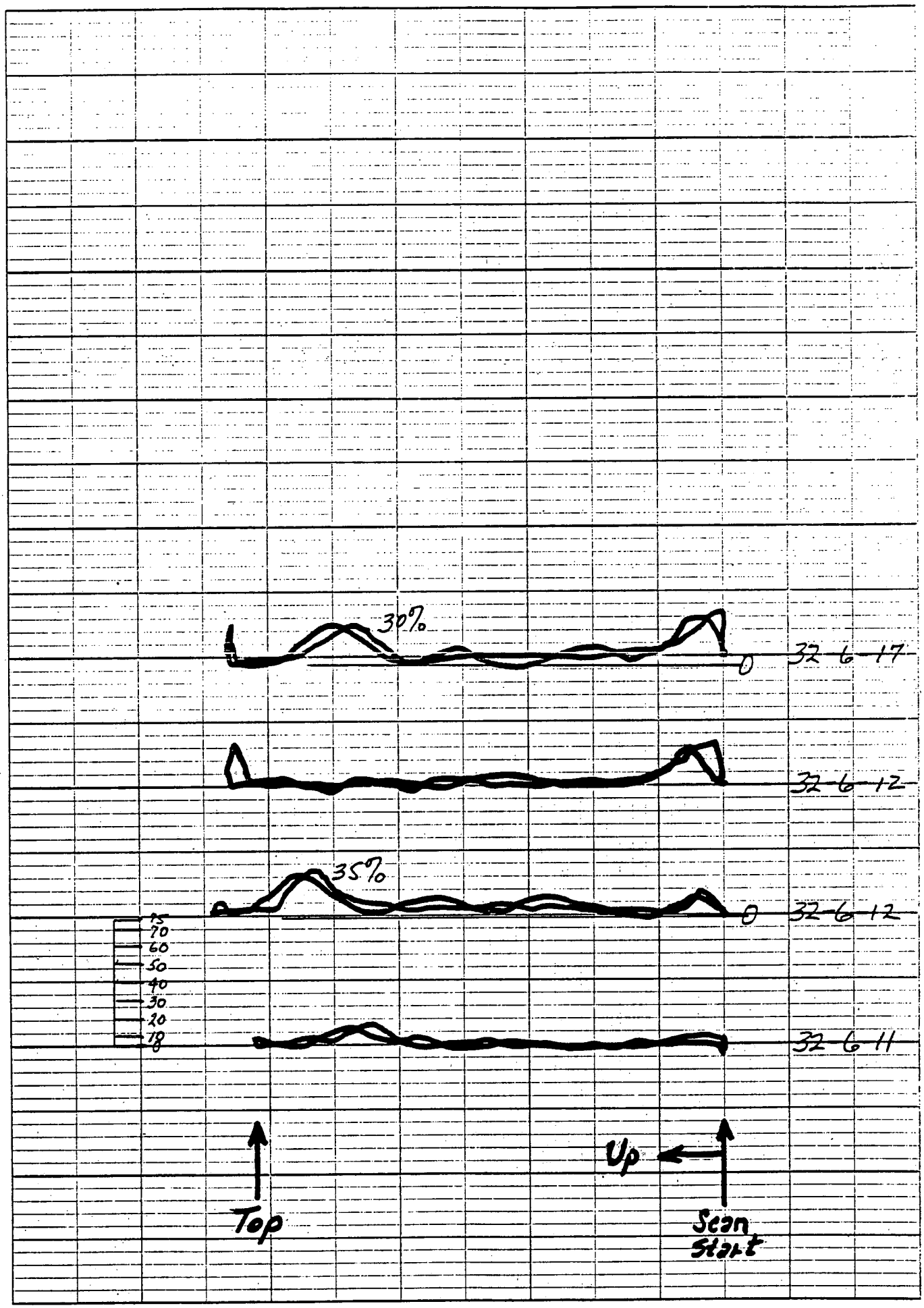

Figure 11b. X-Y Recordings Steam Generator 32 Area 6

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APPENDIX A

PROCESS SPECIFICATION NPT 81

PROCEDURE FOR ULTRASONIC IN-SERVICE INSPECTION AND EVALUATION OF CHANNEL HEAD FLAW DEFECTS

L. POOLE

Changed

PURPOSE

The purpose of this specification is to give the procedure for in-service inspection of cladding flaws, evaluating the results, and determination if repairs are required in accordance with the criteria given in W Tampa report #TD-MET-77-127.

PART I BASE LINE INSPECTION

At the time flaws are detected, a base line inspection shall be made and clad thickness in the surveillance region measured in accordance with NPT-61.

PART II DETERMINATION OF TOTAL FLAW DEPTH

Ultrasonically determine total flaw depth using Part II of NPT-61. Should the flaw depth exceed 3/8 inch, it must be further defined using Part III of NPT-61.

PART III CALCULATION OF DEPTH OF FLAW INTO BASE METAL

Using the clad thickness, as determined in the base line inspection, and the total flaw depth determined in Part II above, calculate to determine any flaw propagation into the base metal.

PART IV EVALUATION OF FLAWS

1. If no flaws are found which propagate into the base metal no further ev tion is required and the steam generators may be returned to service. ua-

2. If flaws extend into the base metal and if their length vs depth fall the curve as shown in the attached Figure 1, (TD-MET-77-127) the stea generators may be placed back in service and the proper authorities regulatory agencies shall be notified. der ncies

3. If flaws are found which fall above the curve in Figure 1, and belo curve in the attached Figure 2, (TD-MET-77-127) the steam generator placed back in service with the concurrence of the proper authorit regulatory agencies provided the specified design cycles of the p not been exceeded. e with ied the

4. Further flaw propagations can be justified on a case by case ba on stresses at the location of the flaw and expected remaining pending

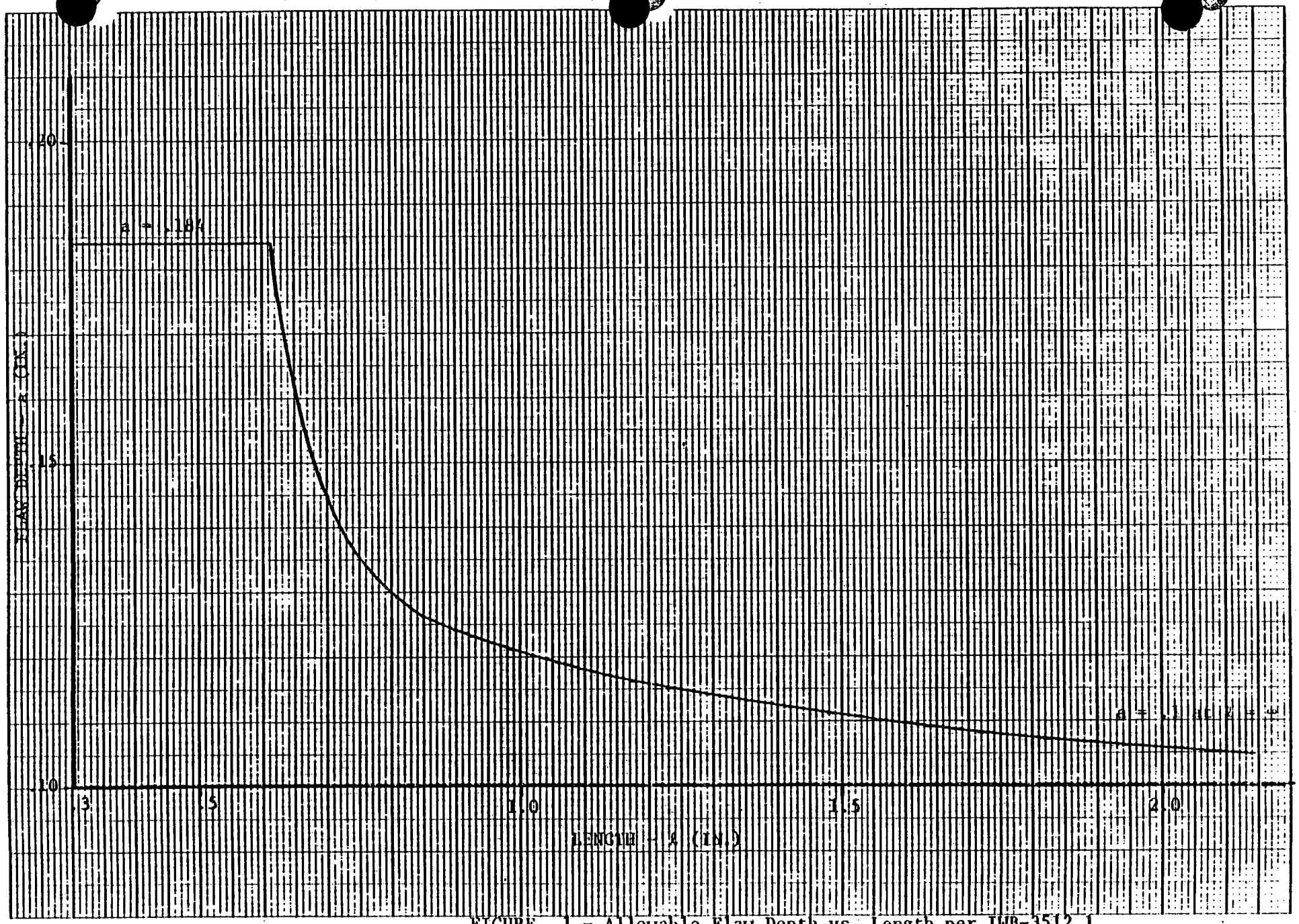

FIGURE 1 - Allowable Flaw Depth vs. Length per IWB-3512.1

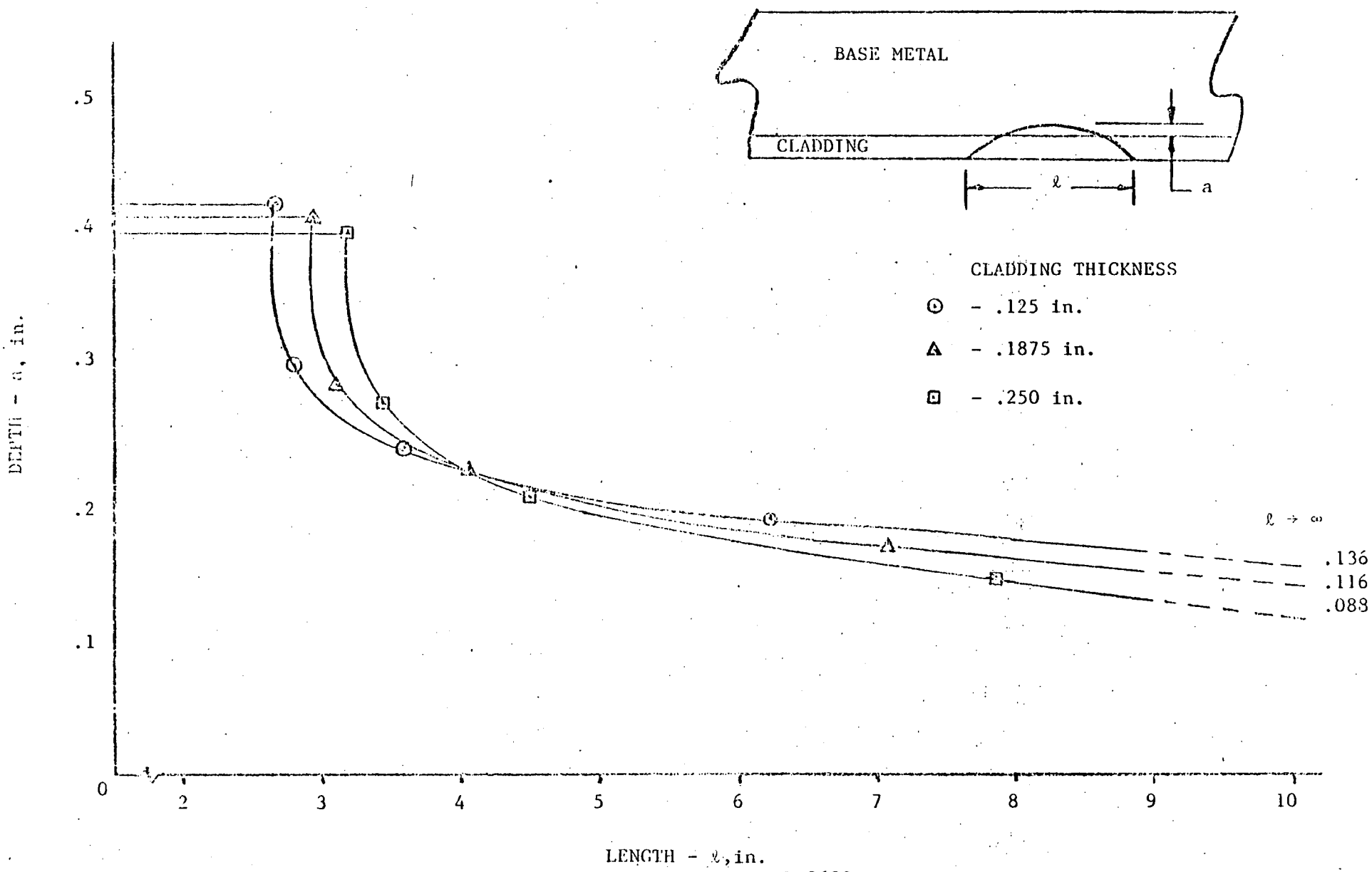

FIGURE 2 - ALLOWABLE FLAW DEPTH VS. LENGTH PER IWB-3600

APPENDIX B

PROCESS SPECIFICATION NPT 61

METHOD OF SHEAR WAVE ULTRASONIC CLADDING SURVEILLANCE

9/29/75

alyen
G. Hughes

Changed	
2/14/77	2
9/28/77	3
6/28/78	4

PURPOSE: Ultrasonic surveillance procedure for periodically determining the extent and possible growth of clad cracking in designated areas of steam generator channel heads. The procedure includes the means to measure clad thickness as a baseline process and the fixturing necessary to duplicate the test program. periodically.

QUALIFICATION OF PERSONNEL: Personnel performing the examination under this procedure shall be qualified in accordance with ASNT-TC-1A, Supplement"C", Level II or III.

OPERATIONS:

Part I: Clad Measurement:

1. Measure clad thickness in the approximate center of designated areas using the procedure detailed below (Ref. Automation Industries'report #TR-71-24A).
2. Record clad thickness determined in each area.
3. Clean and check clad surfaces in examination areas.

Equipment:

a) UM 775 instrument "Automation" (must fit through 18 inch manway).
b) 10N db. pulser/receiver.
c) Search unit fixture 57A6878.
   57A3615 SIZ transmitter search unit.
   57A2796 SIL receiver search unit.
d) Reference standard S/N 1.
e) Glycerine for couplant.

Calibration:

a) Turn on instrument and allow proper warm up.
b) Connect cables from transmitter and receiver search units in fixture 57A6878 to their respective jacks on the 10N db. pulser/receiver
c) Adjust the instrument controls to the following preliminary settings:

UM 775

1) Sweep Delay
   Push Button 5-50
   Vernier - Max. (ccw)
2) Sweep Range
   Push Button - 1
   Material Vernier - Mid Range
3) Vertical - Adjust to locate baseline at 0 vertical position
4) Altn. - Max. (ccw)
5) Rate - Max. (cw)
6) Horizontal - Adjust to center baseline on scope screen
7) Mode - Out

10N db

1) Sens. db control - 16
2) Reject - 1/4 cw
3) Test - Through
4) Pulse Tune - Max. (ccw)
5) Pulse Length - Min. (cw)
6) Freq. - 2.25 MH_z

d) Position transigate switch to "Off".
e) Apply couplant (glycerine/water mix) to reference block, place inspection fixture on reference block and locate signal from block front surface.
f) Position front surface signal near left side of Reflectoscope screen and mark location on screen with grease pencil.
g) Manipulate fixture and adjust sensitivity db control as required until signal is obtained from reference hole A. Position front surface signal at mark obtained in (f) above, using sweep delay Vernier. Mark location of hole "A" signal on Reflectoscope screen with grease pencil.
h) Repeat step (g) for reference holes B, C and D, and mark the respective locations on the Reflectoscope screen. The reference marks from holes A-D represent cladding thickness of 0.20", 0.25", 0.30" and 0.35", respectively. See Figure 1 for typical CRT screen patterns.

Part II: Surveillance Procedure - 1/8 inch-1/2 inch range

Equipment:

a) UM 775 Reflectoscope (Automation)
b) 5N Weld Pulser/Receiver
c) Alarm and recording module (Transigate)
d) Westinghouse Immersion/contact search fixture 20° incident angle
e) 1.0 MH_z 1-1/8" dia., heavy backing, SIZ transducer, Style #57A3453
f) Scanning fixture (WTD)
g) X-Y Recorder
h) Clad Channel Head reference block with 3/4 in. long by 1/8 in., 1/4 in., 3/8 in., and .450 deep Elox notches.
i) Couplant: 2 parts glycerine, 1 part water, 4-5 drops wetting agent per pint.

Procedure:

1. Set "feet" on search unit fixture as follows:
   a) Place assembled "empty" search unit fixture on 0.040-0.045 inch thick shim on flat surface.
   b) Adjust feet to touch flat surface.
2. Fill fixture with water and pressurize so that approximately 75-80% of flexible bladder width touches flat surface on which four "feet" are resting.
3. Mount scanning fixture including search unit on reference block so that sound beam is projected perpendicular to notches.
4. Calibration
   a. Direct sound beam at center of 3/8 inch deep Elox notch (position is marked on scanning fixture) and adjust instrument to obtain an 80-90% of full linear screen height (FSH) response.
   b. Set search unit in line with 1/4 inch and 1/8 inch deep notches (positions are marked on scanning fixture) and note responses--should be approximately 25%-30% (FSH) difference between successive notches.

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G. Hughes

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2/14/77	2
9/28/77	3
6/28/78	4

c. Set recording gate "start" at peak of 1/8 inch notch indication minus 1 inch of test metal distance. Set recording gate "END" at peak point of 1/8 inch notch indication plus 3/4 inch of test metal distance.

d. Connect data potentiometer of scanner (5 inch scan length) to Y coordinate of X-Y recorder. Connect amplitude response to X coordinate of X-Y recorder.

e. Record calibration by scanning across reference notches to record maximum responses and locations from reference notches. Set pen manually to duplicate scan spacings.

5. Place scanner on selected area of channel head. Set search unit on left hand edge of area to be scanned. Move search unit to top of scan (5") and return to bottom of scan length. Move search unit 3/4" to right, move pen on recorder 3/4" and repeat 5" scan. Repeat process at 3/4" increments until specified width (circumferential direction on channel head) of selected area has been traversed.

6. Maintain records for comparison with periodic in-service recordings made in the same manner as described.

7. Clean and identify areas.

8. Follow the same procedure for each exam area by placing the scanning fixture "feet" in positioning holes for each area.

9. Record U.T. results for each area scanned on channel head.

10. Maintain records for comparison with periodic in-service recordings made in the same manner as described.

Part III: Surveillance Procedure - 3/8 inch-3/4 inch range

Equipment:

a) UM 775 Reflectoscope (Automation)
b) 5N Weld Pulser/Receiver
c) Alarm and recording module (Transigate)
d) Westinghouse Immersion/contact search fixture $16^{\circ} + 1^{\circ} -0^{\circ}$ incident angle.
e) 1.0 MHz 1-1/8" dia., heavy backing, SIZ transducer, Style #57A3453
f) Scanning fixture (WTD)
g) X-Y Recorder
h) Clad Channel Head reference block with 3/4 in. long by 1/2", 5/8", and 3/4" deep Elox notches.
i) Couplant: 2 parts glycerine, 1 part water, 4-5 drops wetting agent per pint

Changed	
2	2/14/77
3	9/23/77
4	6/28/78

Procedure:

1. Set "feet" on search unit fixture as follows:

   a) Place assembled "empty" search unit fixture on 0.040-0.045 inch thick shim on flat surface.
   b) Adjust feet to touch flat surface.

2. Fill fixture with water and pressurize so that approximately 75-80% of flexible bladder width touches flat surface on which four "feet" are resting.

3. Mount scanning fixture including search unit on reference block so that sound beam is projected perpendicular to nothces.

4. Calibration

   a. Direct sound beam at center of 3/8 inch deep Elox notch (position is marked on scanning fixture) and adjust instrument to obtain an 80-90% of full linear screen height (FSH) response.

   b. Set search unit in line with 1/4 inch and 1/8 inch deep notches (positions are marked on scanning fixture) and note responses--should be approximately 25%-30% (FSH) differences between successive notches.

   c. Set recording gate "start" at peak of 1/8 inch notch indication minus 1 inch of test metal distance. Set recording gate "END" at peak point of 1/8 inch notch indication plus 3/4 inch of test metal distance.

   d. Connect data potentiometer of scanner (5 inch scan length) to Y coordinate of X-Y recorder. Connect amplitude response to X coordinate of X-Y recorder.

   e. Record calibration by scanning across reference notches to record maximum responses and locations from reference notches. Set pen manually to duplicate scan spacings.

   f. Maintain calibration records for comparison with periodic in-service recordings.

5. Place scanner on selected area of channel head. Set search unit on left hand edge of area to be scanned. Move search unit to top of scan (5") and return to bottom of scan length. Move search unit 3/4" to right, move pen on recorder 3/4" and repeat 5" scan. Repeat process at 3/4" increments until specified width (circumferential direction on channel head) of selected area has been traversed.

9/75

C. Galyen
G. Hughes

Changed	
2/14/77	2
9/28/77	3
6/28/78	4

6. Clean and identify area.

7. Follow the same procedure for each exam. area by placing the scanning fixture "feet" in positioning holes for each area to be examined.

8. Record U.T. results for each area scanned on channel head.

9. Maintain records for comparison with periodic in-service recordings made in the same manner as described.

APPENDIX C

TD-MET-77-110 (REVISED)

DEVELOPMENT OF IMPROVED ULTRASONIC TESTING TECHNIQUE FOR IN-SERVICE EXAMINATION OF CLADDING FLAWS IN STEAM GENERATOR CHANNEL HEADS

E. T. Hughes
February 1977
Revised
September 1977

APPENDIX C

DEVELOPMENT OF IMPROVED ULTRASONIC TESTING TECHNIQUE FOR IN-SERVICE EXAMINATION OF CLADDING FLAWS IN STEAM GENERATOR CHANNEL HEADS

Prepared By:

E. T. Hughes

February 7, 1977

Revised

September 23, 1977

REVIEWED BY:

L. K. Poole, Fellow Engineer
Materials Engineering

C. A. Galyen, N.D.E. Supervisor
Reliability

APPROVED BY:

E. P. Loch, Manager
Materials & Processes Eng.

SUMMARY

Experimental testing on notched test sections shows that crack depth definition for clad cracking surveillance purposes can be extended from the 3/8 inch limit to at least 3/4 inch. A 16° incident angle (37° shear in the material) technique produces an acceptable linear response from the 1/2, 5/8 and 3/4 inch deep notches in the channel head test section. A two (2) step procedure, one for the 1/8 - 3/8 inch depth range using a 20° incident angle, and another for the 1/2 - 3/4 inch range using a 16° incident angle, is proposed for the first-refueling-surveillance testing of the Indian Point #3 steam generator channel heads.

INTRODUCTION

The Materials Engineering Branch of the NRC, based on their review and evaluation[1] of the Consolidated Edison Report on Steam Generator Channel Head Cladding Surveillance has recommended revision of Section 10, "Proposed Action", of that report. The NRC recommendation was to continue development of the proposed technique to permit definition of deeper penetrations, i.e., deeper than the 3/8 inch proposed in the Con. Ed. report, of clad cracks into the base metal and, to incorporate the results of the extended development into the procedure to be used in the first-refueling-surveillance-examination of the Indian Point #3 channel heads. Definition to a total depth of at least 3/4 inch was recommended to cover the 0.250 inch maximum clad thickness found to date plus the approximate 0.4 inch critical flaw depth calculated for the cast carbon steel base metal.

An experimental testing program, based on notches in representative SA-216 WCC channel head test sections, was prepared in response to the NRC request. Guidelines for this extended test program were the same as those established for the earlier test program.[3,4] The goal of the extended program was a linear response from 1/2, 5/8 and 3/4 inch deep notches with a 1/16 inch definition or resolution capability, achieved either by (1) extending the present surveillance procedure, (2) modification of the present procedure or (3) development of a new procedure.

The test program, the results obtained, the test parameters, and the procedures needed to extend crack depth definition beyond the 3/8 inch maximum to at least 3/4 inch are described in this report.

TEST PROGRAM

ELOX notches of 1/2, 5/8 and 3/4 inch depth by 3/4 inch long were added to one of the notched (1/8, 1/4, 3/8 and 0.45 inch deep) clad channel head reference block sections used in the initial, 1/8-3/8 inch, test program. The added notches, as in the earlier program, were located in the surveillance region, See Figure 1, of the reference block. The notches were oriented parallel to the cladding beads and perpendicular to the clad surface to simulate the critical crack orientation and predicted direction of possible growth.

The notched test sample was examined using immersion techniques so that sound beam angles, transducer sizes and configurations, test frequencies, mode of propagation, etc. could be independently varied as needed to define the required test parameters. The sound beam in all cases was directed toward the "top" edge of the tapered channel head reference section, perpendicular to the

3/4 inch length of the notches to duplicate the scanning direction proposed for channel head surveillance purposes.

The experimental scanning of the notched test sample was conducted first using the 20° incident angle procedure[4] prescribed and successfully applied in the baseline examination of the IPP #3 channel heads. When a satisfactory linear response could not be achieved from the 1/2, 5/8, and 3/4 inch notches, the sample section was scanned using several beam angles above and below the incident 20° setting. The incident beam angles and the resulting refracted shear wave angles in the channel head material are listed in the following table.

Incident Angle (Through Water)	Refracted Angle (In Material)
*20°	48°
21°	51°
23°	58°
19°	45°
17°	39°
16°	37°
15°	34°

*The angle prescribed for the 1/8-3/8 inch range of depths.

The results of the scanning conducted at the various incident angles are shown in the amplitude vs. notch depth plots in Figure 2. This method of presenting the test data shows in graphic fashion the response linearity attainable at each test angle and the interpolation or resolution available between the 1/8 inch notch depth increments. The amplitude values shown in the plotted results represent a general average of several (5 to 7) separate scans conducted at each incident angle setting.

DISCUSSION

The experimental scanning of the notched test sample was conducted first using the 20° incident angle procedure to determine to what extent the proposed procedure could be used in defining crack depth beyond the present 3/8 inch limit. The 20° test results confirmed the linear response from the 1/8, 1/4 and 3/8 and the 1/16 inch minimum definition or resolution capability that were developed in the original test program. The 20° incident angle also produced a linear response from the 1/2, 5/8 and 3/4 inch deep notches, however, the increase in response amplitude per 1/8 inch increment of notch depth was not considered sufficient for surveillance purposes. The 5% of screen height change per 1/8 inch increment of notch depth is less than the expected reading and instrument error of the test system; 12-15% of screen height is the smallest definable change in amplitude considered reliable for the proposed test system.

The test results show that a 16° incident angle with the same test parameters recommended for the 20° incident angle testing, will provide a linear response from the 1/2, 5/8, and 3/4 inch notches with a 1/16 inch minimum definition or resolution capability. A 16° NPT-61 flexible membrane "immersion/contact fixture" was mocked up for trial on the channel head test sections. Plotting the 1.0 MH_z, 16° incident angle, 37° shear wave, "fixture" test results from the 1/2, 5/8 and 3/4 inch notches as shown in Figure 3 shows the linear response and depth definition capability of the 16° test system. The Amplitude/Notch Depth plot for the 20° incident angle, 48° shear wave procedure is included in Figure 3 to show the crack depth definition capability of the test system over the 1/8-3/8 inch and 1/2-3/4 inch ranges of notch depth.

The nonlinearity or inflection found in the 0.4-0.5 inch depth range for all of the incident angles investigated is a function of the 1/0 MHz wave length. This nonlinearity precludes depth definition within the 0.4-0.5 inch range. A lower and less sensitive test frequency, for example, 0.5 MHz, would shift the inflection to the critical 5/8 inch depth point; the inflection for 2.25 MHz occurs at approximately 0.25 inch.

CONCLUSIONS

1. The 1.0 MHz, 20° incident angle - 48° shear wave technique previously proposed[3,4] produces a sufficiently linear response from the 1/8, 1/4 and 3/8 inch notches in channel head test sections for surveillance purposes.
2. The 1.0 MHz, 16° incident angle - 37° shear wave technique described herein produces a sufficiently linear response from the 1/2, 5/8 and 3/4 inch notches in channel head test sections for surveillance purposes.
3. Notches exceeding 3/8 inch but less than 1/2 inch in depth can be indicated but definition within the 3/8-1/2 inch range is not available at the 1.0 MHz test frequency used.
4. A 1/16 inch change in notch depth in the 1/8-3/8 inch range and in the 1/2-3/4 inch range is the minimum definable change available.

RECOMMENDATIONS

It is recommended that:

(1) A two step surveillance program be developed for the selected areas of the IPP #3 steam generator channel heads for in-service monitoring of clad cracking. Apply Step I (NPT-61 Part II) which is the presently proposed

1.0 MHz 20° incident angle (48° shear) technique, to the selected areas for comparison with the baseline data obtained using the 20° incident angle technique and for monitoring growth through the 1/8-1/2 inch depth range. When change or growth approaching 3/8 inch is indicated, apply Step II, (NPT-61 Part III) which is the 1.0 MHz, 16° incident angle (37° shear) technique described in this report, to the affected areas for monitoring growth through the 3/8-3/4 inch range.

(2) The present procedure be modified to incorporate the 1/2-3/4 inch detection procedure.

(3) A 1.0 MHz, 16° +1° -0° incident angle flexible membrane immersion/contact search unit fixture be made up for use in the scanning or guidance fixture fabricated for the baseline and in-service surveillance program proposed for the IPP #3 steam generator channel heads.

BIBLIOGRAPHY

1. NRC Reference.

Plant Name - Indian Point #3.

Docket Number - 50-236

Report Title - Technical Report On Steam Generator Channel Head Cladding

Orig. Organization - Consolidated Edison Co.

2. MM-MPE-1872 "Proposed Program - Continued Development of Surveillance UT for Indian Point #3 Steam Generator Channel Heads".

3. TD-MET-75-080 "Evaluation of Cladding, Steam Generator Channel Heads, Consolidated Edison - Indian Point #3.

4. Supplement to TD-MET-75-080 "In-Service Examination Techniques For Surveillance of Cladding, Consolidated Edison IPP #3 Steam Generators".

APPENDIX D

PERSONNEL AND EQUIPMENT DOCUMENTS AND CERTIFICATIONS

Third In-Service Survellance of
Indian Point 3 Channel Head
Clad Cracking

WESTINGHOUSE ELECTRIC CORPORATION
WATER REACTOR DIVISIONS (WRD)

NDE CERTIFICATION CARD

DATE 9/15/80 SERIAL NO. 013

THIS CERTIFIES THAT Eugene T. Hughes
(Name)

HAS BEEN EXAMINED IN ACCORDANCE WITH CURRENT ASME CODE REQUIREMENTS (SNT-TC-1A) AND WRD PROCEDURES FOR THE FOLLOWING METHODS AND LEVELS.

Level III - RT:UT:MT; & PT
(Re-certification)

LIMITATIONS None EXP. DATE 9/15/83

E. T. Hughes 9/15/80 B. R. Johnson 9/15/80
Signature Date NDE Level III Date

FORM 552598 When (R) is shown, see Reverse Side

THIS CERTIFICATE WILL BE SURRENDERED WHEN: (A) LEAVING EMPLOYMENT OF ABOVE FACILITY, (B) TRANSFERRED TO POSITION WHERE THE CERTIFICATION IS NOT REQUIRED, (C) REFUSED RENEWAL OF CERTIFICATE AT PERIODICAL EXAMINATION, (D) WHEN CERTIFICATION IS REVOKED

ANNUAL RECORD OF EYE EXAMINATION

DATE EXAMINED	EXAMINED BY
8/14/80	A. A. Spritzer, M. D.
9/10/81	A. A. Spritzer, M.D.
3/15/82	A. A. Spritzer M.D.

* Restricted to those activities which include:
1. Witnessing or monitoring of specific NDE operations and/or techniques.
2. Auditing of approved NDE procedures for compliance.
3. Evaluation and/or interpretation of NDE results to applicable standards.

NUCLEAR ENERGY SERVICES, INC.

CERTIFICATION OF PERSONNEL QUALIFICATION

NAME Robert Lucas

CERTIFICATIONS

METHOD	LEVEL	DATE	EXAMINER LEVEL III	GEN.	SPEC.	PRAC.	COMP.	TNG. HRS.	RECERTIFICATION/RESTRICTIONS
UT	II	9/30/80	[signature]	90	97.5	90	92.25	80	None
				(.3)	(.3)	(.4)	(1.0)		

EXPERIENCE

FROM	TO	COMPANY	NDT METHODS & HIGHEST LEVEL ATTAINED
1960	Present	Nuclear Energy Services, Inc.	UT II

VERIFIED BY [signature]

In accordance with the NES, Inc. QA Manual 80A9021, NES Division Procedure 80A9068 and/or 80A9069 and the 1975 Edition of SNT-TC-1A.

"All historical information supplied by me to compile this certification is true and correct to the best of my knowledge".

[signature]
EXAMINEE

9/30/80
DATE

EDUCATION AND TRAINING (HIGHEST PUBLIC, ADVANCED AND NDT)

SCHOOL	LOCATION	DATE	LENGTH	SUBJECT
Danbury High	Danbury, CT	1959	4 yrs.	General
Sperry Schools	Danbury, CT	1967	40 hrs.	Ultrasonics
Sperry Schools	Danbury, CT	1969	40 hrs.	

EYE EXAMINATION REPORT

NAME: ROBERT LUCAS

NEAR ACUITY

(THE EXAMINEE IS REQUIRED TO PASS A JAEGER J-1 OR EQUIVALENT AT 16 INCHES)

	UNCORRECTED	CORRECTED (if applicable)
RIGHT EYE	J-4	J-1
LEFT EYE	J-3	J-1
BOTH	J-3	J-1

DISTANCE ACUITY

	UNCORRECTED	CORRECTED (if applicable)
RIGHT EYE	20/30-	20/20
LEFT EYE	20/20	20/20
BOTH	20/20	20/20

COLOR PERCEPTION

(THE EXAMINEE IS REQUIRED TO DISTINGUISH BETWEEN CONTRASTING COLORS)

TEST USED A.O HRR PSEUDOISOCHROMATIC COLOR TEST

PASSED ALL PLATES FAILED LIMITED

*PLEASE EXPLAIN THE DEGREE OF IMPAIRMENT (if any) _____

ARE CORRECTIVE LENSES REQUIRED? YES

FOR WHAT PURPOSE? (NEAR, DISTANCE, OR BOTH) BOTH

VISUAL FIELD DEFECT YES _____ NO X

SIGNED Harold C Pattinson TITLE M.D.

DATE 1/8/82

ULTRASONIC INSTRUMENT LINEARITY RECORD

ULTRASONIC INSTRUMENT

MODEL NO. UM 771 SERIAL NO. S/N 28

TRANSDUCER

BRAND AI FREQUENCY 2.25

BRAND FREQUENCY

CALIBRATION BLOCK

TYPE IIW SERIAL NO. N/A

SIZE 1/2 STRAIGHT BEAM (✓)

SIZE ANGLE BEAM ( )

Pulser/Receiver 2853-9
Alarm/Recording Module B5066-4

HORIZONTAL LINEARITY

BACK REFLECTOR	GRID LOC.	ACCEPT LIMITS
1	1	1
2	2	1.90-2.10
3	3	2.85-3.15
4	4	3.80-4.20
5	5	4.75-5.25
6	6	5.70-6.30
7	7	6.65-7.35
8	8	7.60-8.40
9	9	8.55-9.45
10	10	10

VERTICAL LINEARITY

SIGNAL AMPLITUDES IN % FSH

NO.	ACTUAL HIGHER SIGNAL	(CALCULATE) 1/2 OF HIGHER	(CALCULATE) ACCEPT. LIMITS*	ACTUAL LOWER SIGNAL
1	100	(50)	(45)-(55)	55
2	80	(40)	(35)-(45)	40
3	62	(31)	(36)-(26)	30
4	52	(26)	(31)-(21)	24
5	40	(20)	(25)-(15)	20
6	32	(16)	(21)-(11)	15
7	25	(12)	(17)-(8)	11
8	19	(9)	(14)-(4)	9
9	15	(7)	(12)-(2)	8
10	10	(5)	(10)-(0)	5

*ACCEPTANCE LIMITS ARE 1/2 OF THE HIGHER SIGNAL ± 5% FSH

AMPLITUDE CONTROL LINEARITY

INITIAL AMPLITUDE	db CHANGE	RESULT	LIMIT
80% FSH	DOWN 6	40	32% - 48%
80% FSH	DOWN 12	19	16% - 24%
40% FSH	UP 6	80	64% - 96%
20% FSH	UP 12	21	64% - 96%

THE INSTRUMENT IS CONSIDERED: ( ) ACCEPTABLE
( ) NOT ACCEPTABLE

SIGNED [illegible] LEVEL II DATE ~~10/7/82~~ 3/7/82 [illegible] 4/1/82

NUCLEAR ENERGY SERVICES, INC.

SEARCH UNIT ACOUSTICAL ANALYSIS

Frequency, Damping Factor, Beam Width/Dia., Focal Length, Beam Symmetry

SERIAL NO. C82575 PART NO. 57A3453 DATE 4/23/82

TYPE SIL ___ SIZ ✓ SIJ ___ SIQ ___ OTHER ___ LENS RADIUS FLAT

CRYSTAL TYPE LI_2SO_4 ___ QUARTZ ___ CERAMIC ✓ CRYSTAL SIZE 1.125"

FREQUENCY 1.0 ✓ 2.25 ___ 5.0 ___ 7.5 ___ 10.0 ___ 15.0 ___ 20 ___ 25.0 ___ OTHER ___
In MHZ

REFLECTORS Steel Ball 1.0" Steel Wire ___" Flat Glass Plate ✓ OTHER ___
A. PLATE B. BALL C. BALL D. ___ E. ___

DRIVER PULSE
Duration: 0.020 ✓ microseconds
0.025 ___ microseconds
0.0 ___ microseconds

AMPLITUDE
CRYSTAL OUTPUT 530 millivolts
140 Volts
Total Loop Gain -48.4 Db

CONNECTION CABLES

	Length	Type
Pulser to Crystal	4'	RG-62
Receiver to Scope	2'	RG-62

* NOTE: Water path as stated below is not always at the focal length. It is an operational setting.

TRACE

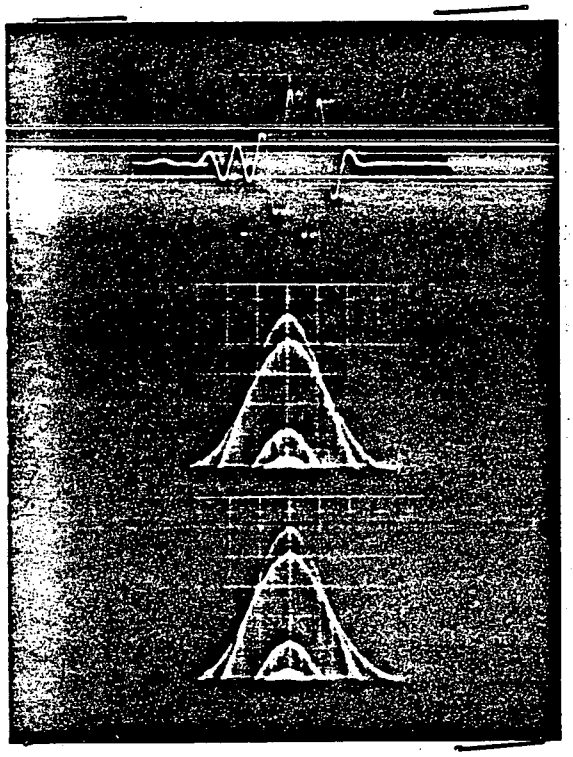
A.
1.0 mircoseconds
0.5 volts

B.
50 microsec/cm
0.1 volts/cm
.100 inch/div.

C.
50 microsec/cm
0.1 volts/cm
.100 inch/div.

D.
___ microsec/cm
___ volts/cm
___ inch/div.

E.
___ microsec/cm
___ volts/cm
___ inch/div.



Measured Frequency 1.0 MHZ
Trace A.

Focal Length ___ inches
*Water Path 5.4 inches
186 microsec water path
(round trip time)

Damping Factor 3.0
Trace A.

Beam Width or Dia. .200"
@3 Db Down Amp. Points
Trace B.

Beam Symmetry:
Length V.S. Amplitude
270°-90° ___
Trace ___
360°-180° ___
Trace ___
315°-135° ___
Trace ___
45°-225° ___
Trace ___

U.A. MODEL 5052UA
REP. RATE 1K
DAMPING 500
ENERGY 1
RCVR ATTEN(DB) 26
GAIN 40
H.P. FILTER OUT

Remarks: ___

Q.C.FORM 201
REVISED SEPT. 1980

AUTOMATION INDUSTRIES, INC.
SPERRY DIVISION
SHELTER ROCK ROAD
DANBURY, CONNECTICUT 06810 U.S.A.
(203) 746-3581

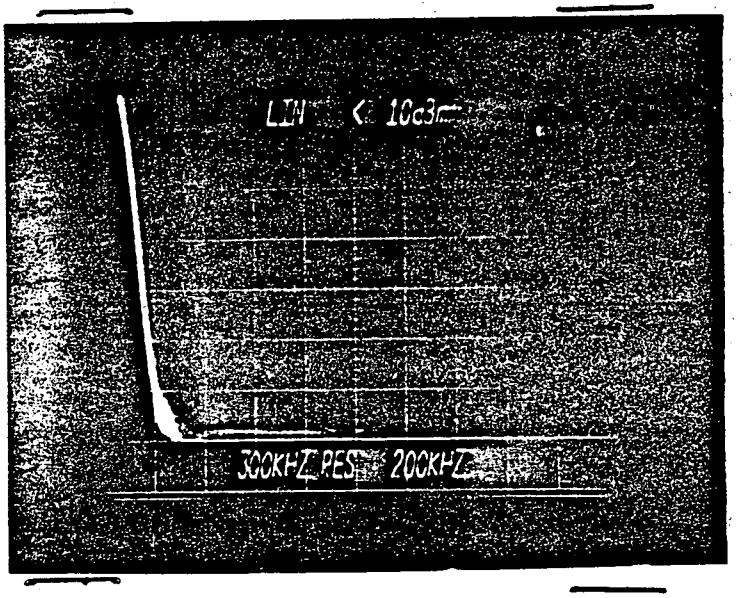
FREQUENCY SPECTRUM ANALYSIS

Center Frequency 1.0 MHz
Dispersion .2 MHz/cm
Vertical Display Mode-Linear

Excitation pulse
UA Model 5052 UA

Serial No. C82575

PART NO. 57A3453



RECEIVED SPECTRUM

Q.C. FORM 203A
REVISED SEPT. 1980

AUTOMATION INDUSTRIES, INC

APPENDIX E

X-Y RECORDINGS PRE-SERVICE, FIRST AND SECOND IN-SERVICE SURVEILLANCE EXAMINATIONS

SECOND IN-SERVICE SURVEILLANCE

X-Y RECORDINGS

STEAM GENERATOR #32

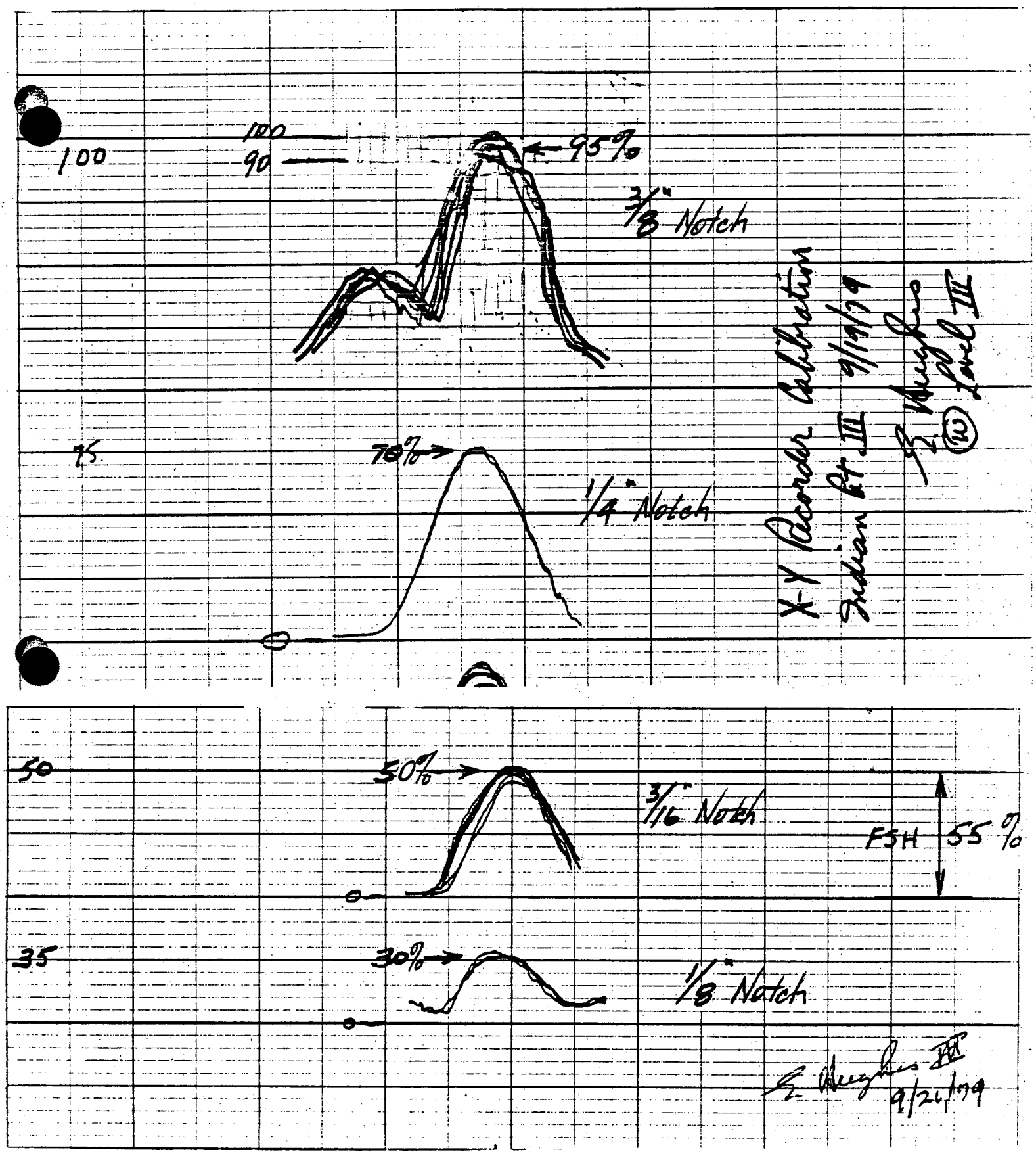


FIGURE 4 RECORDED X-Y CALIBRATION

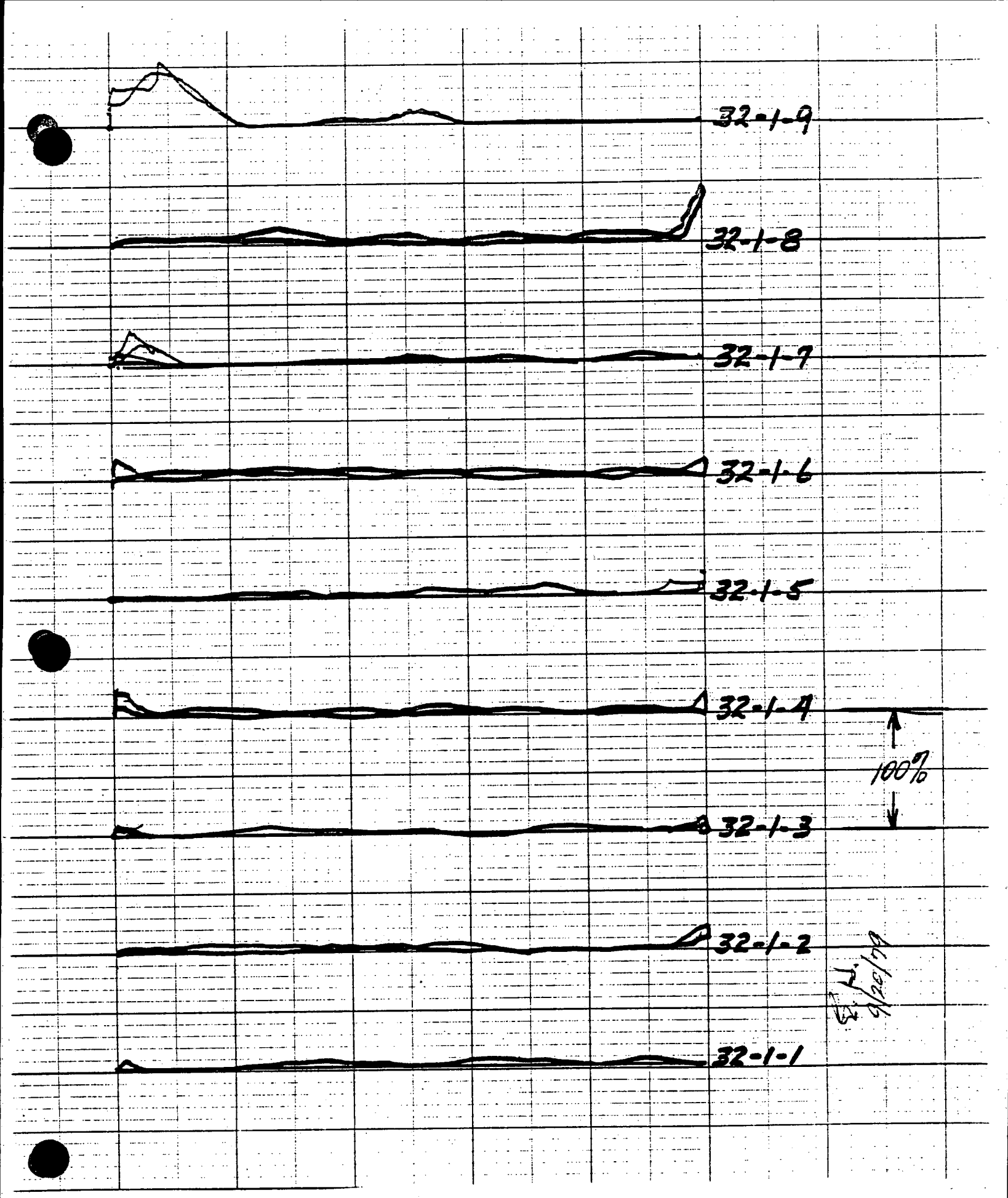


FIGURE (a X-Y RECORDINGS ST. GEN. 32 AREA 1

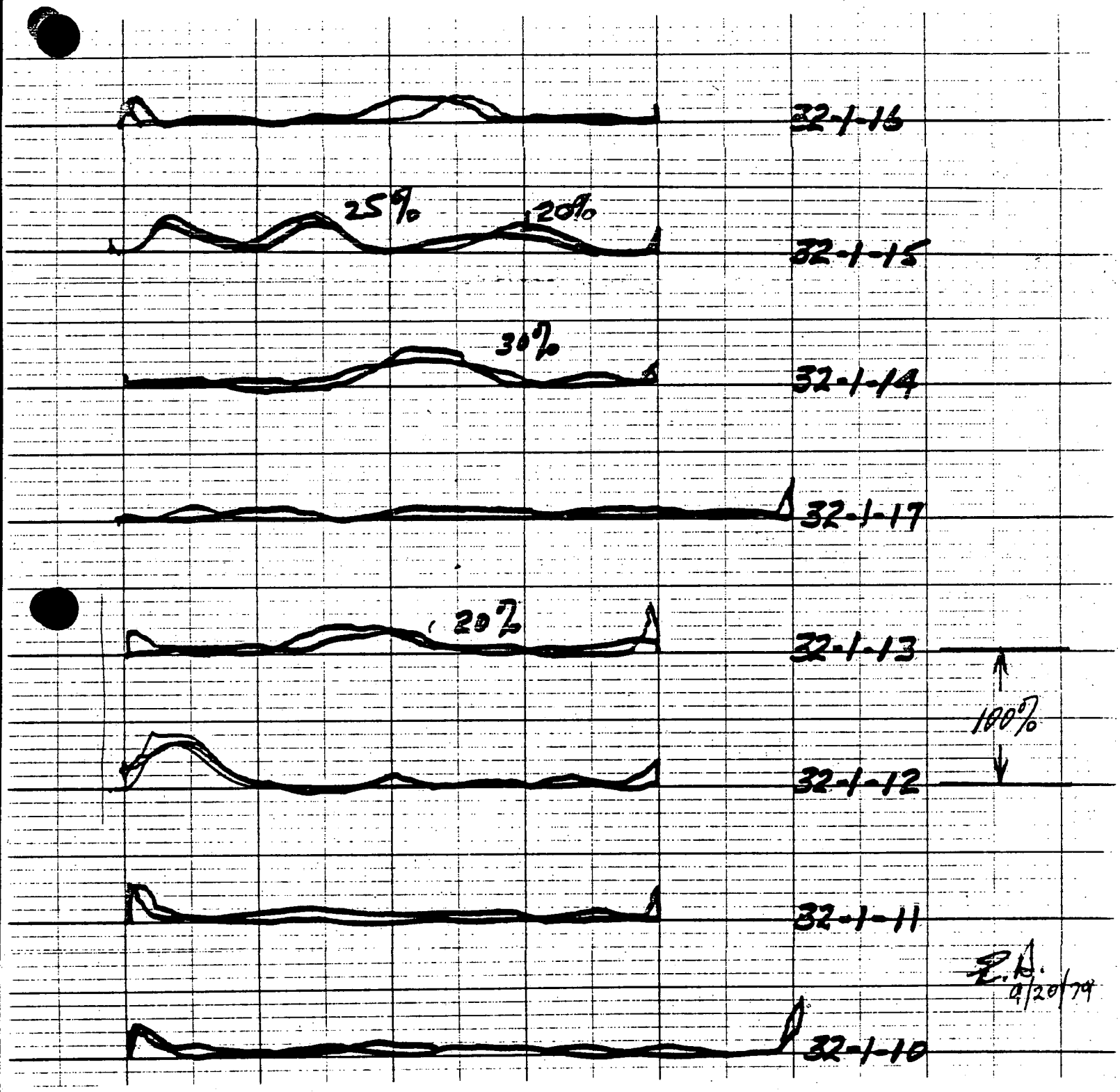


FIGURE 6b X-Y RECORDINGS ST. GEN. 32 AREA 1

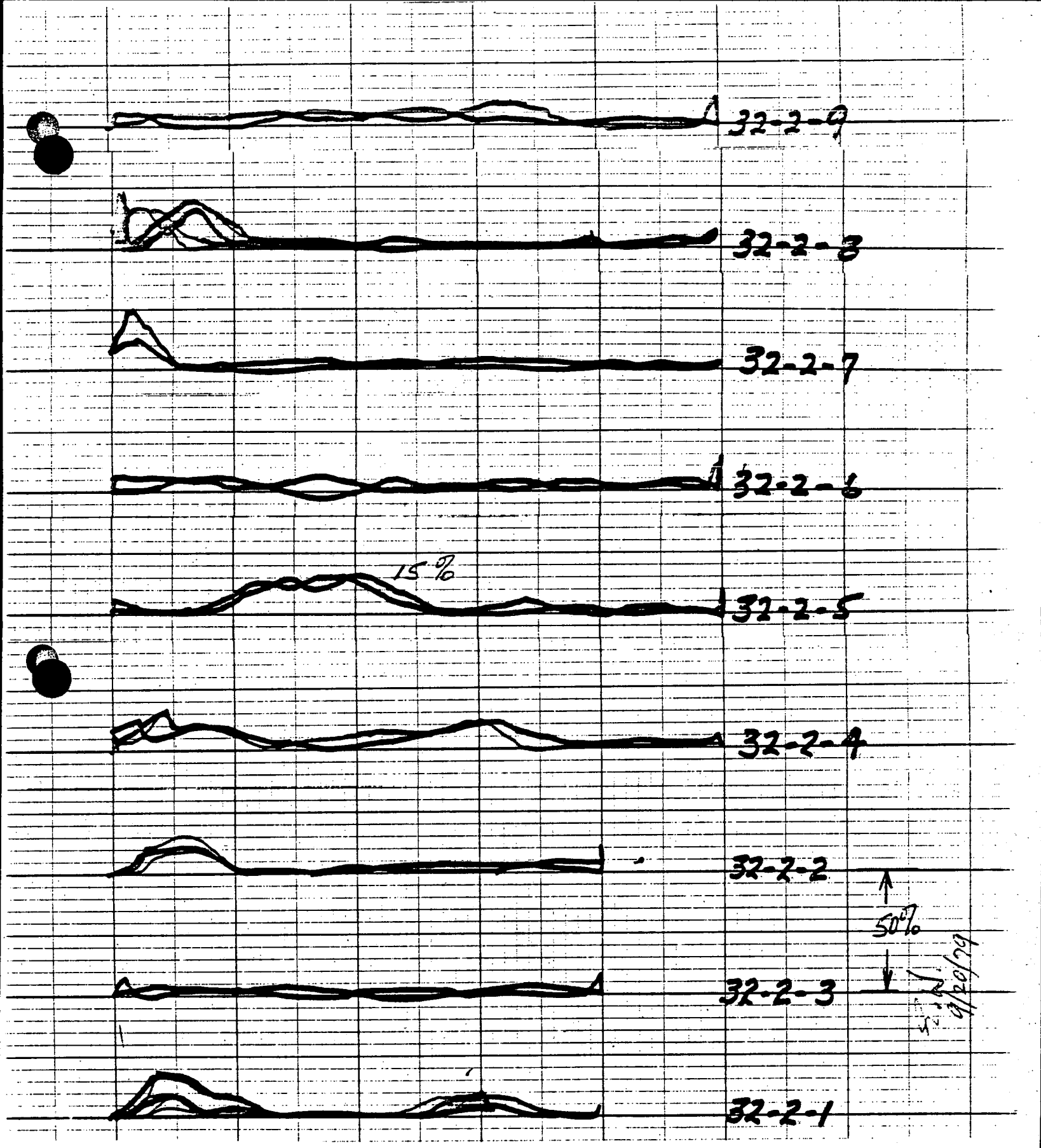


FIGURE 7a X-Y RECORDINGS ST. GEN. 32 AREA 2

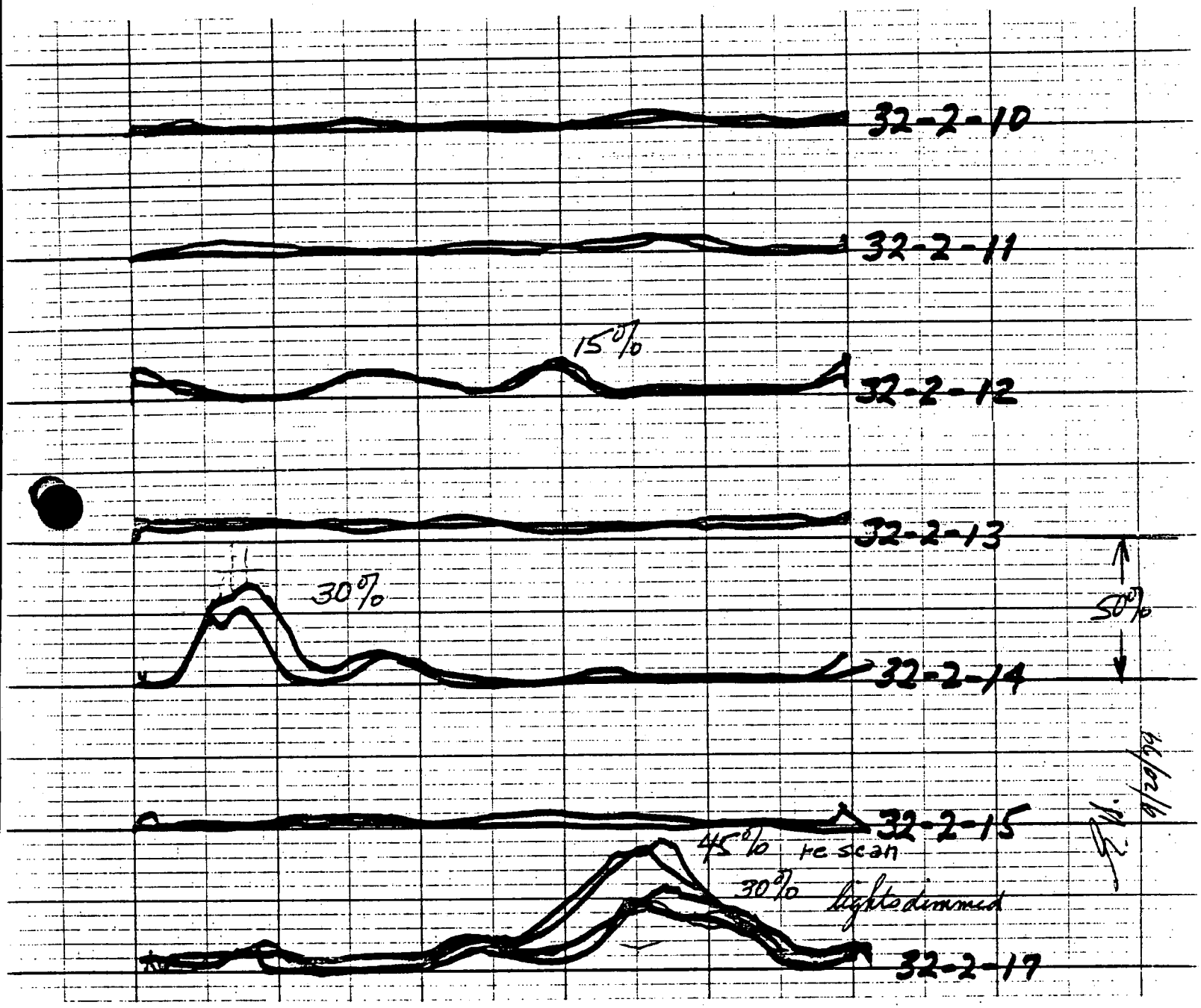


FIGURE 7b X-Y RECORDINGS ST. GEN. 32 AREA 2

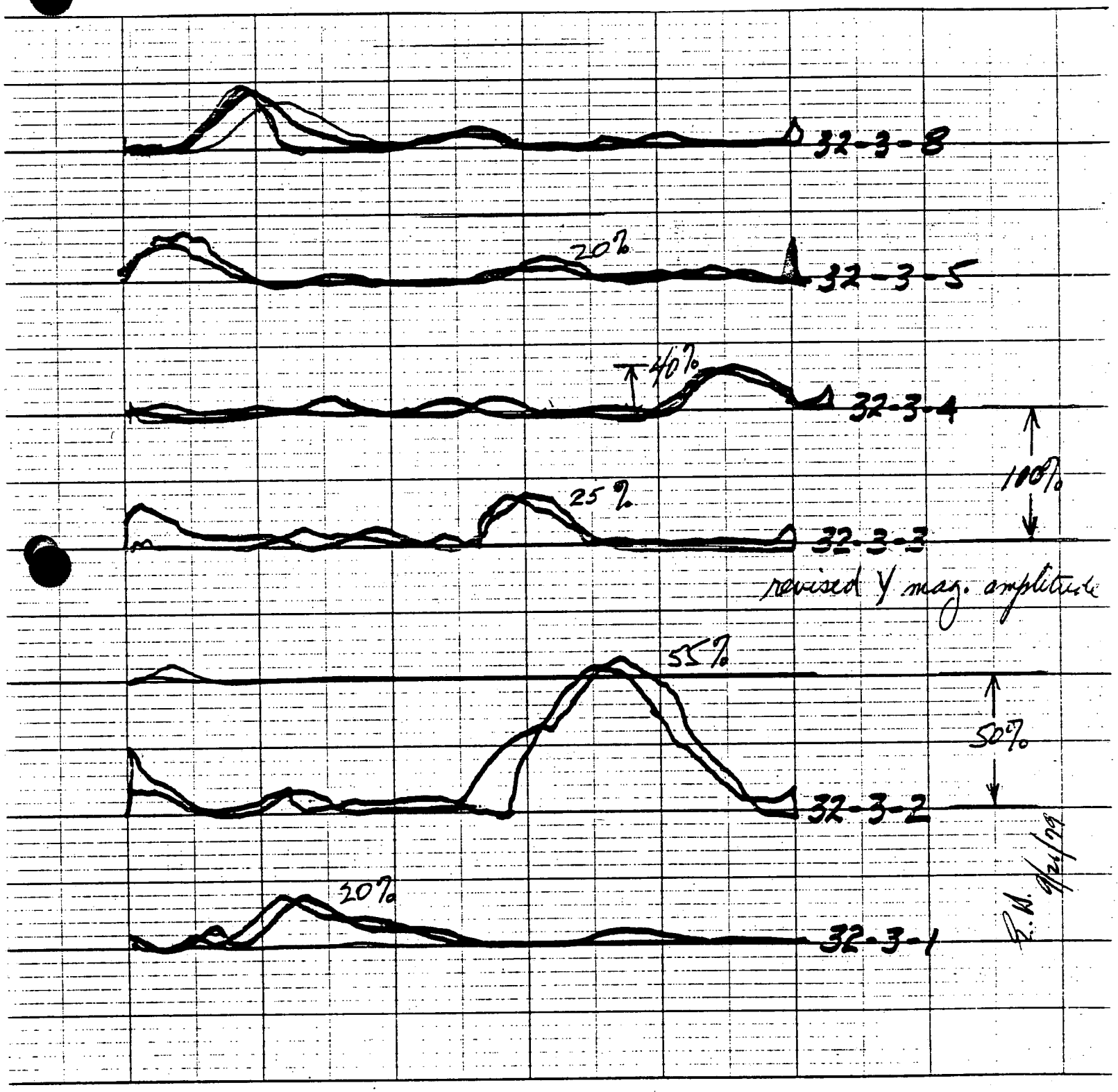


FIGURE 8a X-Y RECORDINGS ST. GEN. 32 AREA 3

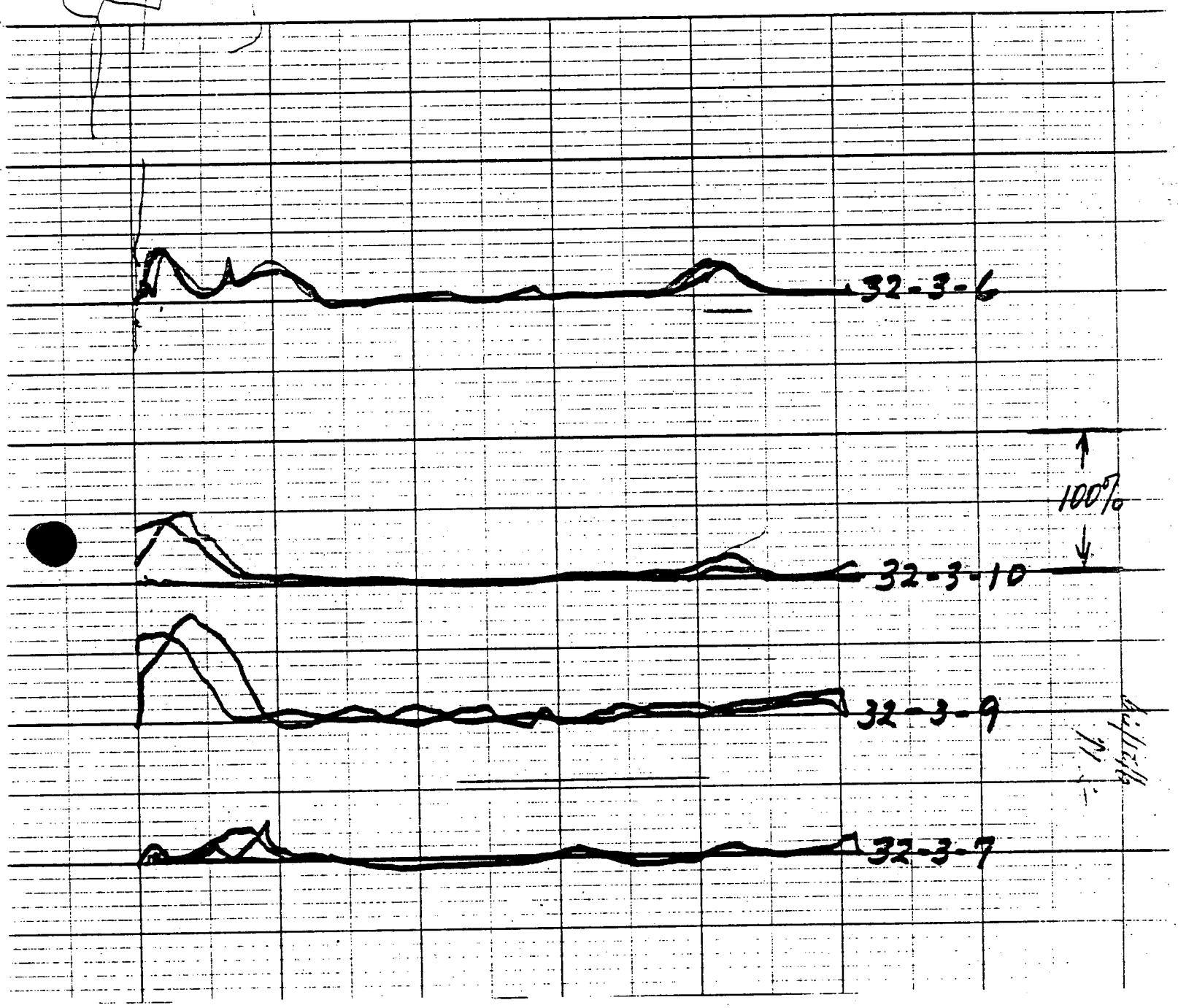


FIGURE 8b X-Y RECORDINGS ST. GEN. 32 AREA 3

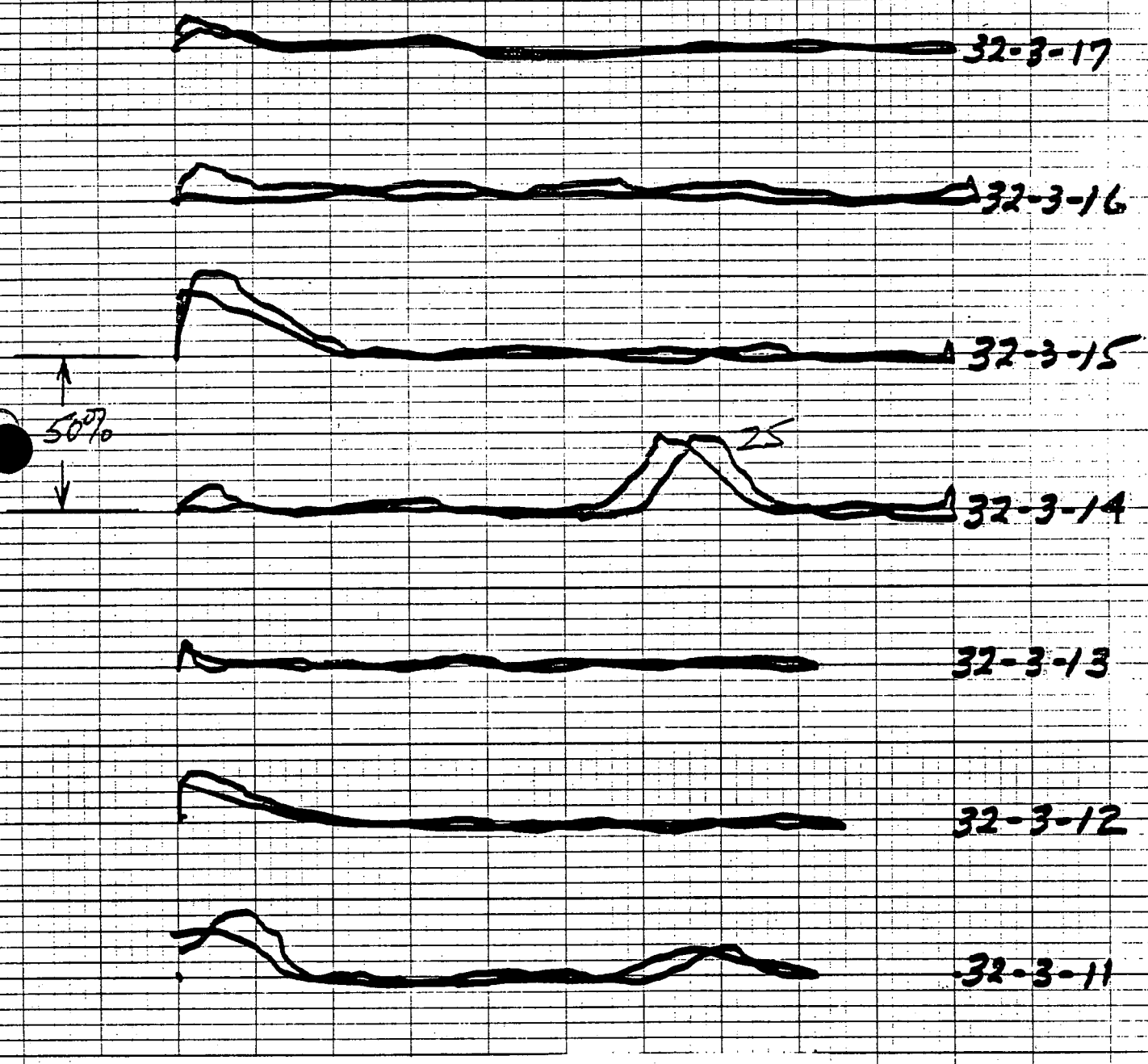


FIGURE 8c X-Y RECORDINGS ST. GEN 32 AREA 3

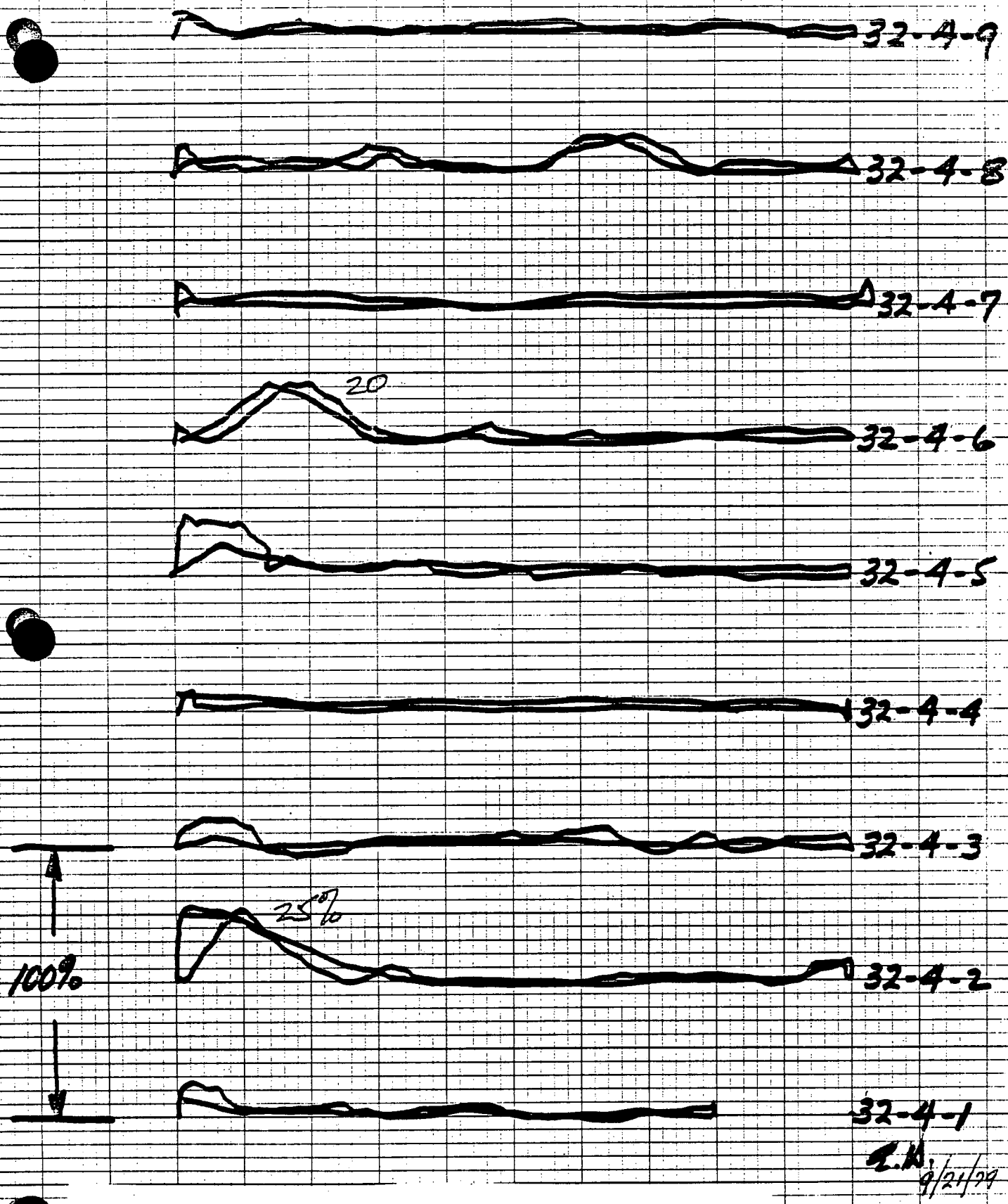
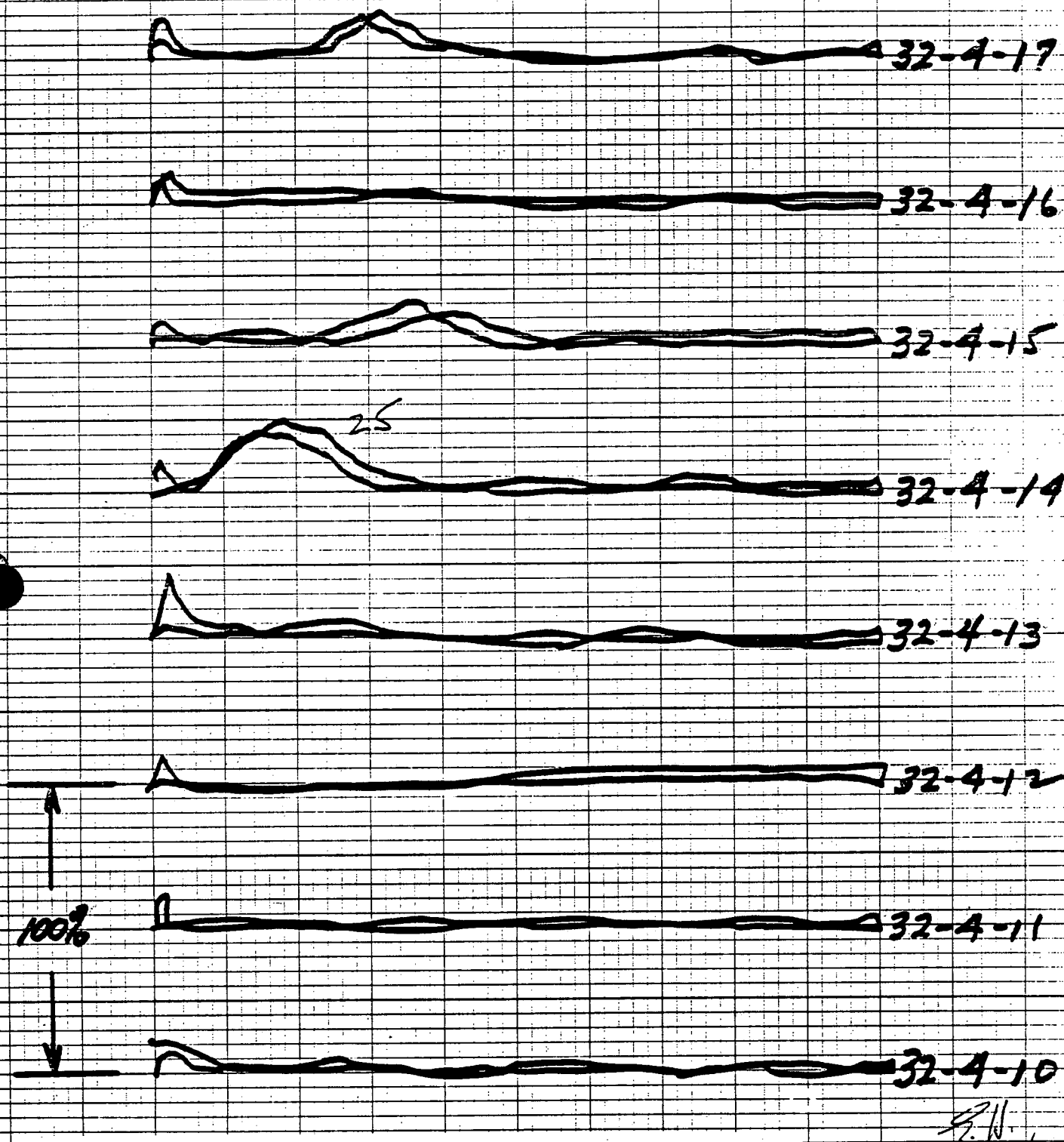


FIGURE 9a X-Y RECORDINGS ST. GEN. 32 AREA 4



S.W.
9/21/79

FIGURE 9b X-Y RECORDINGS ST. GEN. 32 AREA 4

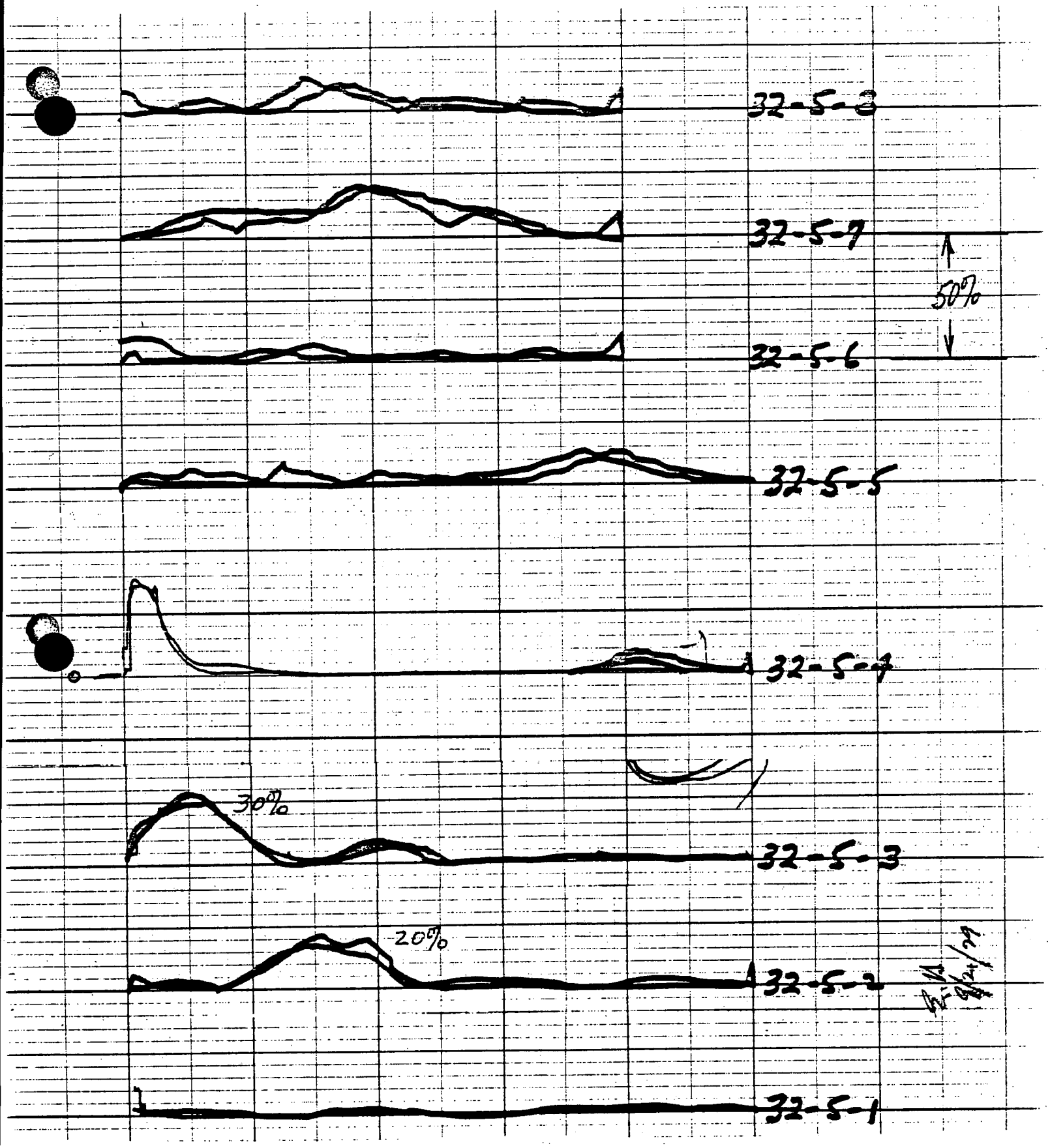


FIGURE 10a X-Y RECORDINGS ST. GEN. 32 AREA 5

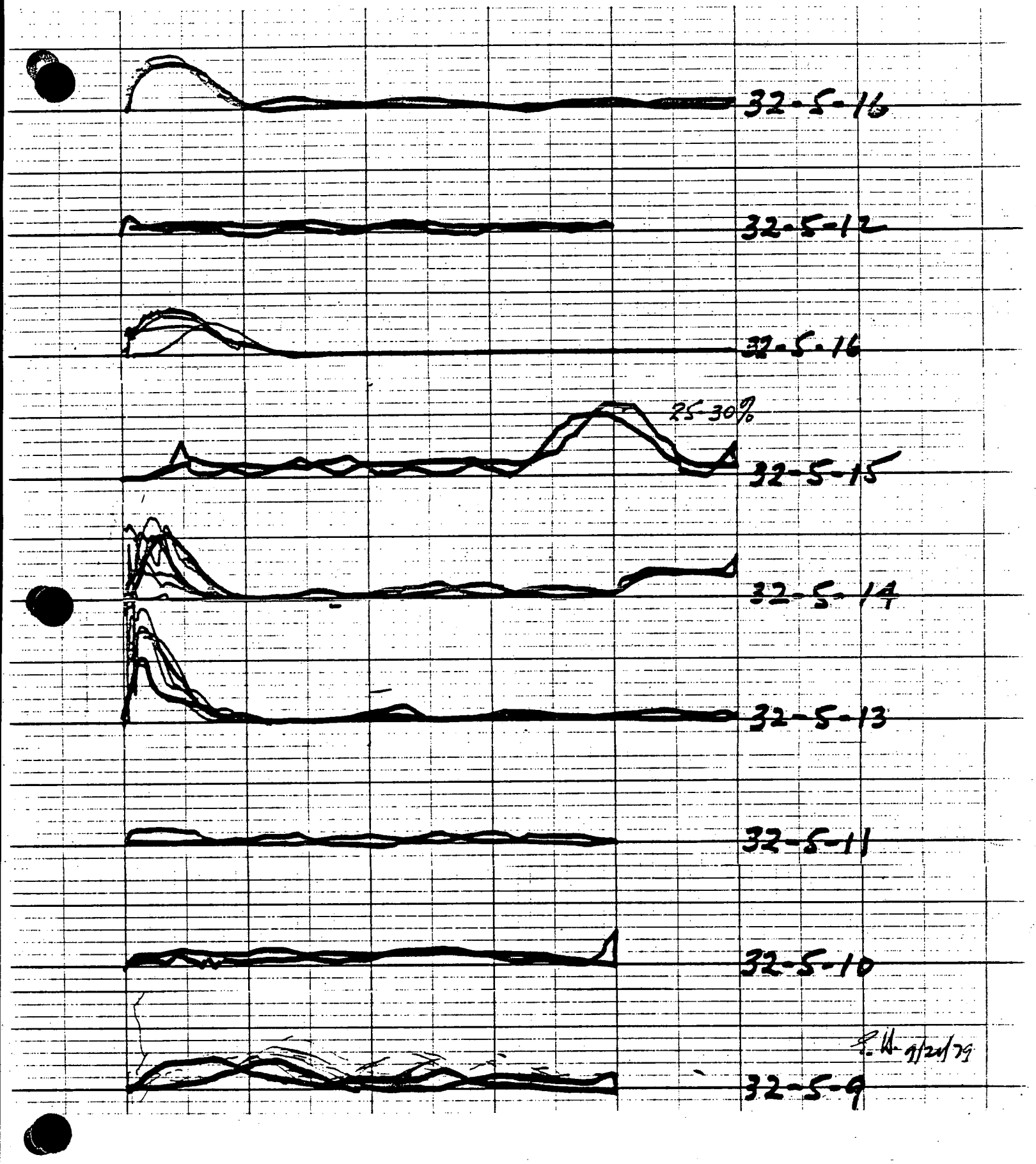


FIGURE 10b X-Y RECORDINGS ST. GEN. 32 AREA 5

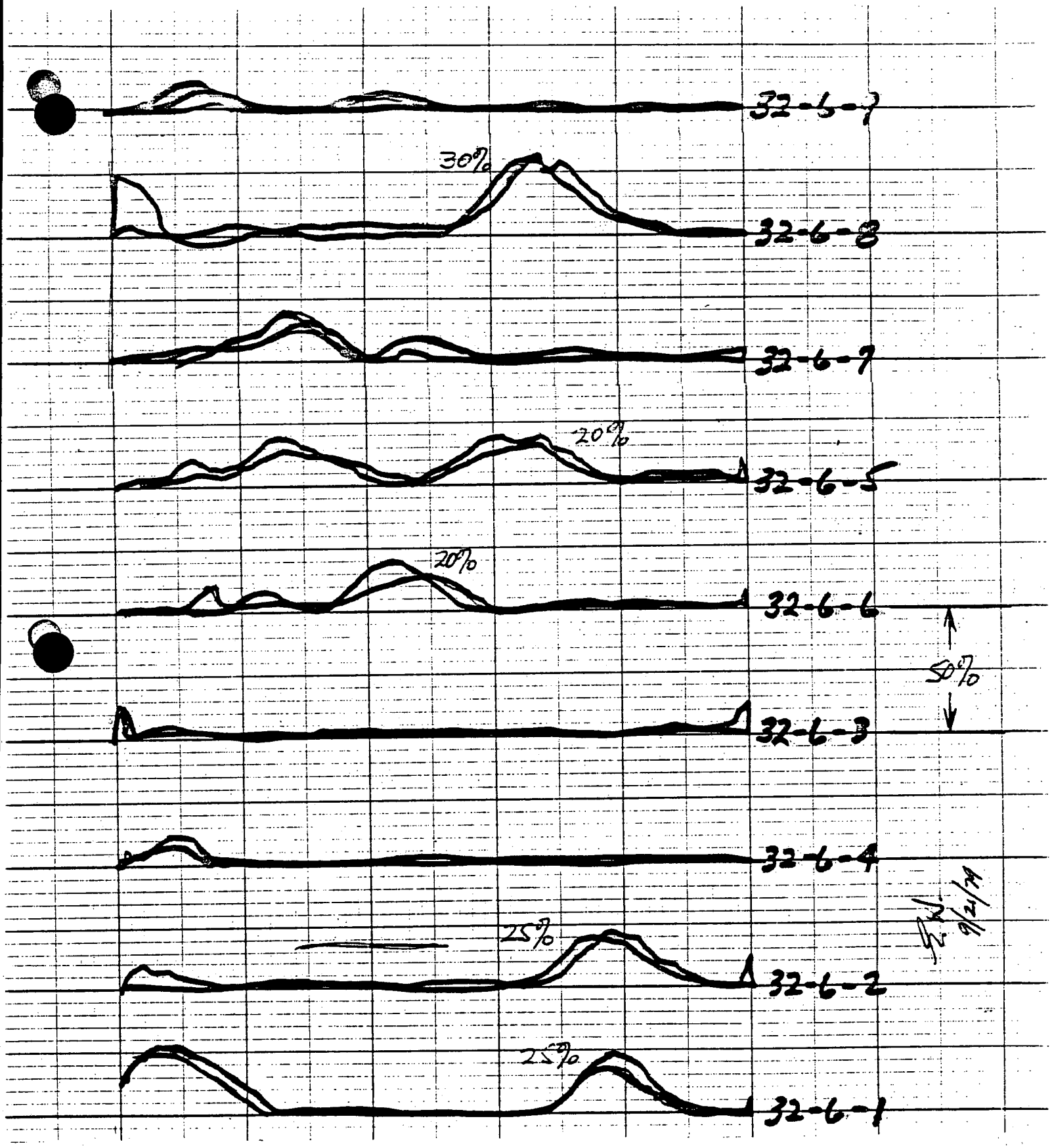


FIGURE 11a X-Y RECORDINGS ST. GEN. 32 AREA 6

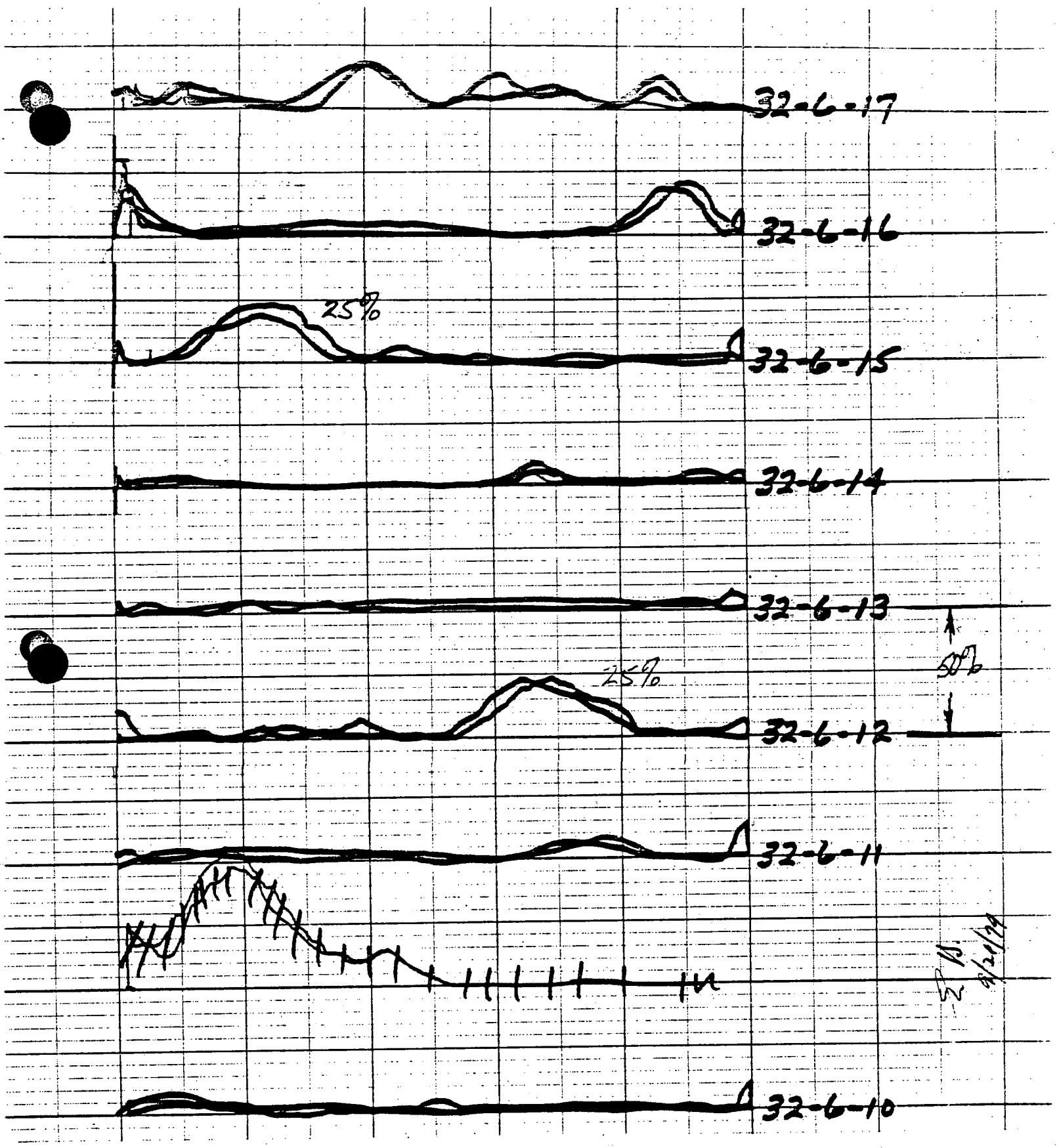


FIGURE 11b X-Y RECORDINGS ST. GEN. 32 AREA 6

FIRST IN-SERVICE SURVEILLANCE

X-Y RECORDINGS

STEAM GENERATOR #32

Calibration - Surveillance UT
Cladding Steam Generator 31, 32, 34
Channel Heads Indian Point #3
June 15, 1978

S. Hughes
Level III

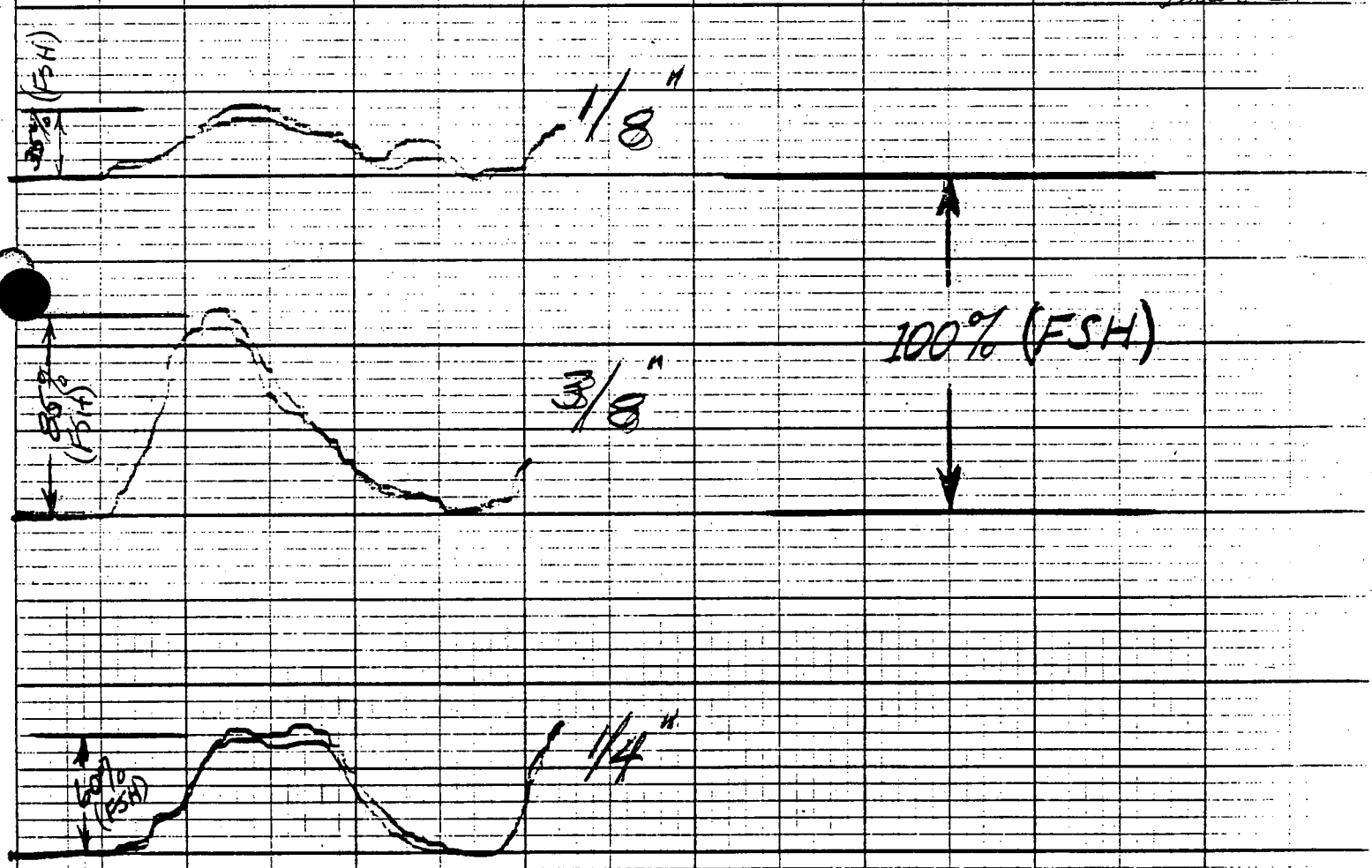


FIGURE 12 RECORDED X-Y CALIBRATION FIRST IN-SERVICE EXAM. IPP3

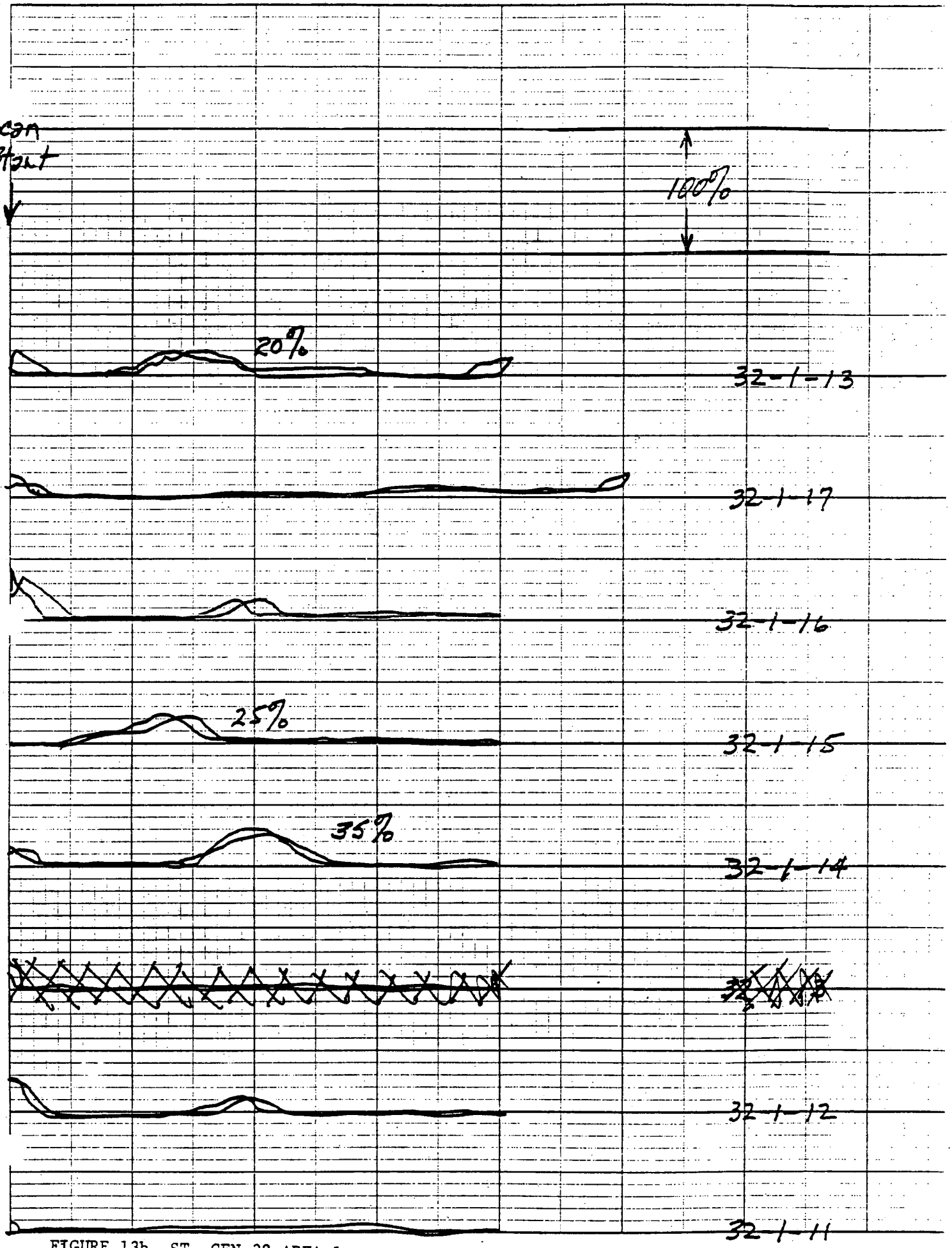


FIGURE 13b ST. GEN 32 AREA 1

G.W. 6/15/78

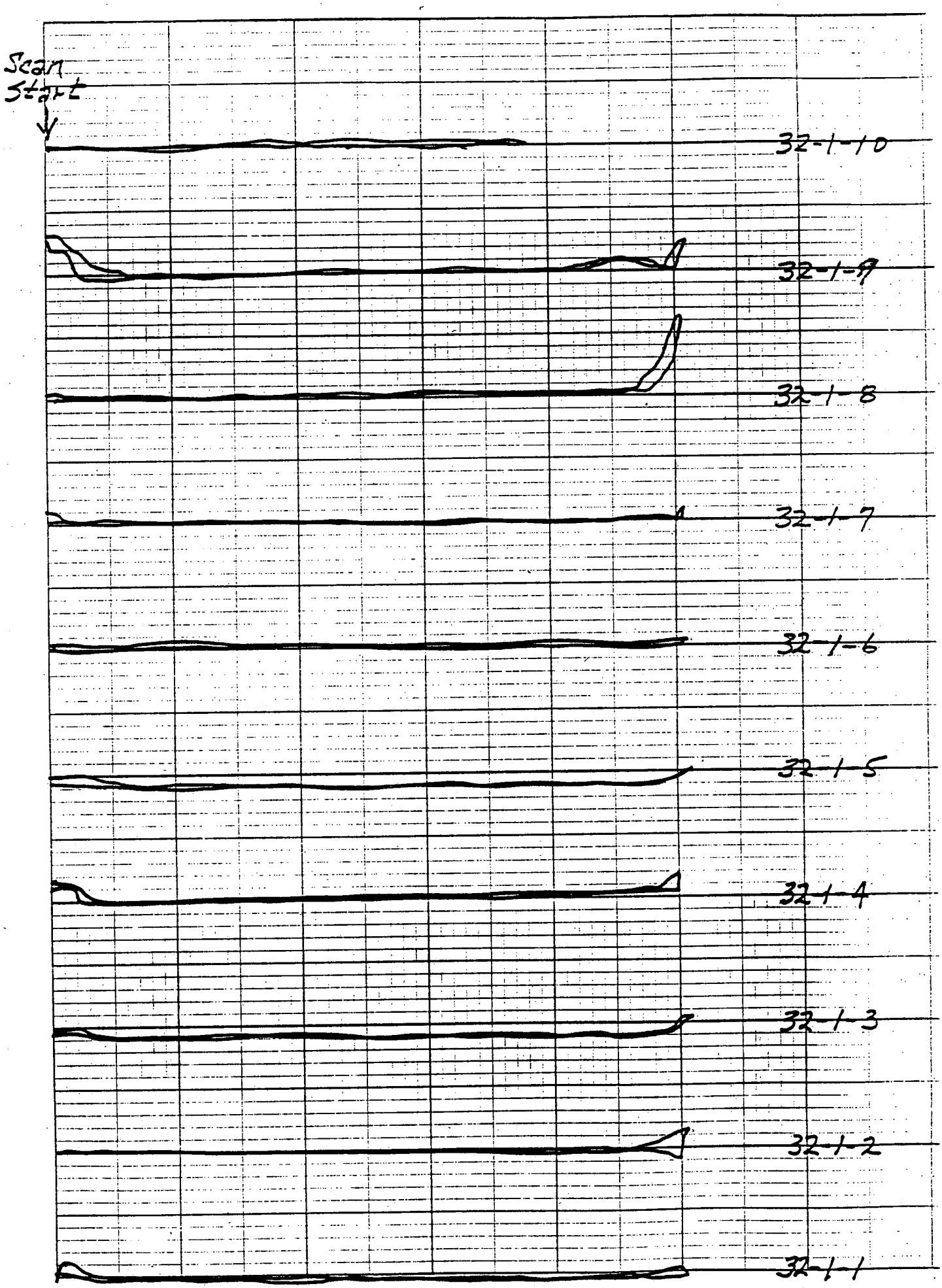


FIGURE 13a ST. GEN 32 AREA 1

R. A. 6/15/78

HEWLETT-PACKARD 9270-1005

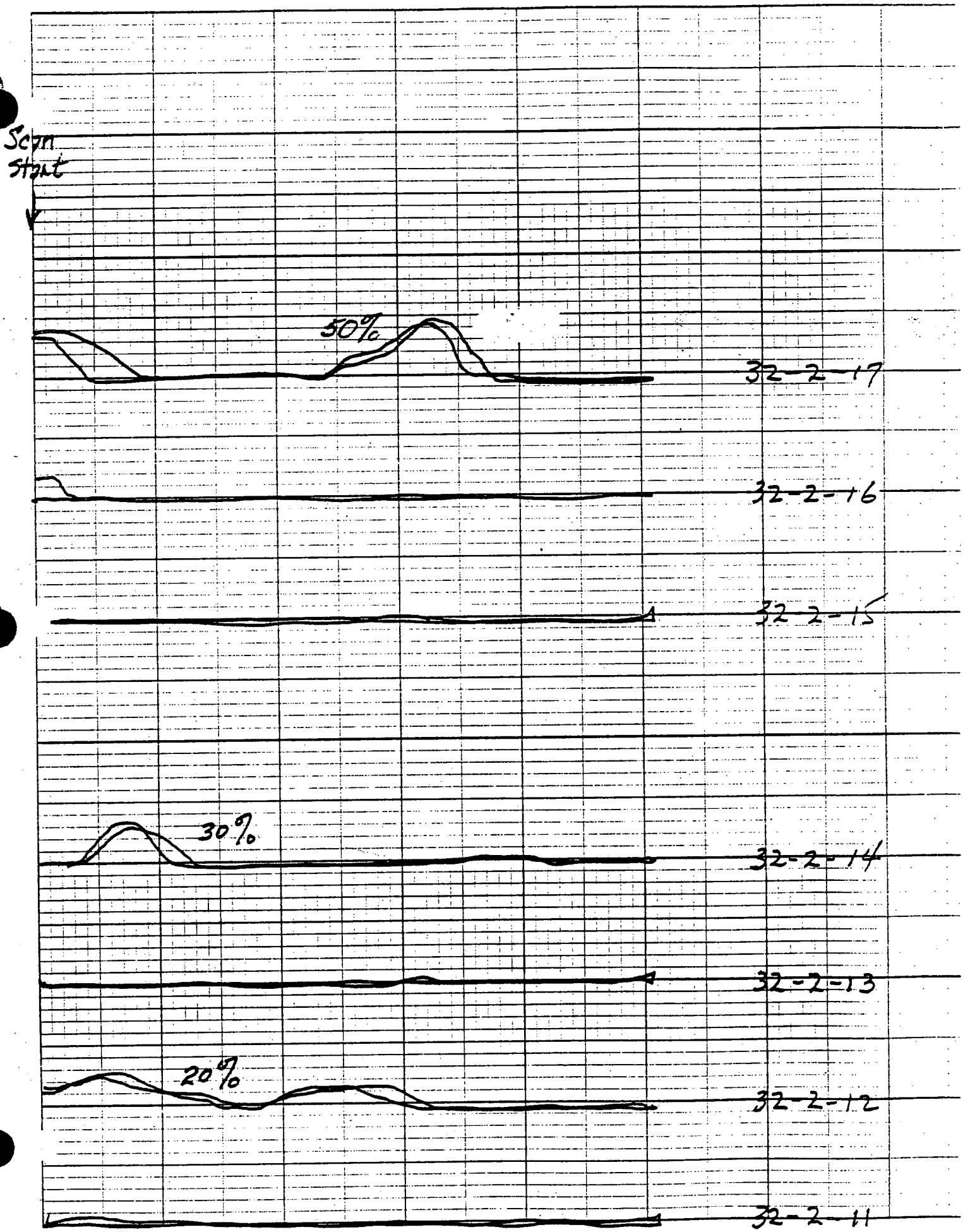


FIGURE 14b ST. GEN. 32 AREA 2

E. W. 6/15/78

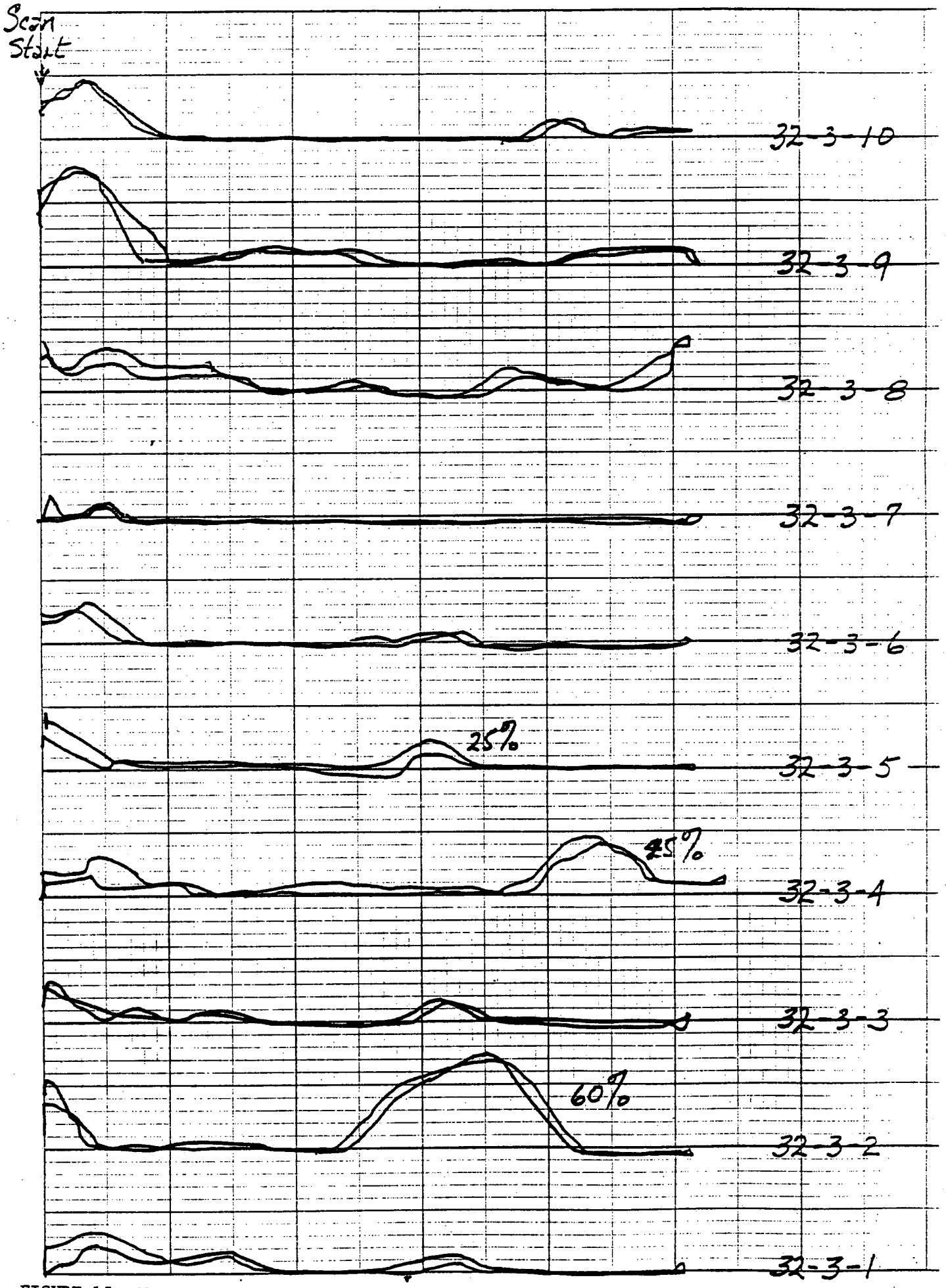


FIGURE 15a ST. GEN. 32 AREA 3

G. W. 6/15/78

HEWLETT-PACKARD 9270-1005

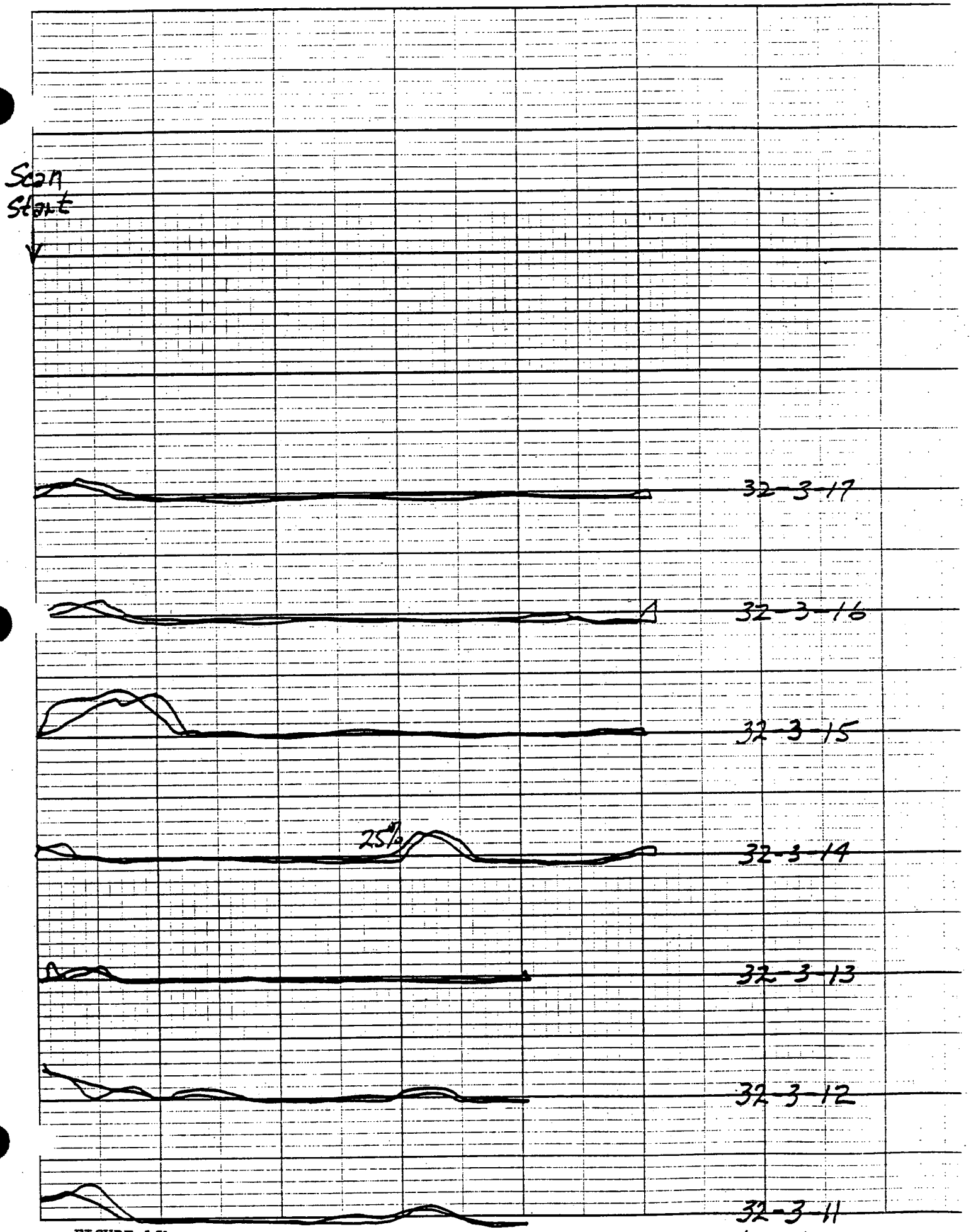


FIGURE 15b ST. GEN. 32 AREA 3

E. W. 6/15/78

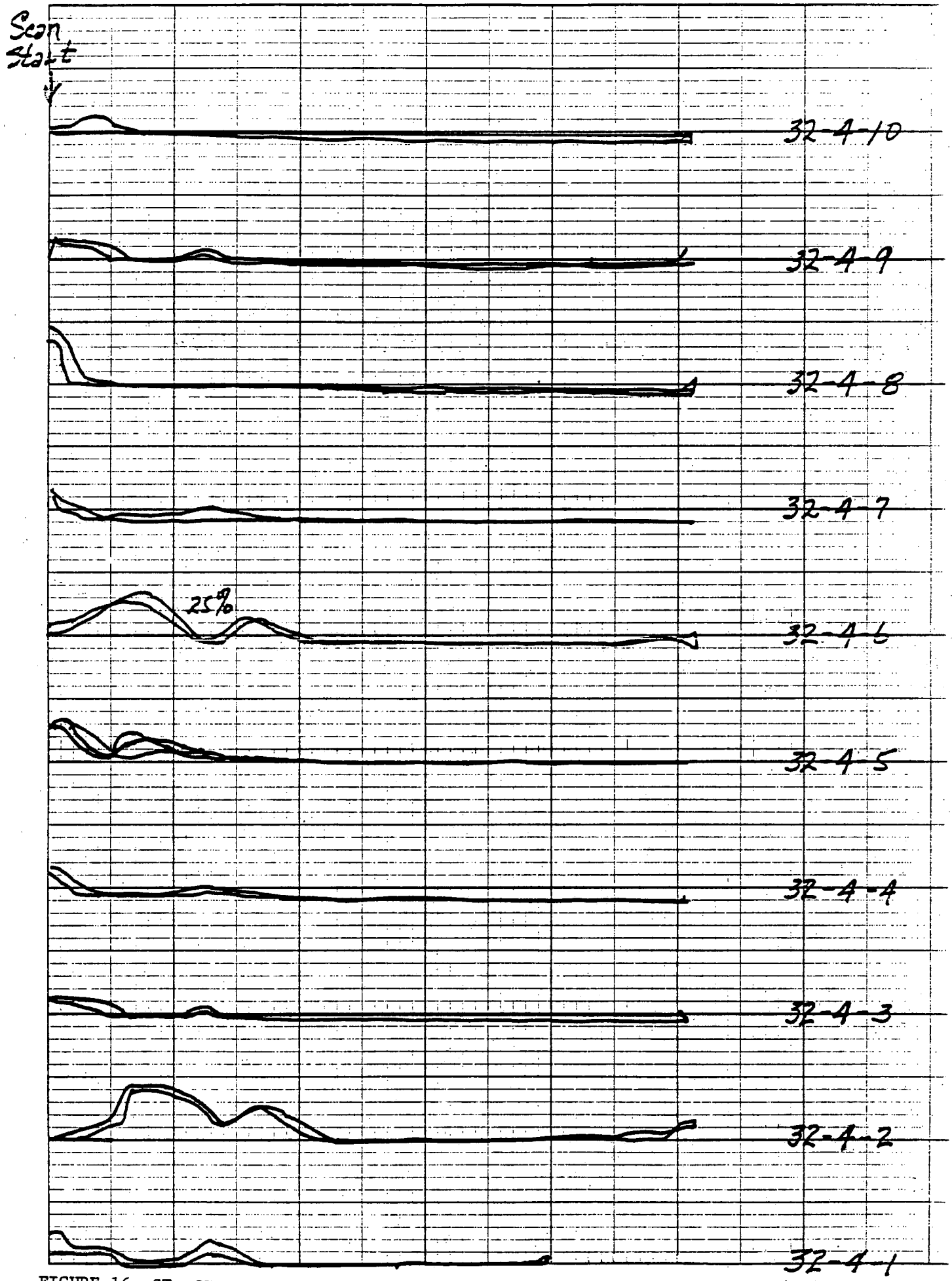


FIGURE 16a ST. GEN. 32 AREA 4

S. B. 6/15/78

HEWLETT-PACKARD 9270-1005

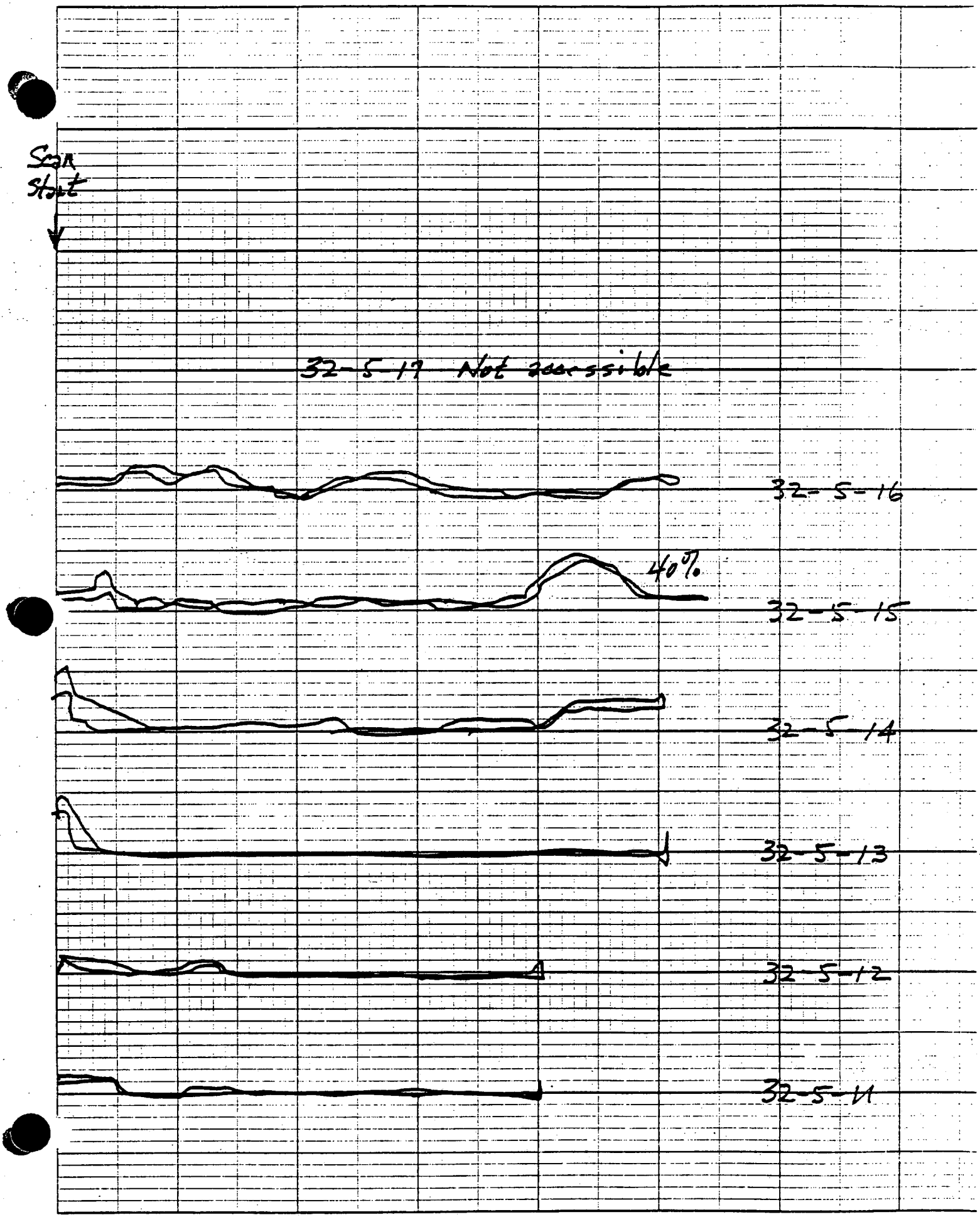


FIGURE 17b ST. GEN. 32 AREA 5

E.H. 6/15/78

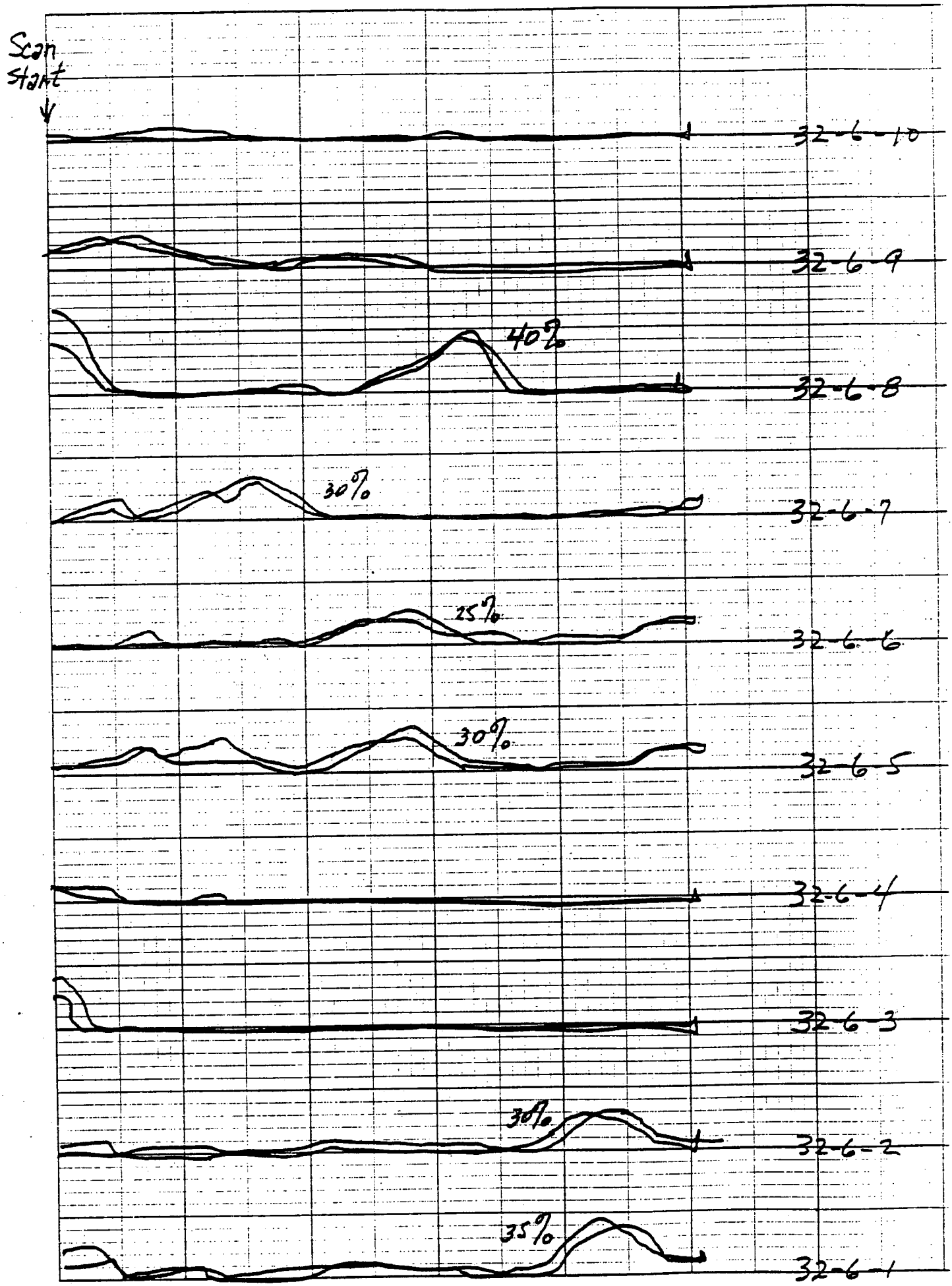


FIGURE 18a ST. GEN. 32 AREA 6

E. W. 6/15/78

HEWLETT-PACKARD 9270-1005

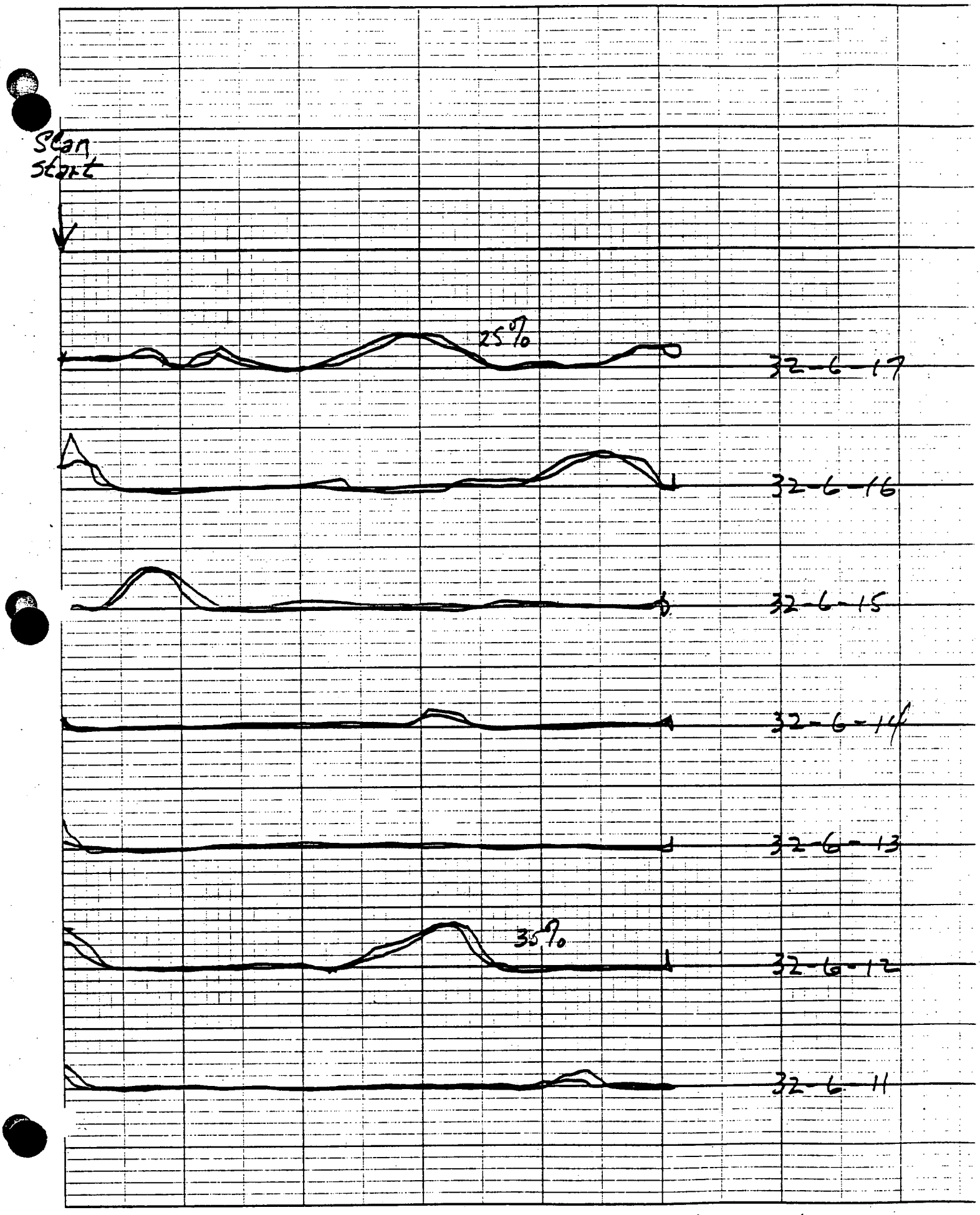


FIGURE 18b ST. GEN. 32 AREA 6

E.W. 6/15/78

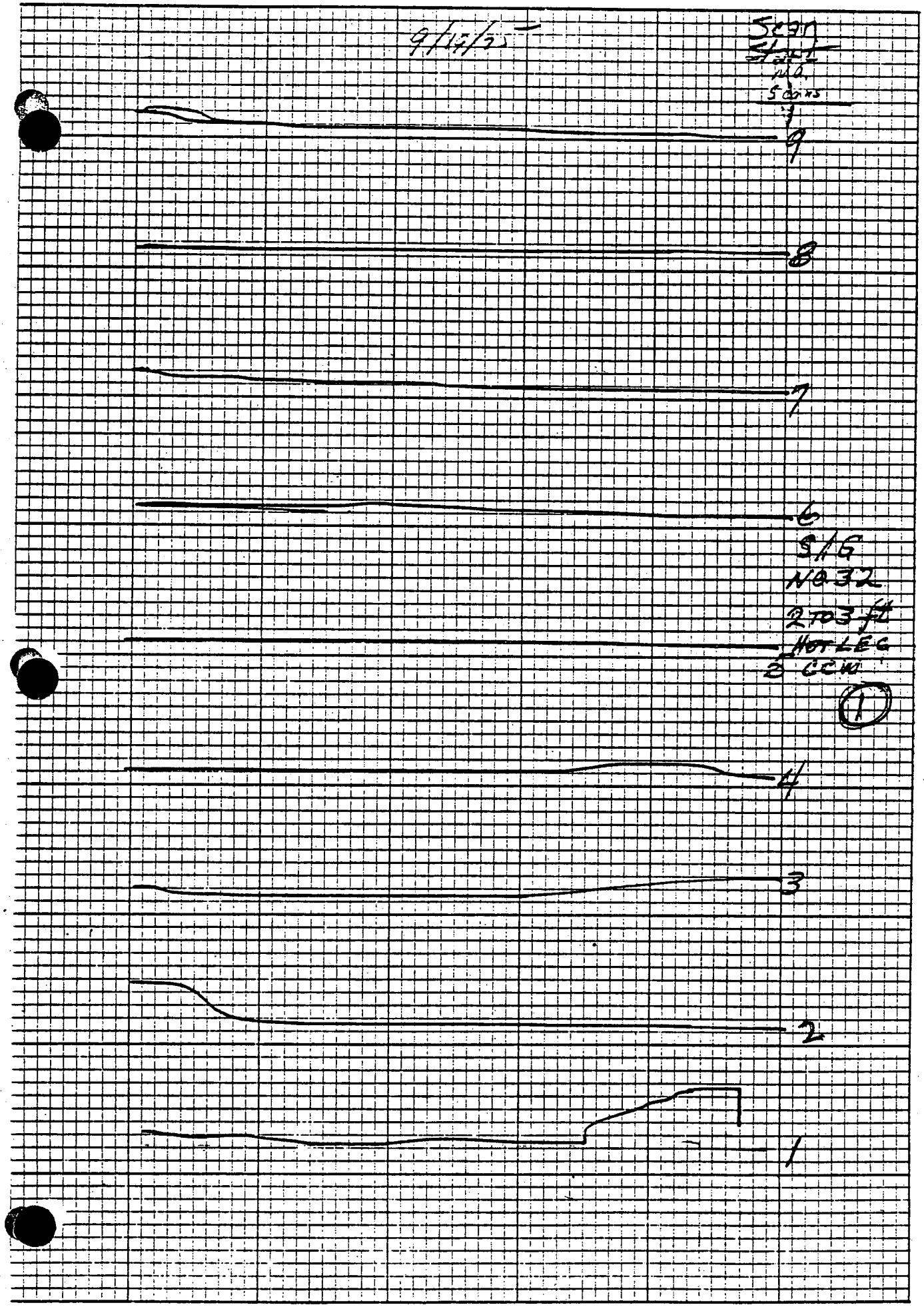
PRE-SERVICE OR BASELINE

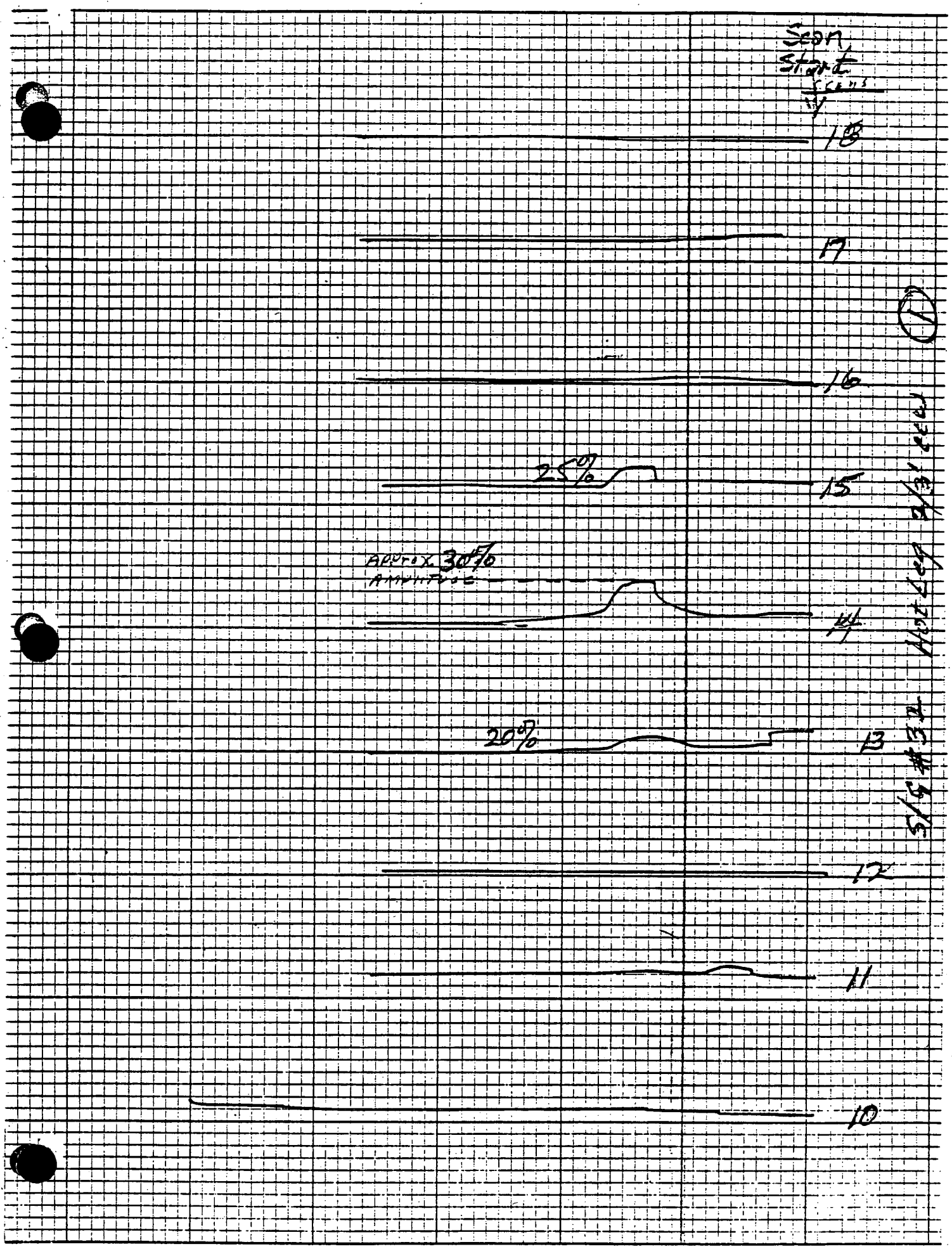
X-Y RECORDINGS

STEAM GENERATOR #32

9/14/25

Scan
~~Start~~
n/a
5 cons




Scan Start
18
17
16
25%
15
Approx. 30%
Amplitude
14
20%
13
12
11
10
Hot Leg 9/13/ cell
S/G #3 2

9/19/75

Scan
Static
Trace

9

8

7

S/G
NO 32
8'-9'
Cold Leg

6

2

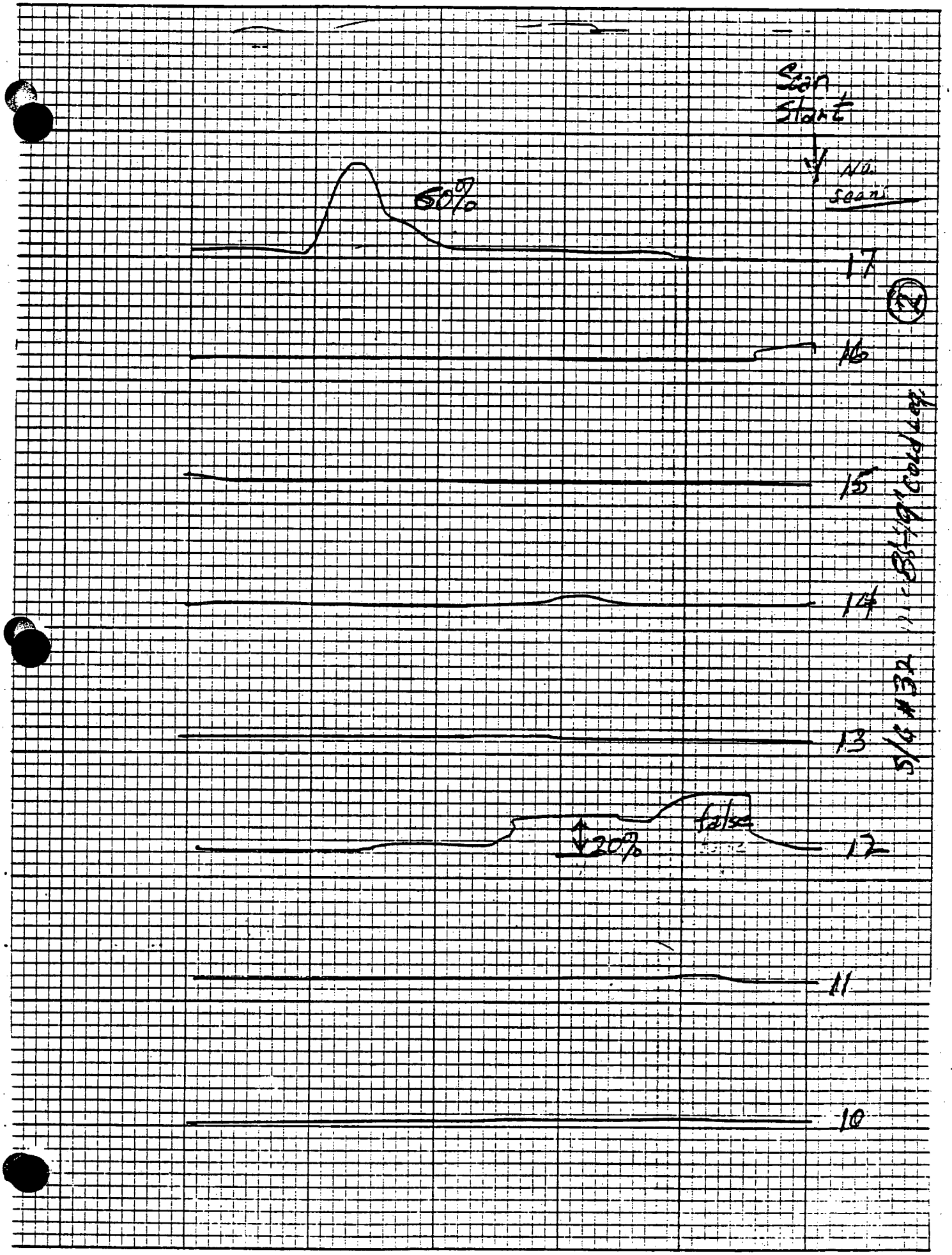
5

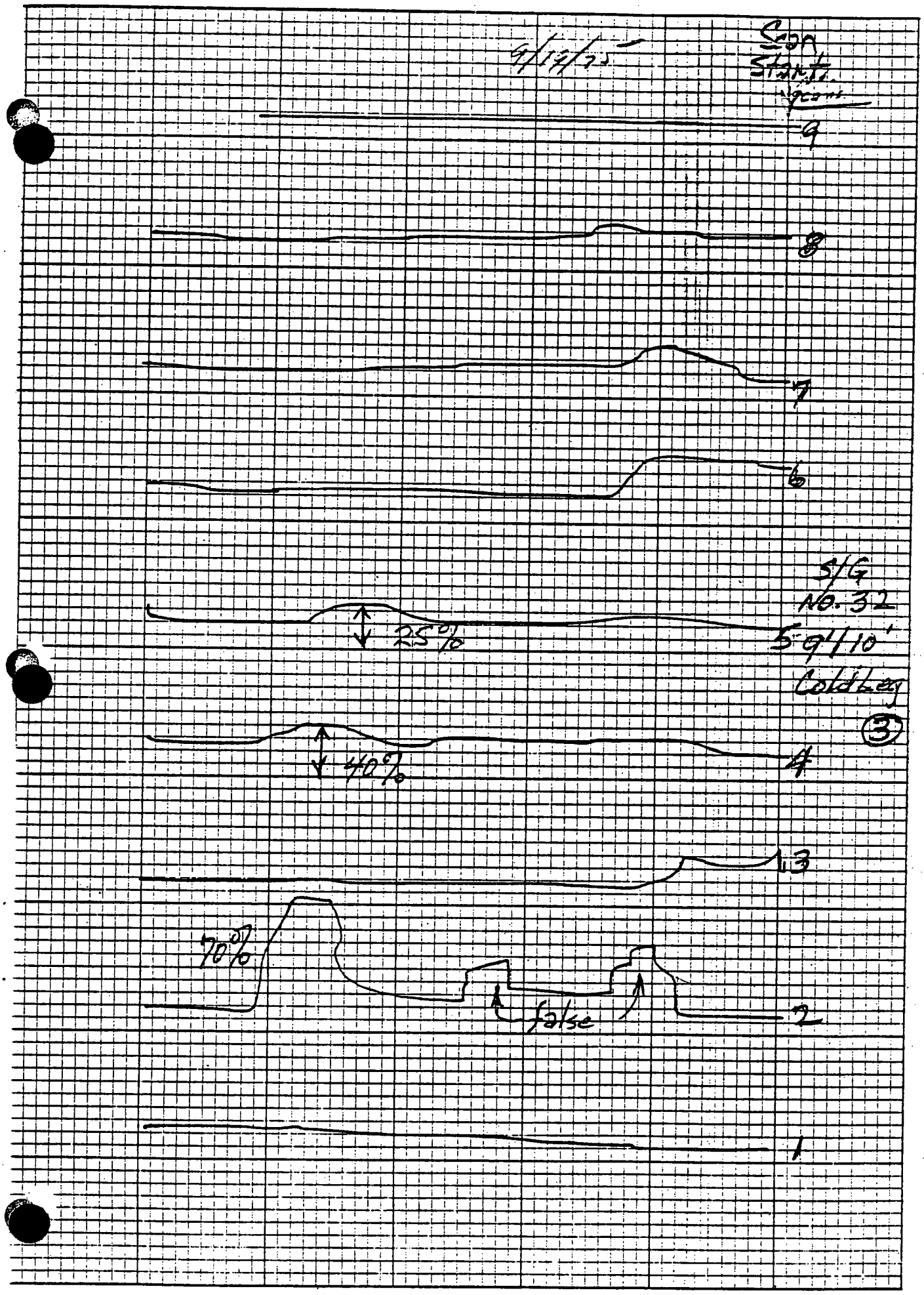
4

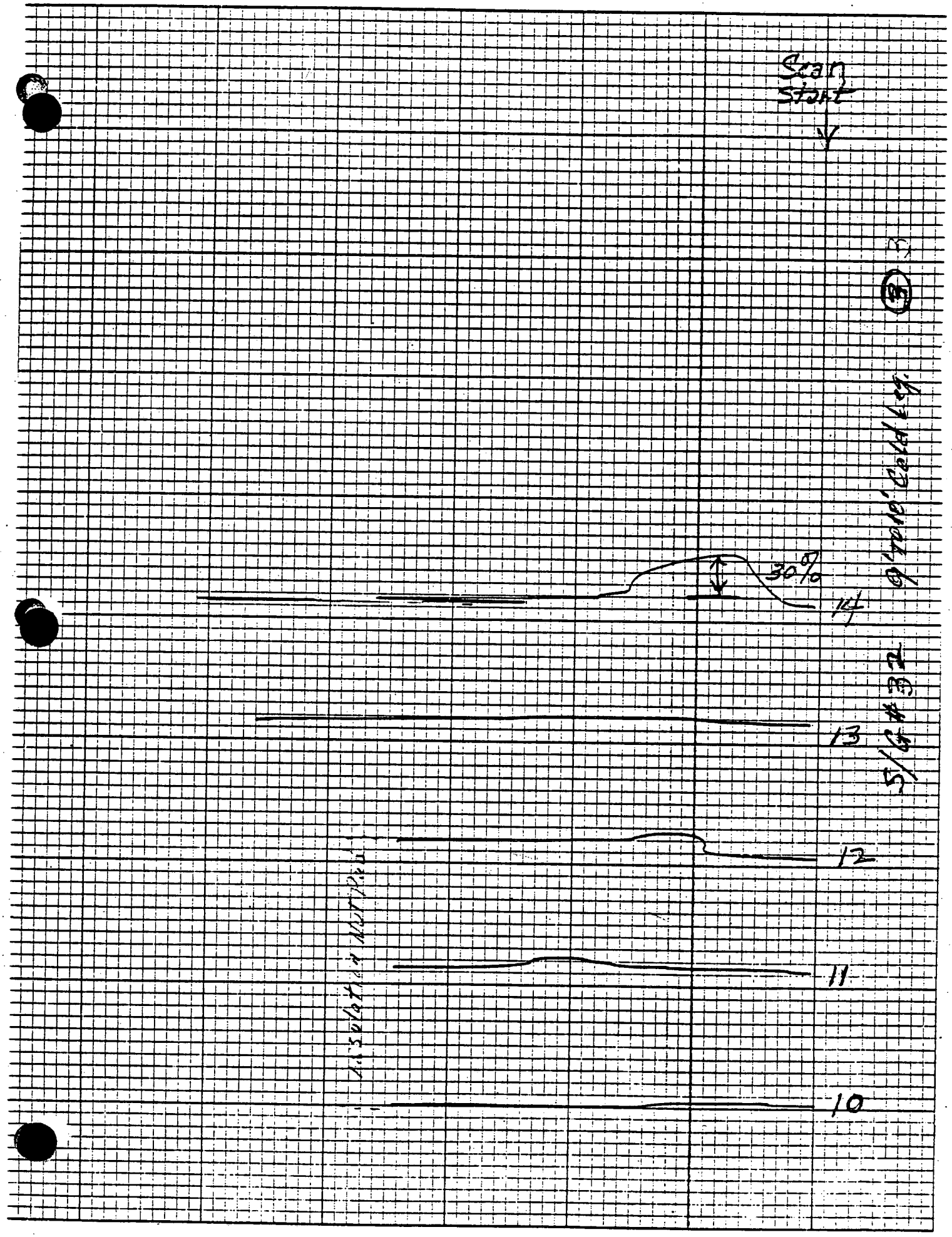
3

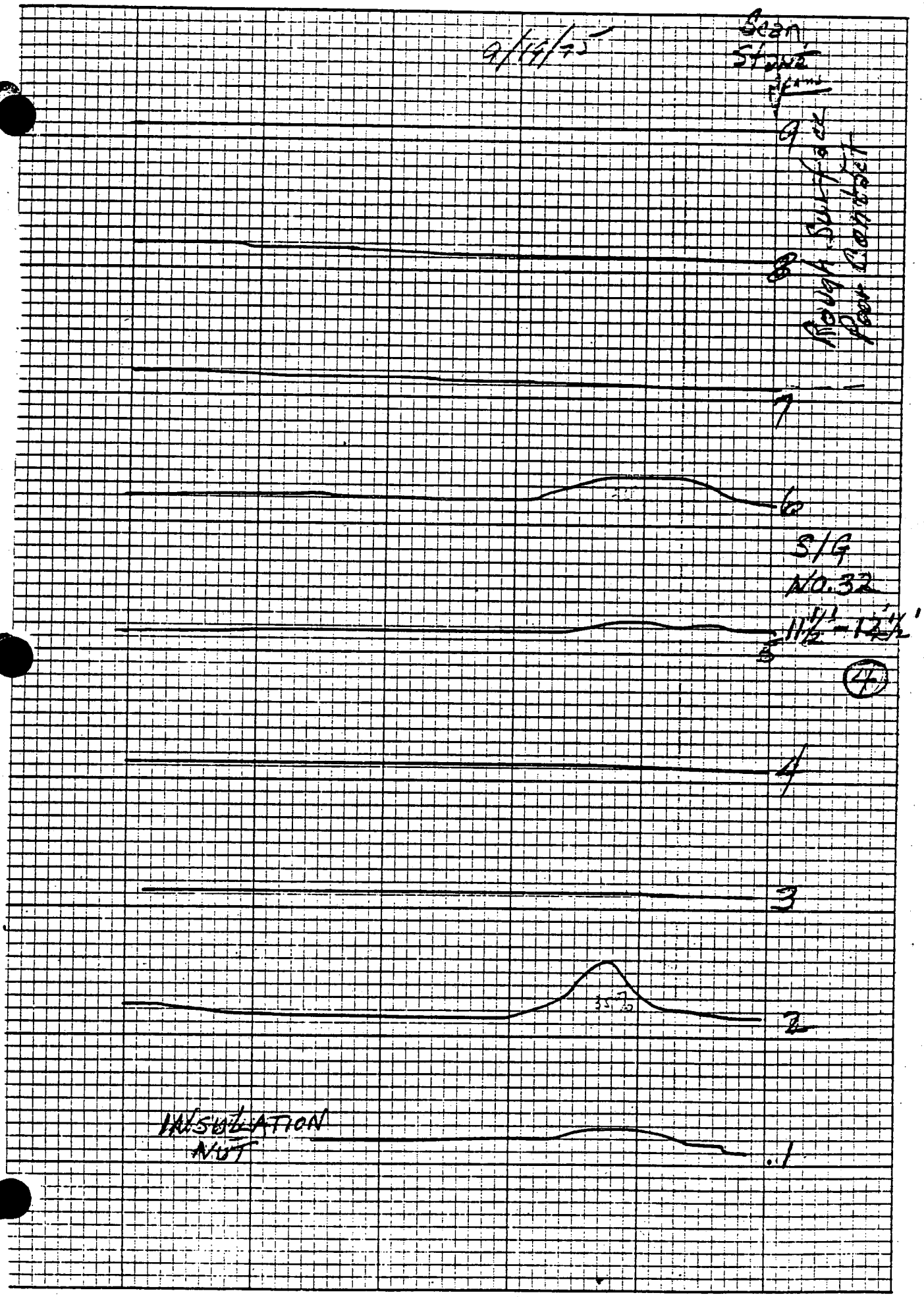
2

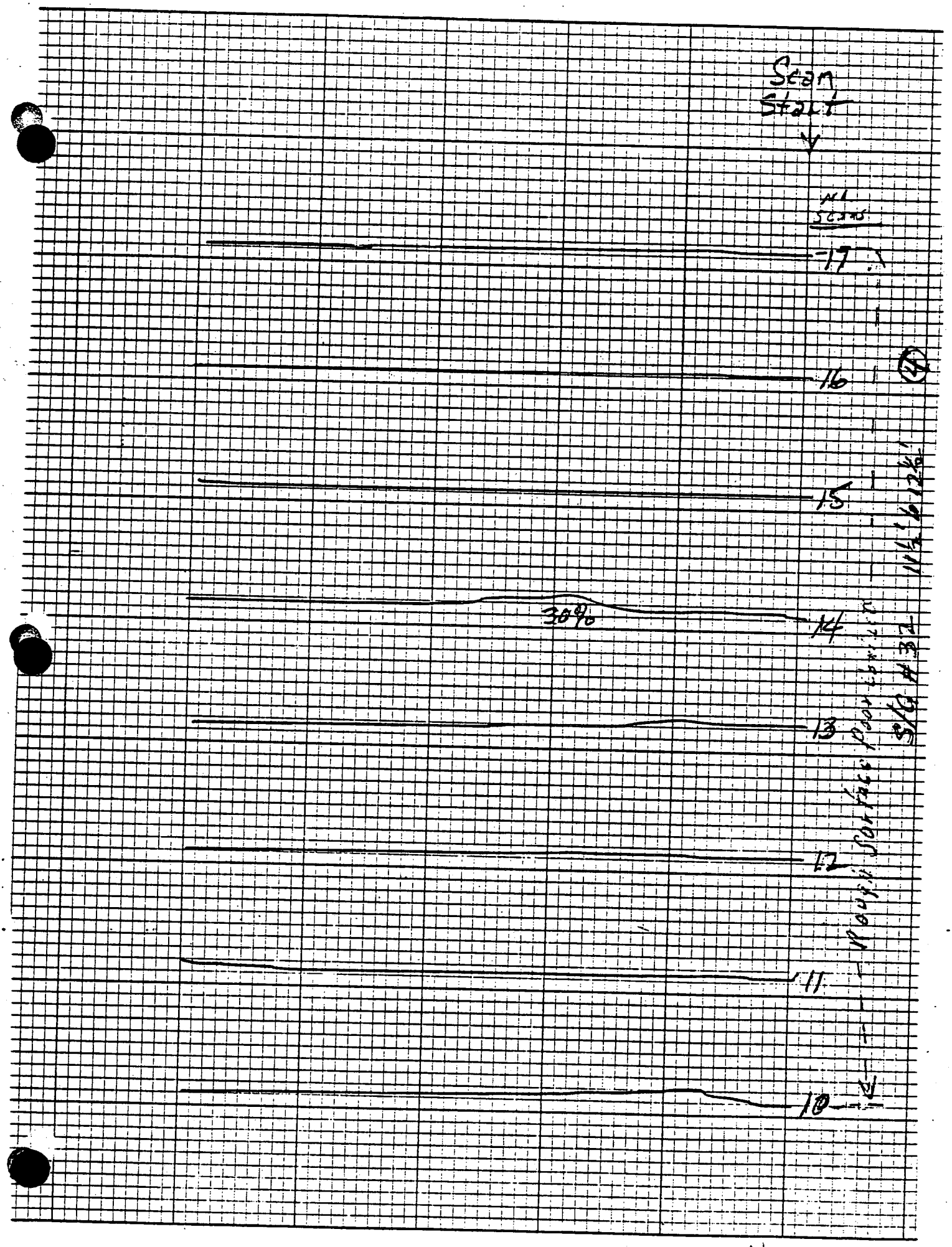
1


Scan Start
No scan
50%
17
16
15
14
13
12
11
10
20%
false
5/6 #32 "Bright cold day"

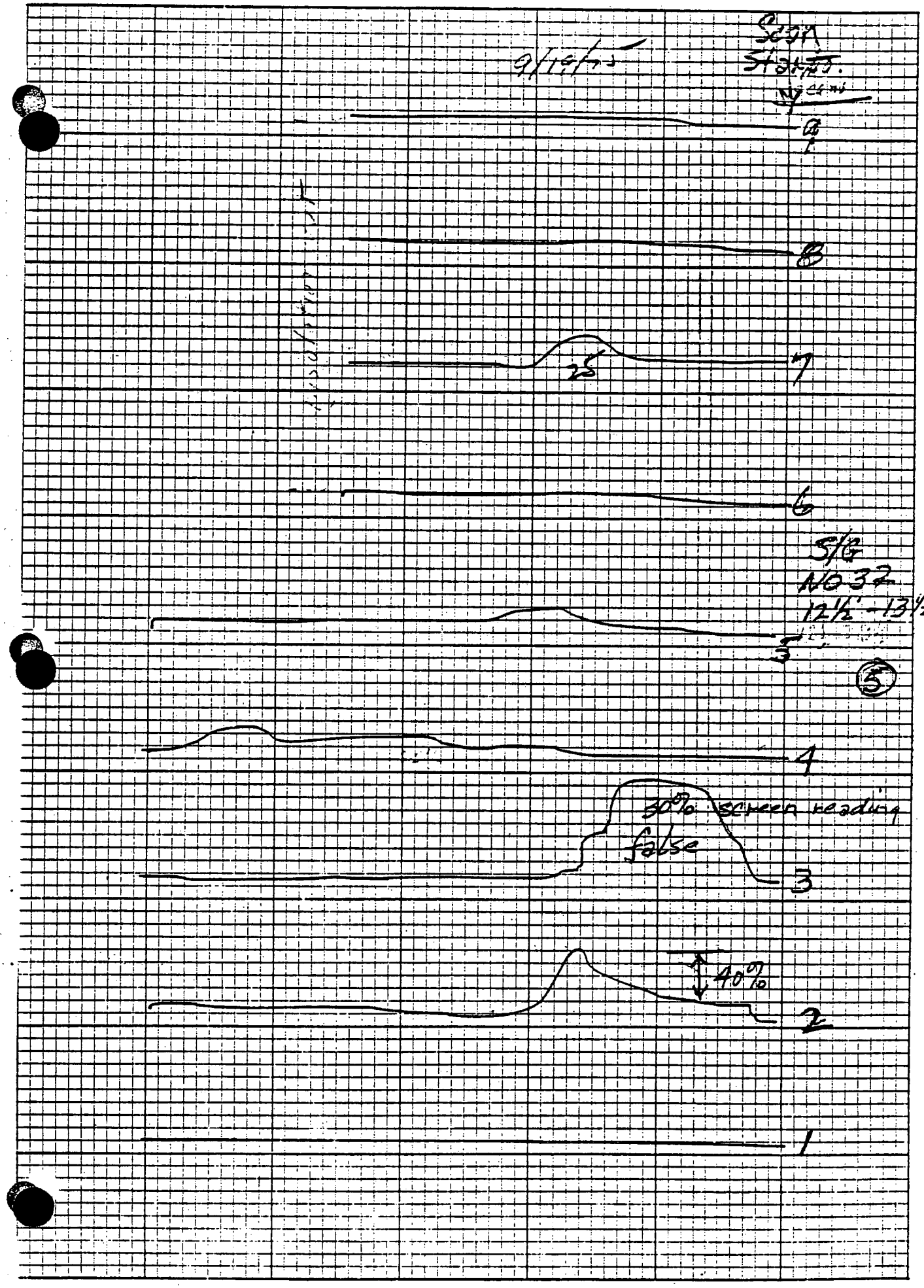

9/17/75
Scan Start
9
8
7
6
S/G
NO. 32
5 9'/10'
Cold Leg
3
25%
4
40%
3
70%
false
2
1


Scan Start
30%
14
13
12
11
10
Quartz, Cold Eg.
5/6 #32
Absolutely NOTHING

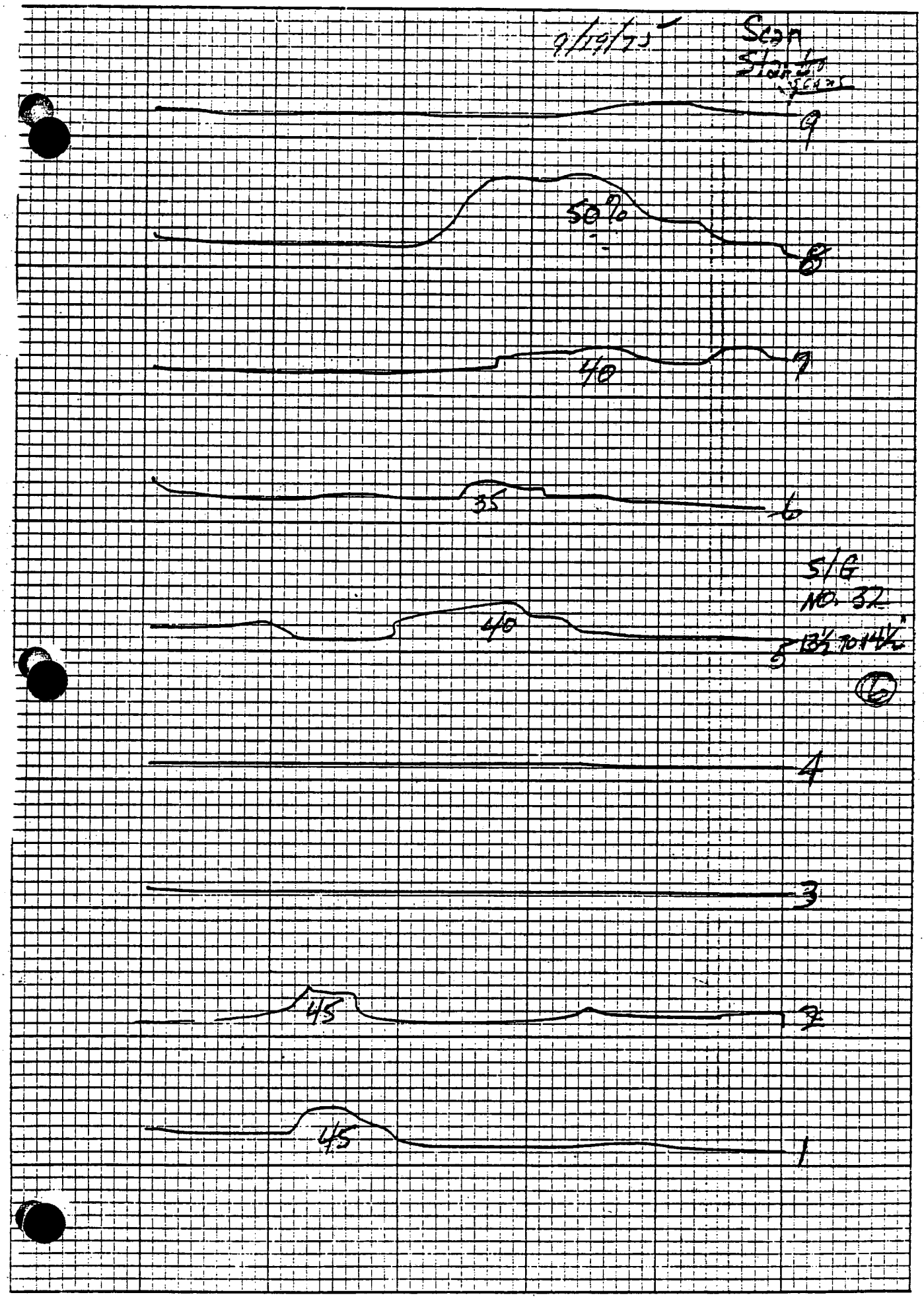

9/19/75
Sean Stone
Rough Surface
Poor Contact
9
8
7
6
S/G
NO. 32
11½ - 12½'
5
4
3
2
INSULATION NUT
1

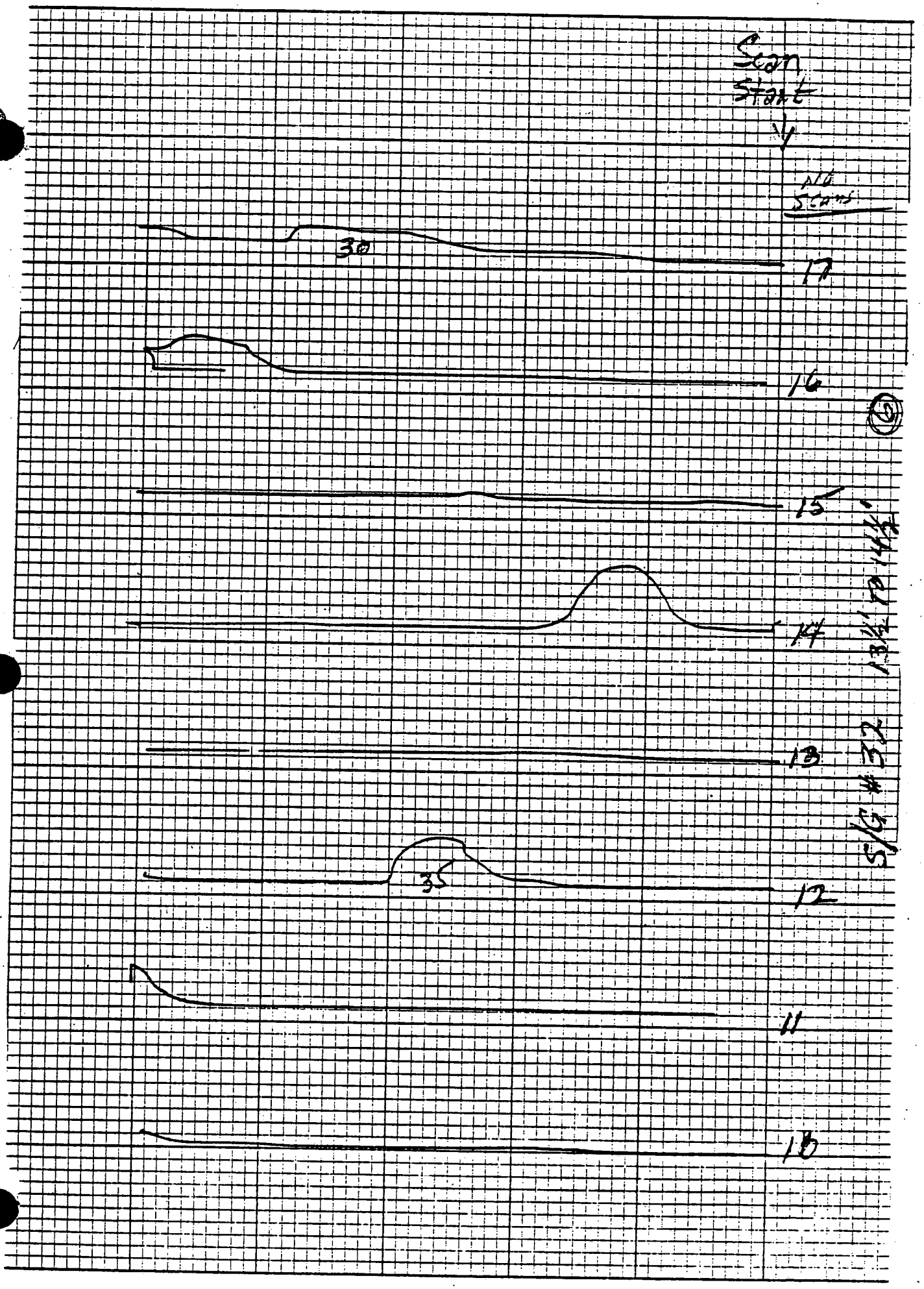

Scan Start
Scan
17
16
15
30%
14
13
12
11
10
Mouth Sorter Room Left
S/G #32
11/16/124

11/24/12


9/15/75
Scan
Start.
Scan
A
B
7
25
6
S/G
NO 32
12½' - 13½'
5
5
4
50% screen reading
false
3
40%
2
1

Scan Start
Scans
35%
16
15
14
13
12
11
10
INSULATION OUT
S/G #32
12½' to 13½'


9/19/75
Sean
Starting
9
50%
8
40
7
35
6
S/G
NO. 32
40
5
13½ to 14½
4
3
45
2
45
1


Scan Start
No Scans
30
17
16
15
14
13
35
12
11
10
S/G # 37
13½ to 14½'