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BOMB ALARM SYSTEM STUDY

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The Western Union Telegraph Company
Water Mill, New York
May 1, 1964

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BOMB ALARM SYSTEM STUDY

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May 1, 1964

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[redacted]

ACKNOWLEDGMENT

The technical data provided by the Mitre/Nudets working group was necessary for the completion of this study.

The following documents were made available as reference material:

(1) Threat Spectrum for 477L, Mitre/Nudets Working Group (9 April 1962) AF 33(600)-39852 (W-4905) SECRET

(2) 477L Phase II Alternate Configuration Studies, Mitre/Nudets Working Group (7 December 1962) AF 33(600)-39852 (TM-3512) SECRET

(3) Propogation Time of the Electromagnetic Pulse (U) P 477L, Mitre/Nudets Working Group (12 July 1963) AF 19(628)2390 (W-6239) SECRET

(4) Operation Dominic - Optical and Seismic Report Mitre 477L Proof Test (U), Mitre/Nudets Working Group (8 January 1963) AF 19(628)2390 (W-5631) SECRET

(5) Summary of Problem Areas for the Phase II Nudet Optical Sensor (U), Mitre/Nudets Working Group (25 July 1963) AF 19(628)2390 (W-6279) SECRET

(6) KILLCOM Attack, (29 January 1964) AF 19(628)-3384 (S) 618,023-1) SECRET

(7) Air Shock Effects from Nuclear Detonation, Mitre/Nudets Working Group (28 November 1961) AF 33(600)29852 (W-4499) SECRET

(8) Study of 477L System Technical Problem Areas (U), Mitre/Nudets Working Group (30 January 1963) AF 19(628)2390 (TM-3542) SECRET

Access to several unpublished documents was also provided.

ABSTRACT

The purpose of this study is to determine the present capabilities of the Bomb Alarm System and to present a program whereby the system may be improved to yield enough additional data to provide an attack assessment capability.

The study of the present system availability was based on an analysis of one year's operational logs. The mean Sensor availability for the year was 99.0%. To a 90% significance level, Sensors were available better than 98.2% of the time. Ultimate target area availability, on a one Sensor basis and to a 90% significance level, was better than 99.98%.

Of the 13 false alarms occurring during the year, most were attributable to personnel errors or disturbances caused by storms. These alarms were all of the single Sensor category. There have been no confirmed or "Map alarms" since the system has been in existence.

The system was also analyzed to determine its effectiveness under hypothetical attack conditions. Under the attack conditions considered, target area availability remained unimpaired on a two Sensor basis for the first twelve minutes of the attack. At the end of twenty five minutes 42% of the target areas still had at least one Sensor capable of reporting. All facilities falling within the 5 PSI contours were considered destroyed.

Features, originally designed into the system to increase the probability of reporting the early alarms, reduce the systems repeat capability and degrade the unique value of the separate reports. Simple modifications of the present hardware can clarify and double the systems repeat capability at some sacrifice in the reliability of the system to report the first or any single weapon.

Feasible additions to target area hardware could provide increased survivability, a measure of yield, a discrimination between air and ground bursts and localization to a specific target area. Increasing the data rate between Master Control Centers and Display Centers to 1200 bauds would reduce the need for adding real time to events at target areas since all reports can be processed on a close-to-current basis yielding a worst-case 6 second resolution and a probable 3 second resolution. Present message format would be retained and the system configuration, insofar as communications circuits are concerned, would remain essentially as they are.

For attack assessment purposes, the system should probably be expanded to include more of the various types of target areas. A large enough sample of each type of target should be included to aid in determining what type of target is under attack.

Increases in cost for the added capabilities for the present complex would in general be limited to the hardware costs at the various equipment sites. Any increases in costs of circuit facilities would be very slight. If the system were expanded by adding target areas, further increases would be incurred proportional to the degree of expansion.

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1.0 INTRODUCTION

During the summer of 1959, when the Bomb Alarm System was being conceived, the emphasis was on reliability insofar as reporting the first nuclear detonations were concerned and on speed of implementation. At that time it was felt that if the first several nuclear detonations were reported with a high degree of reliability and if the system remained in operation for as long as five minutes, it would have served its purpose.

Sensors were required to detect aerial detonations in the range 0.4 to 20 megatons and were located with respect to target areas so as to assure a constant, worst weather surveillance. This placed them close enough to ground zero so that nuclear detonations of any appreciable size would probably destroy many installations. The Sensors were, however, designed to report nuclear detonations within two seconds to increase the probability that an alarm would have been sent before the arrival or accumulation of any damaging effects.

Sensors were designed to report to Signal Generating Stations, where the raw alarm messages were converted to common telegraphic code, and where storage existed so that an orderly report from a multiplicity of locations could be made at a 60 word per minute rate without losing any of the first alarm reports. Signal Generating Stations were located at appreciable distances from target areas to assure their survivability. Signal Generating Stations were arranged in series loops to reduce the wire mileage necessary to serve them. Practical maintenance considerations caused a gradual reduction in the number of stations per loop from an original design goal of twenty per loop to the present maximum of seven per loop.

Three Sensors were located about target areas in a manner to assure a simultaneous report from at least two in case of a detonation, taking into account the fact that one might be lost because of a direct hit. According to the original concept, an alarm consisted of the simultaneous receipt of two or more alarm messages from the same target area. These alarms were displayed on a Map and were accompanied by an audible alarm. The Communicator's Panel was conceived as an availability display and was designed to keep the Communications Officer fully informed as to the status of the system. Single red reports were also displayed here as pertinent information that should be investigated.

These reports were not to be treated as primary alarms. The system was designed for military people, to give them alarm information and to inform them as to which military targets had been hit.

The present system provides surveillance over 99 selected target areas, mostly military installations. As it stands it is capable of being expanded to 120 target areas without materially altering either the Master Control Centers or the Display Centers. Additional Sensors, Generating Stations and associated communications circuitry would, of course, be required.

The system checks itself every two minutes posting the results of each poll on the Communicator's Panel at the Display Centers.

Since 1959 many changes have taken place, not only in the quantity and complexity of parallel and complementary information gathering systems, but also in the thinking of military people and other possible users of information gathered from nuclear detonation detection systems. Today more thinking is concentrated on gathering detailed information relative to nuclear detonations so that such information can be used to make attack and possibly damage assessment estimates. To this end a study of the present, operating Bomb Alarm System has been undertaken to determine to what extent it can be modified to yield additional data. Estimates with respect to increased cost are included to provide a base cost for effectiveness studies and comparisons

2.0 PERFORMANCE STUDY OF THE PRESENT BOMB ALARM SYSTEM

2.1 TARGET AREA AND SYSTEM AVAILABILITY STUDY

2.1.1 Basis of Study and Source of Data

The study of the availability of the system was made by an analysis of the performance of the system during the period December 1962, through November 1963. For this purpose the following records were used as sources:

2.1.1.a <u>ADC CORS Outage Log and Narrative Summary</u>. These are daily reports prepared at Ent Air Force Base. The outage log records the time of the outage, circuits and equipment involved, length of the outage, and where possible, the reason for the outage. Outages noted include:

(1) Circuit failures

(2) Single Sensor losses in excess of one hour

(3) All double and triple Sensor losses at any target area

(4) False reds

(5) Master Control Center (MCC) and Display Center (DC) failures.

The Narrative Summary reduces the detailed data to a short form report.

2.1.1.b <u>Western Union System Representative Report</u>. This report is an internal monthly report of the Senior Systems Representative at Ent AFB to Western Union Headquarters, summarizing the month's operation in the following areas:

(1) False reds, with a more detailed analysis where possible

(2) Results of the system-wide monthly Red Test

(3) Reports of repeated failures on a circuit

(4) Reports of excessive two-detector and three-detector outages in any target area

(5) Equipment troubles at MCC's or DC's.

It should be noted that the term "yellow" in connection with reports and status refers to an unavailable Sensor for whatever reason, and not to the intermediate condition of the Sensor when it is in the process of reporting a burst.

2.1.2 Target Area Availability

These three charts (Figures 2.1, 2.2, 2.3) record the availability of the individual Sensors and of the target areas on a two-sensor and one-sensor basis.

2.1.3 MCC Red Tests

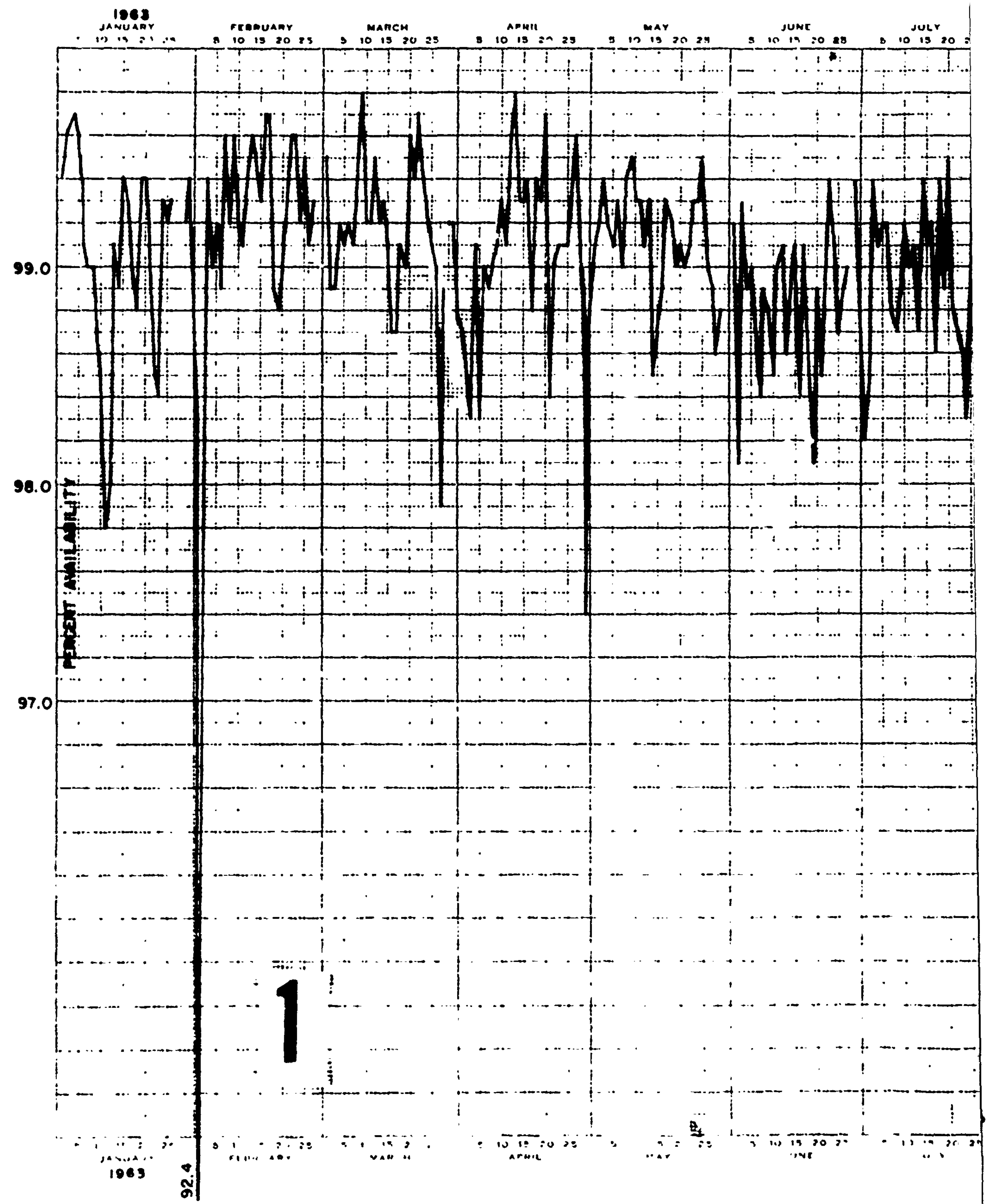
These charts (Figures 2.4, 2.5) record the results of Red Tests terminated at the MCC. In this test a message is sent to all Signal Generating Stations (SGS's) to operate the test light sequence in the Sensor. The test sequence causes the message sent from the SGS to be terminated with the characters NY rather than the normal alarm indicator CY. The MCC disregards the NY status indicator and these messages are not relayed to the DC's. In this analysis, Sensors which were not reporting properly at the time of the test are excluded from the Red Test Data.

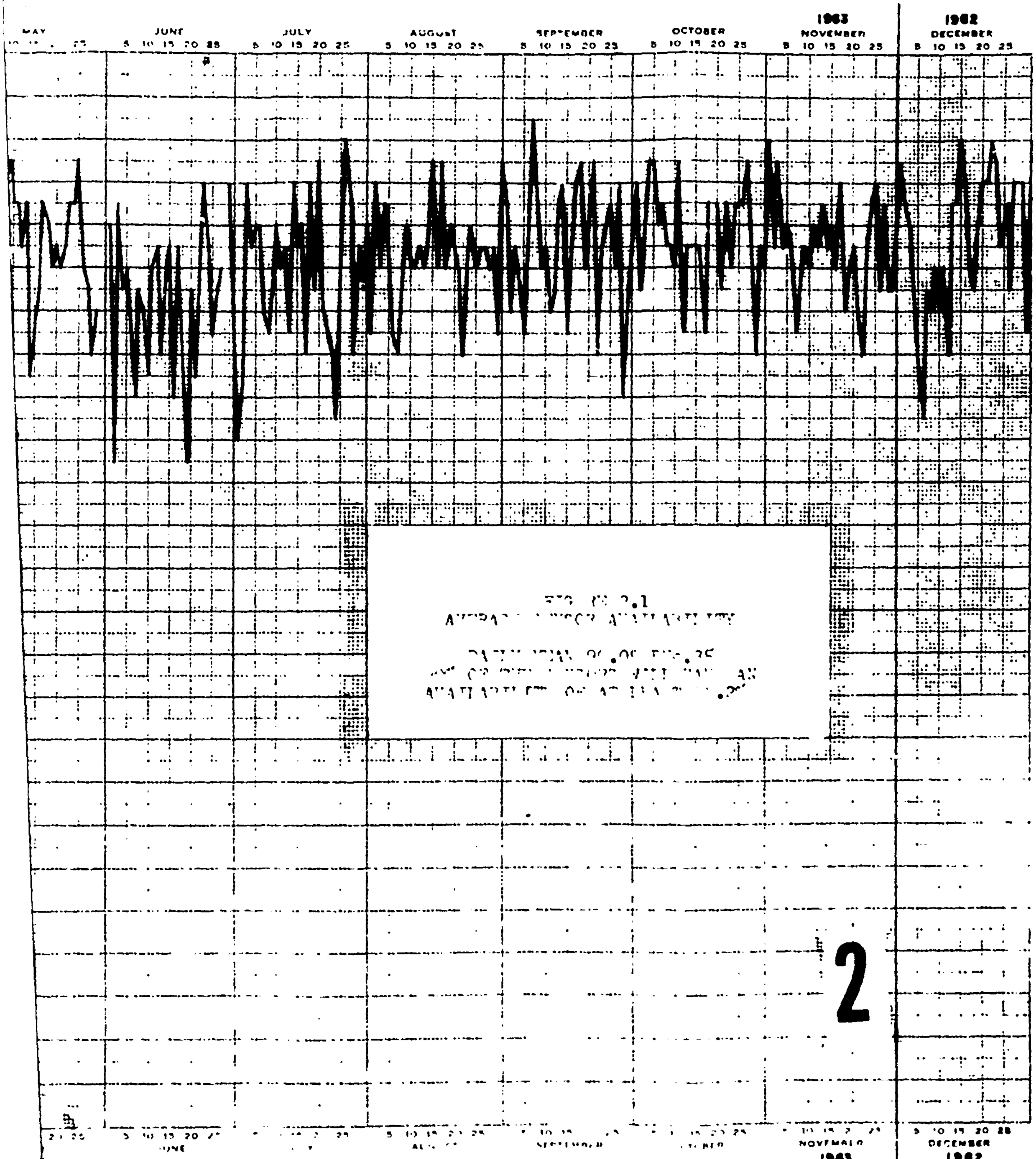
Since the testing sequence is more complex in nature and involves additional equipment over that required to make a normal alarm report, one might expect that the reporting capability for actual alarms is better than that indicated for red tests.

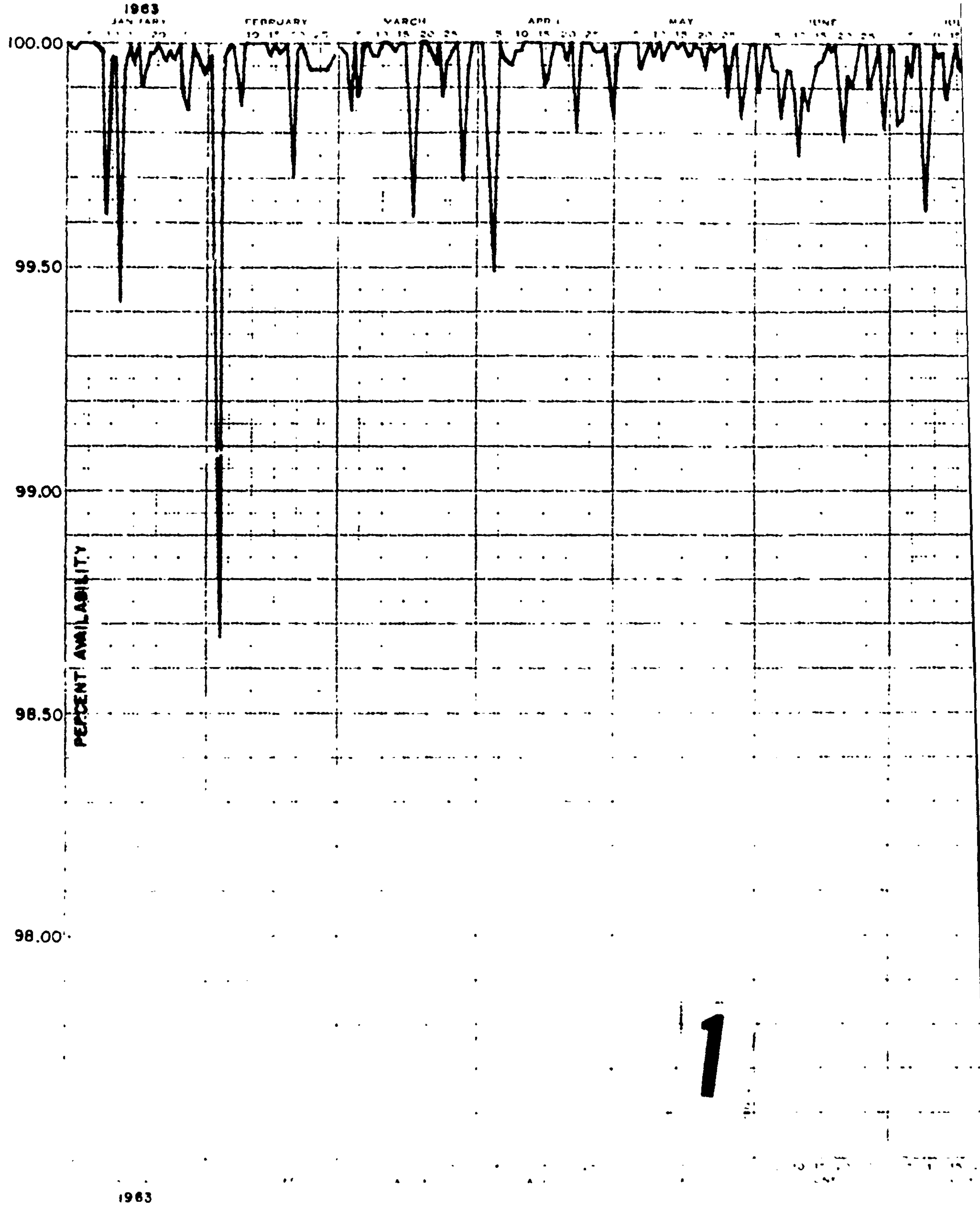
Red tests were conducted on an average of twice a week at each MCC.

2.1.4 System Wide Red Test

A monthly Red Test is made which includes a test of the DC's. This is done in the same manner as the MCC Red Tests, but the operation of a switch at the MCC permits the Test Red Messages to be processed and relayed to the DC's as standard alarm messages. The alarms produced at the Communicator's Panel and Map at each DC are recorded and the results are shown for both Communicator's Panel and Map responses. As in the MCC Red Test, the Sensors which were not reporting at the time of the test are excluded from the Red Test Data.


1963
JANUARY
FEBRUARY
MARCH
APRIL
MAY
JUNE
JULY
99.0
98.0
97.0
PERCENT AVAILABILITY
92.4
1963
1


MAY
JUNE
JULY
AUGUST
SEPTEMBER
OCTOBER
1963
NOVEMBER
1962
DECEMBER
NOVEMBER
1963
DECEMBER
1962


1963
JANUARY
FEBRUARY
MARCH
APRIL
MAY
JUNE
100.00
99.50
99.00
98.50
98.00
PERCENT AVAILABILITY
1963

1

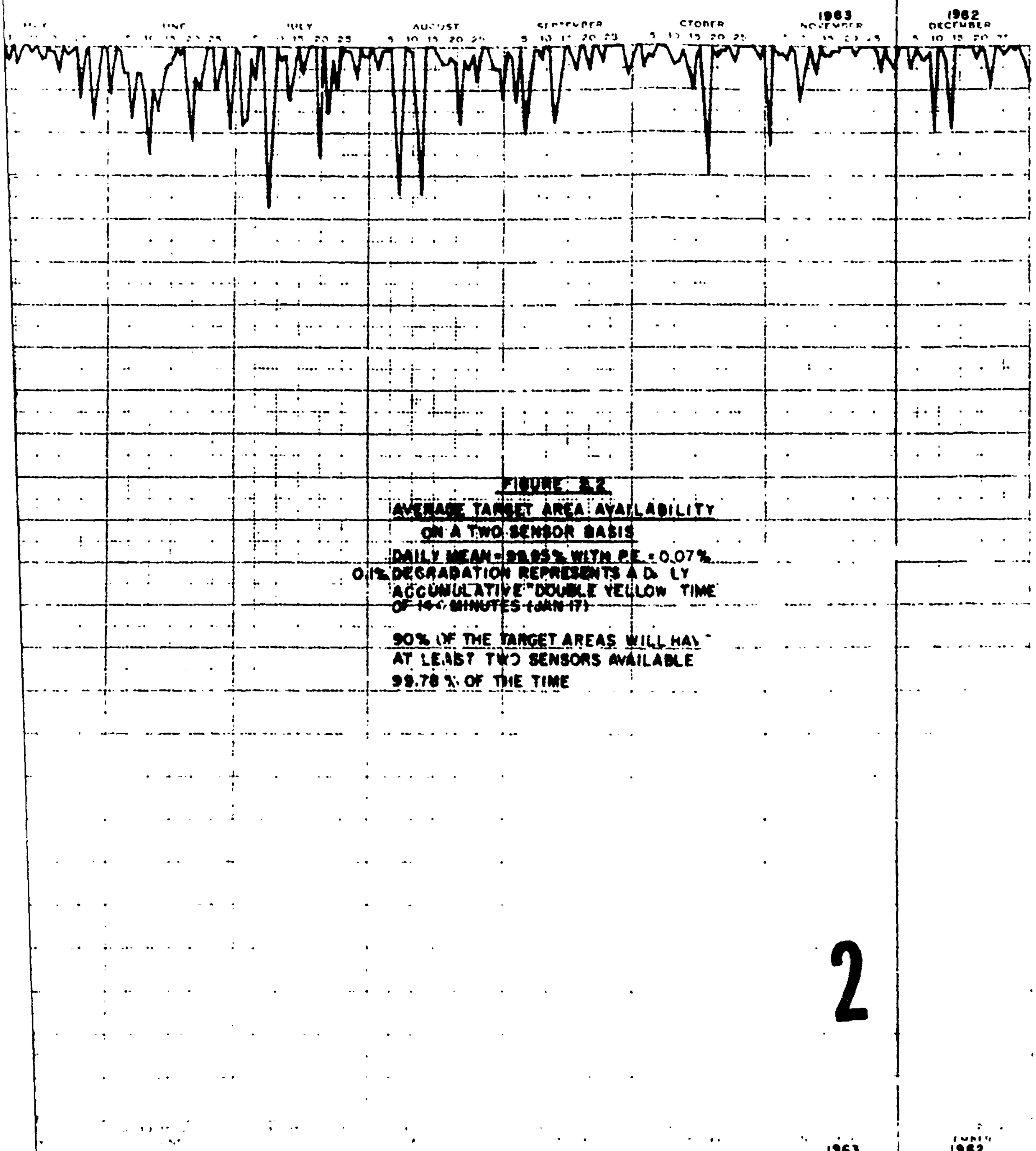
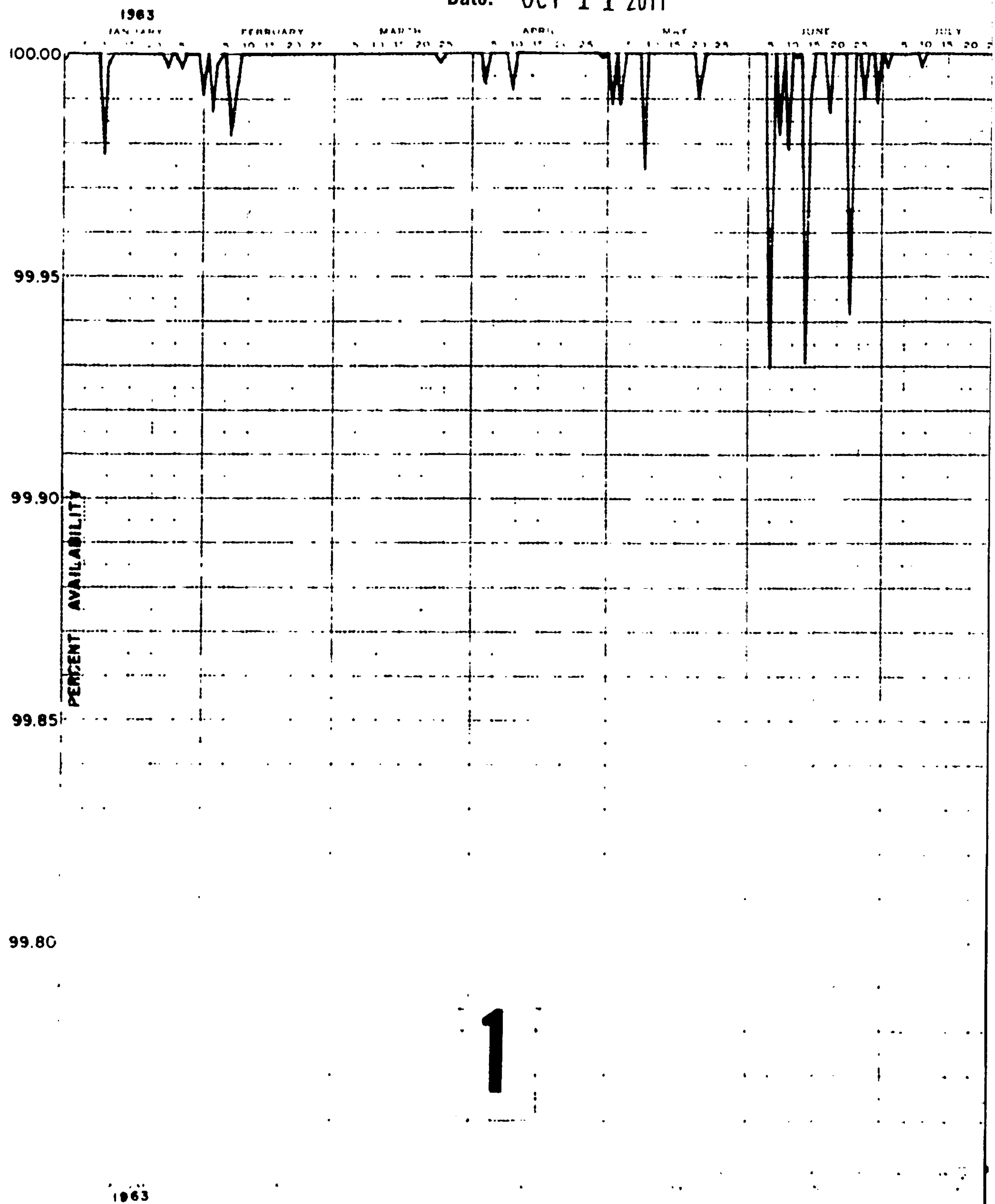


FIGURE [illegible]

AVERAGE TARGET AREA AVAILABILITY
ON A TWO SENSOR BASIS

DAILY MEAN = [illegible] WITH P.E. = 0.07%
0.1% DEGRADATION REPRESENTS A D[illegible]LY
ACCUMULATIVE "DOUBLE YELLOW" TIME
OF [illegible] MINUTES (JAN 17)

90% OF THE TARGET AREAS WILL HA[illegible]
AT LEAST TWO SENSORS AVAILABLE
99.78 % OF THE TIME


1963
JANUARY
FEBRUARY
MARCH
APRIL
MAY
JUNE
JULY
100.00
99.95
99.90
99.85
99.80
PERCENT AVAILABILITY
1963

1

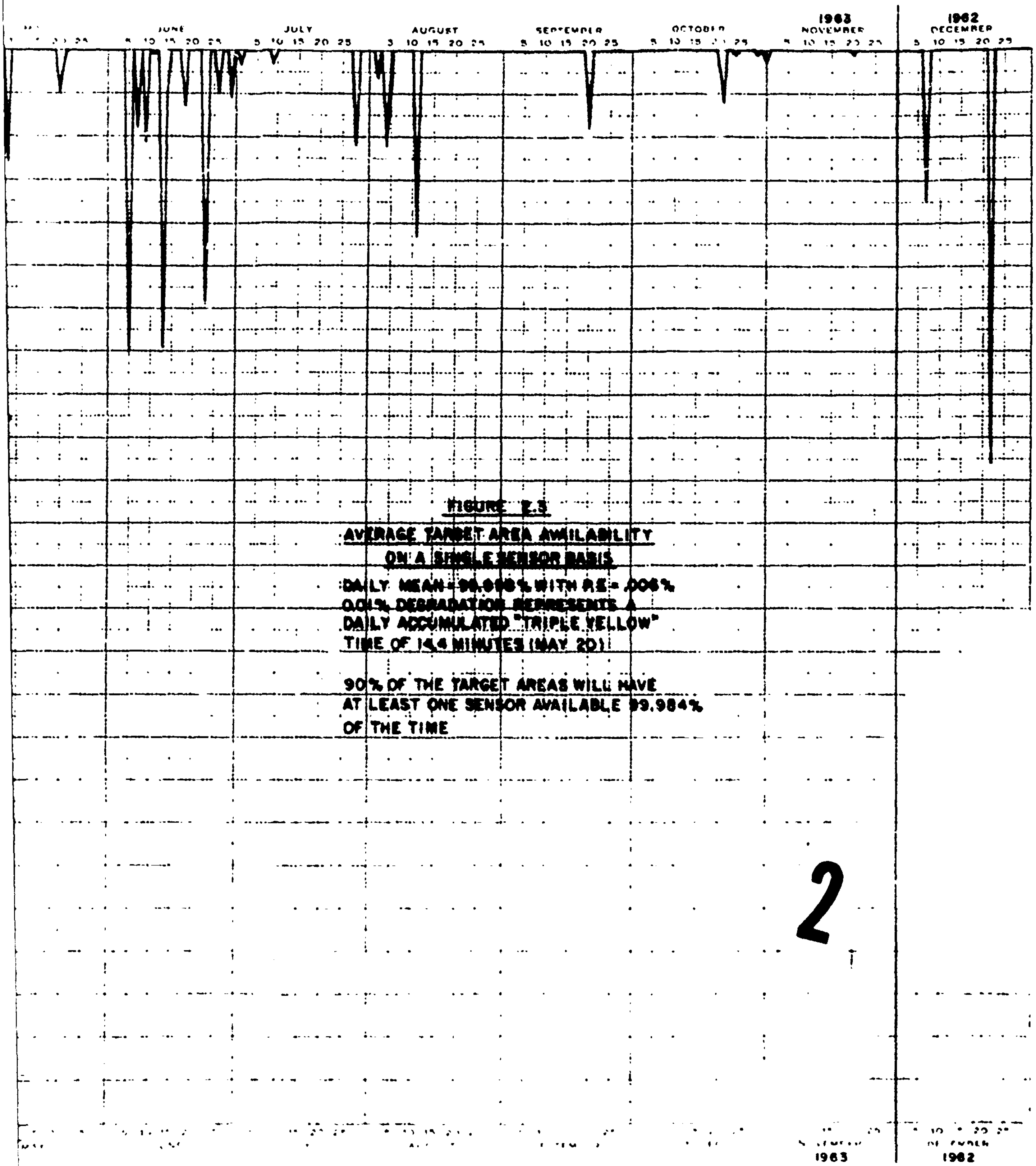
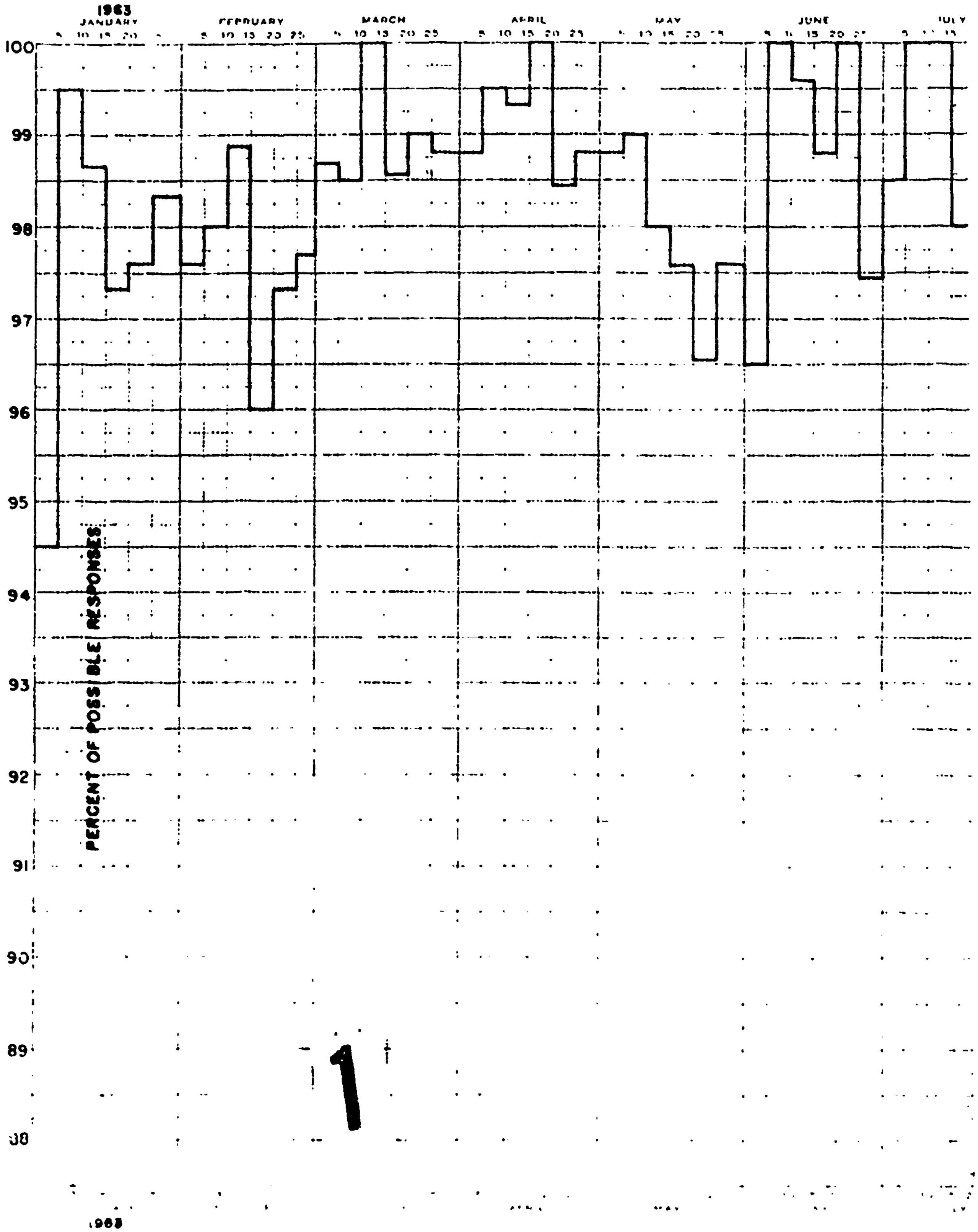


FIGURE 2.3

AVERAGE TARGET AREA AVAILABILITY
ON A SINGLE SENSOR BASIS

DAILY MEAN = [illegible]% WITH P.E. = .006%
0.01% DEGRADATION REPRESENTS A
DAILY ACCUMULATED "TRIPLE YELLOW"
TIME OF 14.4 MINUTES (MAY 20)

90% OF THE TARGET AREAS WILL HAVE
AT LEAST ONE SENSOR AVAILABLE 99.984%
OF THE TIME


1963
JANUARY
FEBRUARY
MARCH
APRIL
MAY
JUNE
JULY
PERCENT OF POSSIBLE RESPONSES
100
99
98
97
96
95
94
93
92
91
90
89
88

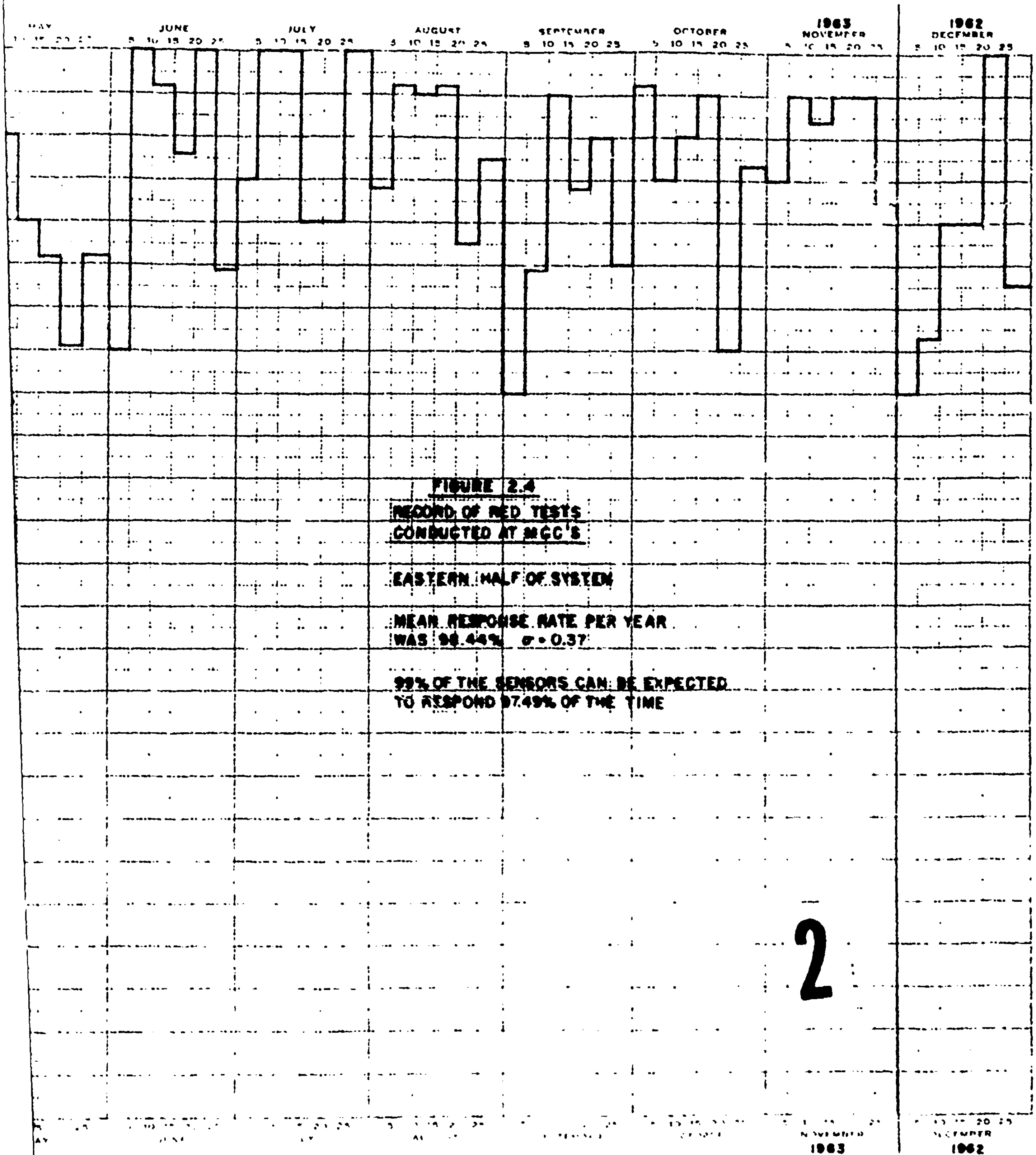


FIGURE 2.4

RECORD OF RED TESTS CONDUCTED AT MCC'S

EASTERN HALF OF SYSTEM

MEAN RESPONSE RATE PER YEAR WAS 98.44% $\sigma = 0.37$

99% OF THE SENSORS CAN BE EXPECTED TO RESPOND 97.49% OF THE TIME

2

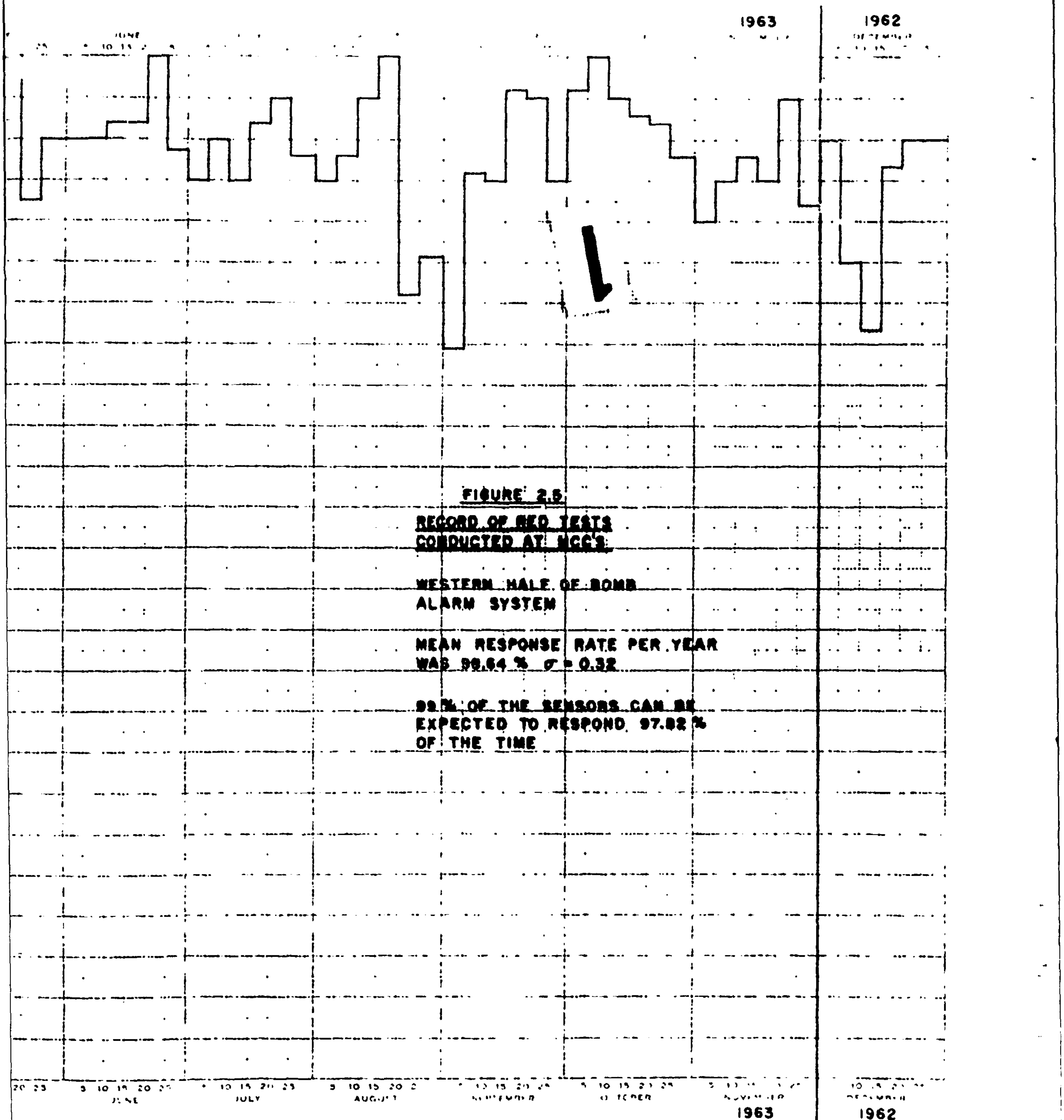


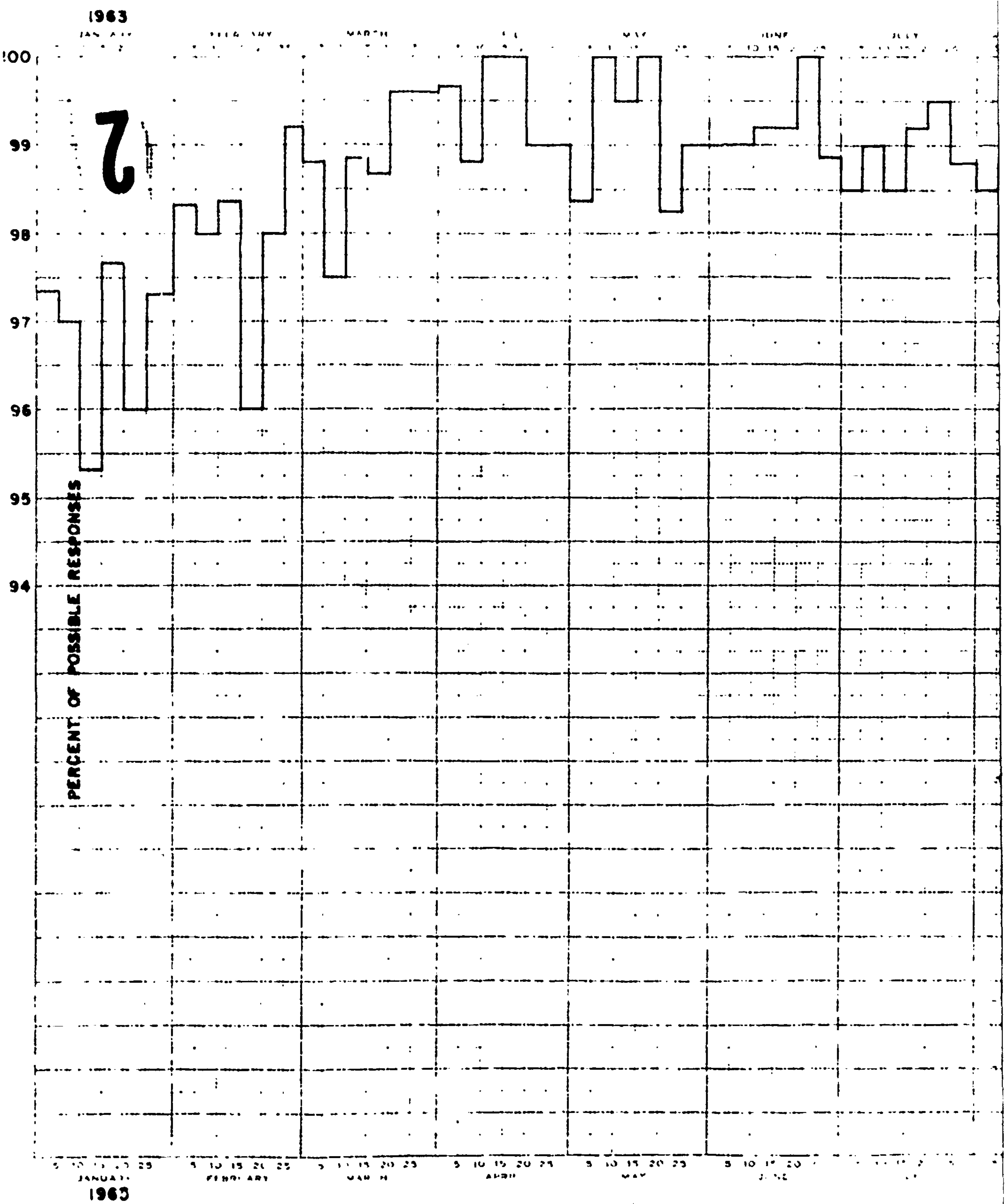
FIGURE 2.5

RECORD OF RED TESTS CONDUCTED AT MCC'S

WESTERN HALF OF BOMB ALARM SYSTEM

MEAN RESPONSE RATE PER YEAR WAS 98.64 % $\sigma = 0.32$

99% OF THE SENSORS CAN BE EXPECTED TO RESPOND 97.82 % OF THE TIME


1963
100
99
98
97
96
95
94
PERCENT OF POSSIBLE RESPONSES
2
1963

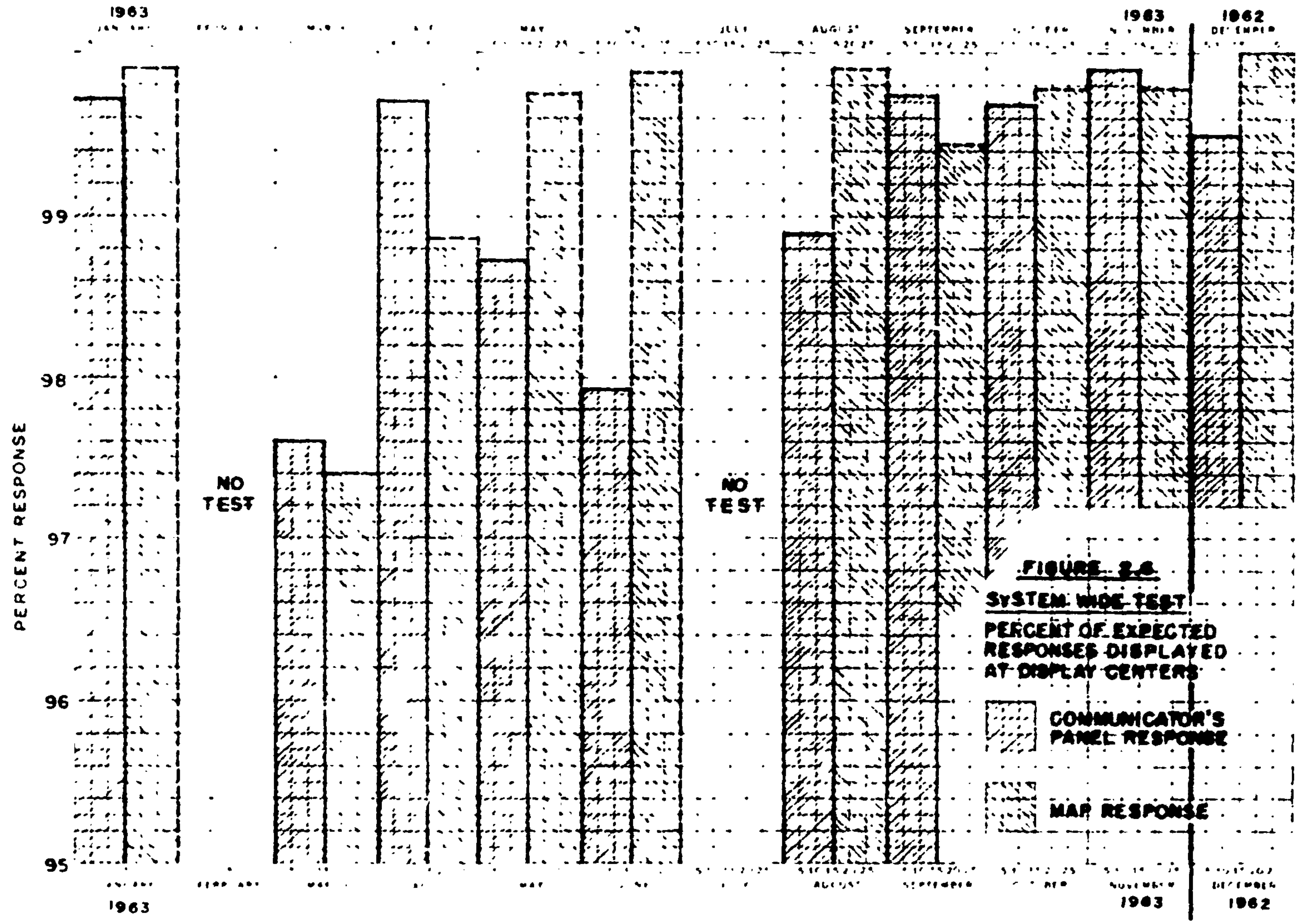


FIGURE 2.6
SYSTEM WIDE TEST
PERCENT OF EXPECTED RESPONSES DISPLAYED AT DISPLAY CENTERS

Since this presentation (Figure 2.6) is based on only one test per month, it should be viewed with somewhat less confidence than the MCC Red Test charts for which the data was much more extensive.

2.1.5 Tabulation of Failures

Table 2.1 classifies the causes of yellow indications at the Communicator's Panel into three categories:

TABLE 2.1

BX NO.	REPEATERS	MILEAGE	BX FAILURES	BAS EQUIPMENT FAILURES	COMMERCIAL POWER FAILURES
101	13	2011	64	13	4
102	11	1230	72	4	9
103	16	1800	52	5	7
104	15	1051	28	1	5
105	20	2454	67	3	3
106	13	1570	36	1	3
107	9	1241	42	2	1
108	15	1002	39	2	5
109 #	24	3020	98	20	8
201	12	2491	63	7	5
202 •	10	2460	111	5	8
203	21	1304	50	0	5
204	13	3093	56	2	4
205	10	2724	61	4	3
206	12	1789	65	5	9
207	6	633	12	1	2
208	6	983	23	0	0
209	13	771	27	1	1
210	10	499	18	6	1
211	16	1085	36	10	3

TABLE 2.1 (Continued)

BX NO.	REPEATERS	MILEAGE	BX FAILURES	BAS EQUIPMENT FAILURES	COMMERCIAL POWER FAILURES
301	19	1673	80	1	7
302	10	1915	118	3	7
303	29	3899	71	7	7
304	11	1678	52	5	2
305	9	610	43	4	3
306	8	901	44	1	4
307	10	1050	34	4	1
308	6	839	13	0	2
309	17	1165	63	5	2
310	12	1319	66	3	4
401	13	3758	45	2	1
402	16	3637	52	10	8
403	11	3186	46	6	4
404	17	3267	65	13	12
405	19	2704	61	2	6
406	11	1764	64	1	7
407	8	1057	46	1	2
408	7	2326	45	0	1
409	13	2187	27	1	6
410	11	1900	21	1	0
501	14	2193	65	7	12
502	5	1546	32	0	4
503	9	1650	37	1	5
504	6	688	43	3	2
505	10	1399	33	3	0
506	14	1252	45	1	3
507	10	845	26	1	7
508	14	2752	63	0	6
509	14	3198	67	1	6
511	17	4139	43	7	12
512	26	3309	63	2	2

TABLE 2.1 (Continued)

BX NO.	REPEATERS	MILEAGE	BX FAILURES	BAS EQUIPMENT FAILURES	COMMERCIAL POWER FAILURES
601	11	1611	53	4	8
602	16	2620	54	8	3
603	13	2394	33	5	10
604	7	2746	41	5	5
605	15	3403	49	3	6
606	16	3972	108	5	11
607	15	4232	53	3	6
608	13	1268	31	2	5
609	9	1271	55	2	5
610	10	2727	66	1	9
81	10	5594	60	1	4
82	11	5982	62	2	1
83	10	5146	72	1	2
84	12	5572	62	3	4
85	12	4738	47	5	1
86	13	8624	74	0	1
881	5	1836	6	1	1
882	3	2389	8	0	0
883	7	2717	4	0	1
884	5	4190	10	3	2
885	6	3076	3	3	1
886	4	2688	13	0	1
6	1	BMEWS	92	0	7
7 *	1	BMEWS	79	5	28
8 *	1	BMEWS	108	1	5
9	0	BMEWS	66	1	5
10	2	BMEWS	52	5	6
11	0	BMEWS	12	1	1
27	1	BMEWS	38	0	4
35	1	BMEWS	24	3	3

* Failures on USAF Facilities.

• Common poor Telco Facility. Special Waiver Area.

\# Includes 6 reported failures on one equipment in a 2-day period.

81-86 Primary Reporting Circuitry
881-886 Secondary Reporting Circuitry

2.1.5.a <u>BX Failures</u>. This category includes all failures of circuitry and communication equipment between the BAS equipments.

2.1.5.b <u>Bomb Alarm System Equipment</u>.

2.1.5.c <u>Commercial Power Failures</u>.

The "BX NO." column is the Western Union designation of the SGS circuits connected to the MCC's. BX6 through 9 and the 100, 200 and 300 series are associated with the eastern MCC's; BX10, 11, 27, 35 and the 400, 500 and 600 series with the western MCC's. BX's 81 through 86 and 881 through 886 are the main and fallback reporting circuits from the MCC's to the DC's.

The "Repeater" and "Mileage" columns indicate the number of telegraph repeaters and the circuit mileage on each loop.

2.1.6 Duration of Failures

In an attempt to relate the duration of the double and triple yellows to the number of such outages, the individual outages were arranged into time interval groups. The length of the intervals was arbitrarily selected. A double yellow outage condition exists when two of the three lights associated with a target area on the Communicator's Panel are yellow, indicating that two of the Sensor triad are unavailable. Similarly, a triple yellow indicates that none of the three Sensors in a target area is available.

The first chart (Figure 2.7) shows the distribution of the number of outages as a function of the outage time interval. The average duration of a double yellow is 55.7 minutes. The average duration of a triple yellow is 12.3 minutes.

The second chart (Figure 2.8) indicates the percentage of the outages which are shorter than a given duration. The median value of double yellow outages is 24 minutes. The median value of triple yellows is 3.5 minutes.

2.1.7 Circuit Failure Analysis

The Figures 2.9, 2.10 and 2.11 "Eastern Loop Failures", "Western Loop Failures" and "Reporting Circuit Failures" represent a further analysis of the previously tabulated "BX Failures". The failures for which a cause was found were assigned three categories.

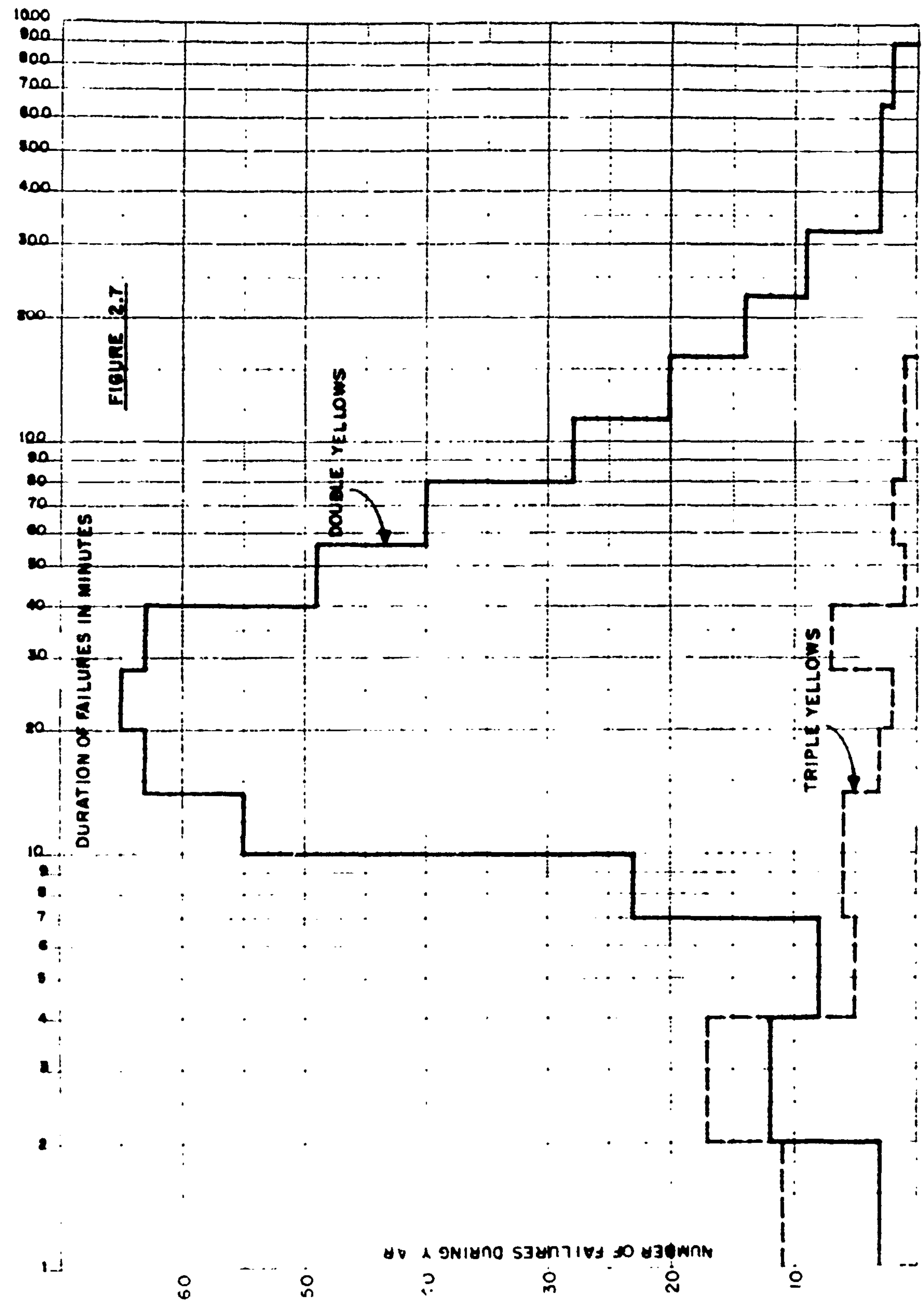
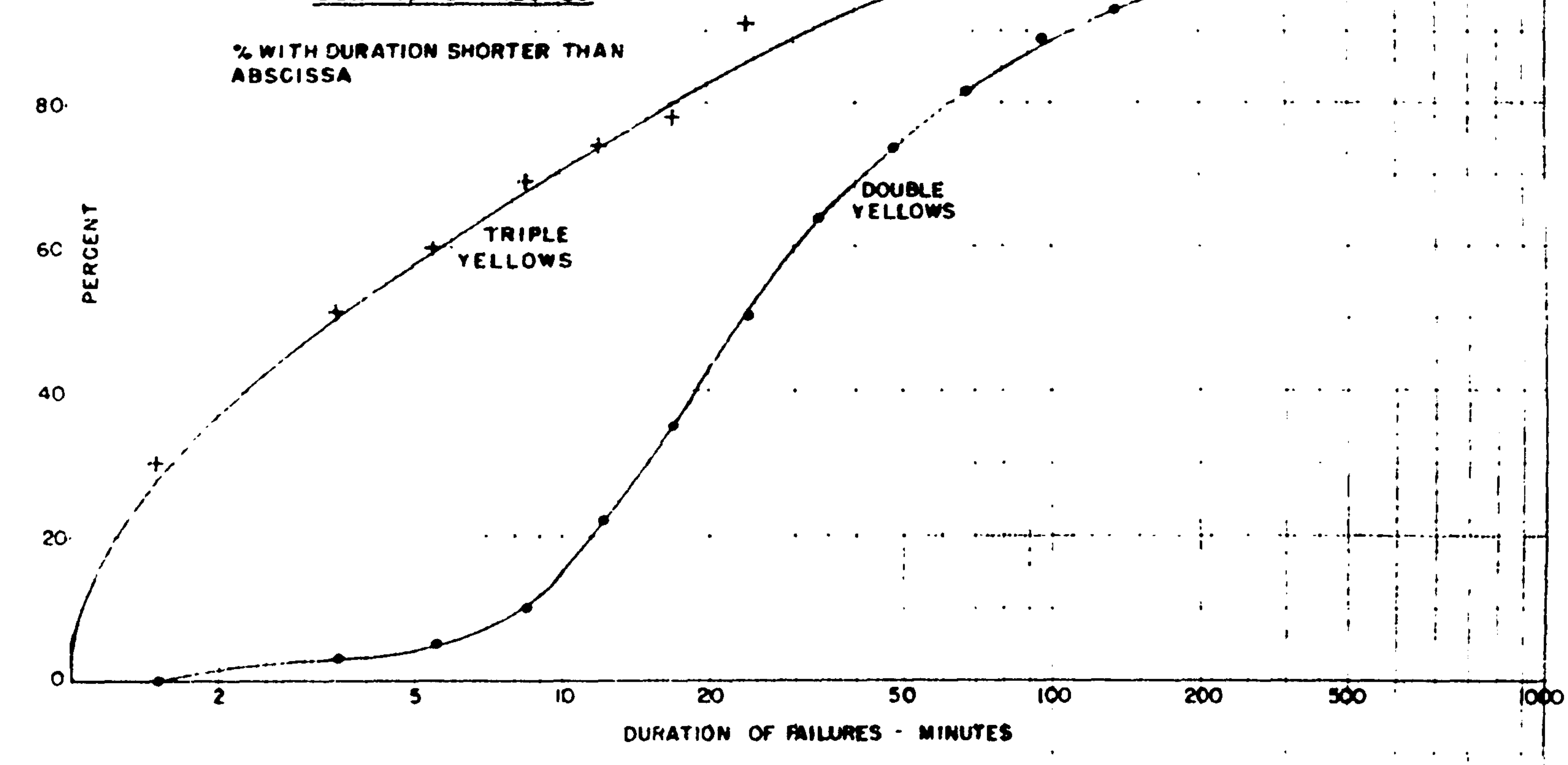


FIGURE 2.7
DURATION OF FAILURES IN MINUTES
NUMBER OF FAILURES DURING Y AR
DOUBLE YELLOWS
TRIPLE YELLOWS
1000
900
800
700
600
500
400
300
200
100
90
80
70
60
50
40
30
20
10
9
8
7
6
5
4
3
2
1
60
50
30
20
10

FIGURE 2.8

DURATION OF FAILURES



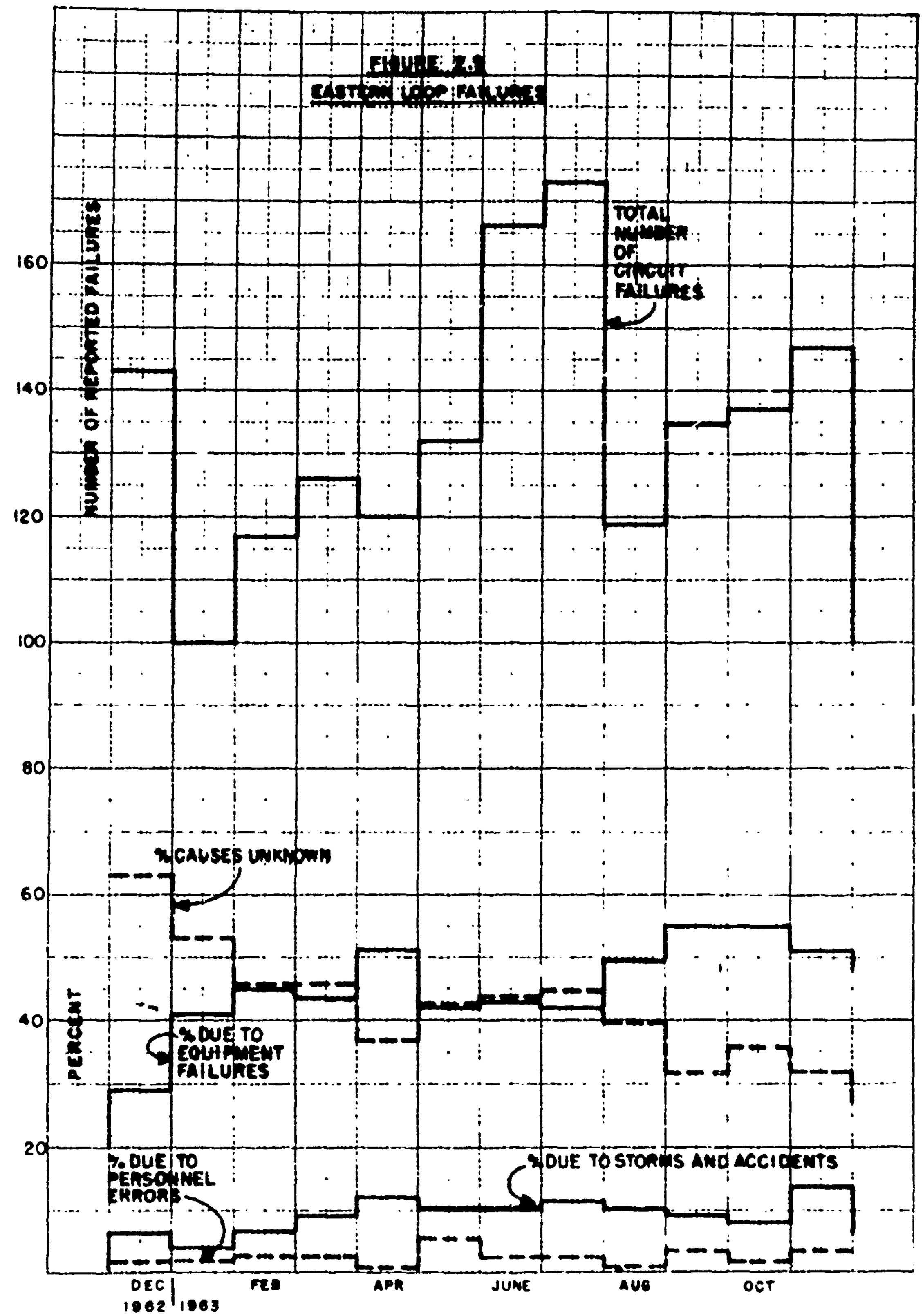


FIGURE 2.9
EASTERN LOOP FAILURES
NUMBER OF REPORTED FAILURES
160
140
120
100
80
60
40
20
PERCENT
TOTAL NUMBER OF CIRCUIT FAILURES
% CAUSES UNKNOWN
% DUE TO EQUIPMENT FAILURES
% DUE TO PERSONNEL ERRORS
% DUE TO STORMS AND ACCIDENTS
DEC
1962
1963
FEB
APR
JUNE
AUG
OCT

FIGURE 2.10

WESTERN LOOP FAILURES

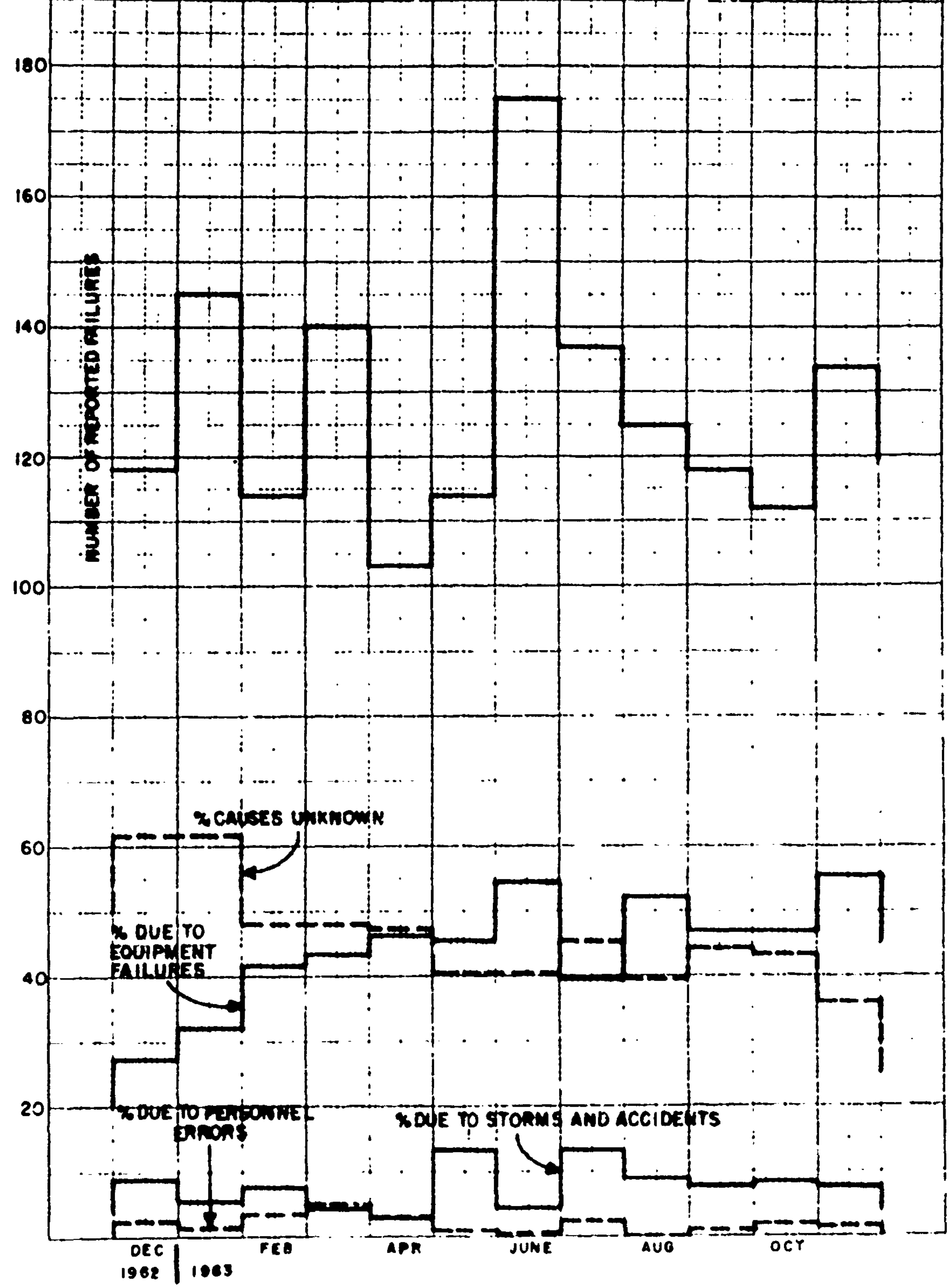
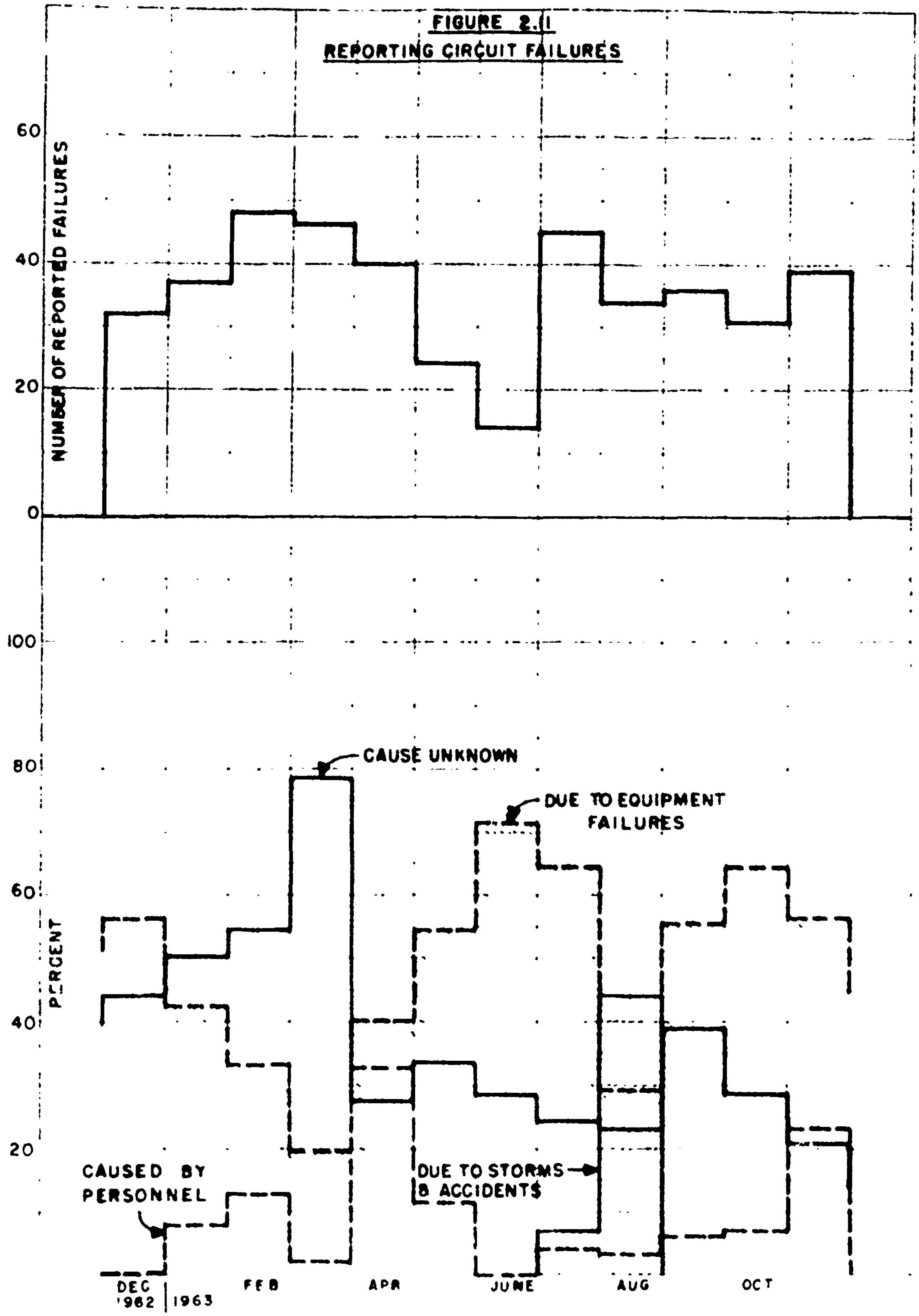


FIGURE 2.1

REPORTING CIRCUIT FAILURES



2.1.7.a Equipment Failures. This category includes failures of telegraph repeaters, carrier equipment and radio equipment.

2.1.7.b Personnel Errors. This category includes losses due to errors in the course of maintenance, operation and testing of the system.

2.1.7.c Storms and Accidents. This category refers principally to loss of telegraph and power wires.

It is interesting to note that the "% Causes Unknown" and "% Due to Equipment Failure" move in an almost complementary manner. This suggests the possibility that the unknown causes are for the most part equipment failures and that the increases in the latter are due to more stringent investigation procedures.

No failures on the reporting circuits due to storms and accidents were reported except in July and August. The high percentage in this category in August is due to the accidental cutting of a cable between Colorado Springs and Ent AFB which was recorded as a failure on each of the 12 circuits so that the percentage for this cause was inflated.

2.1.8 Circuit Failure Correlation

An attempt was made to correlate the number of failures per year to circuit length and to the number of telegraph repeaters in the circuit. Neither function shows a strong correlation, but the number of failures as a function of the number of repeaters is the better of the two. On both plots of the eastern loops the two worst loops (111 and 118 failures) share a remarkably poor facility. These plots are included in Figures 2.12, 2.13, 2.14 and 2.15.

2.1.9 False Reds

All of the false reds occurring during the year were single-sensor (Communicator's Panel) alarms. None were displayed on the Maps and were, therefore, not full alarms. The seventeen false alarms were distributed as follows:

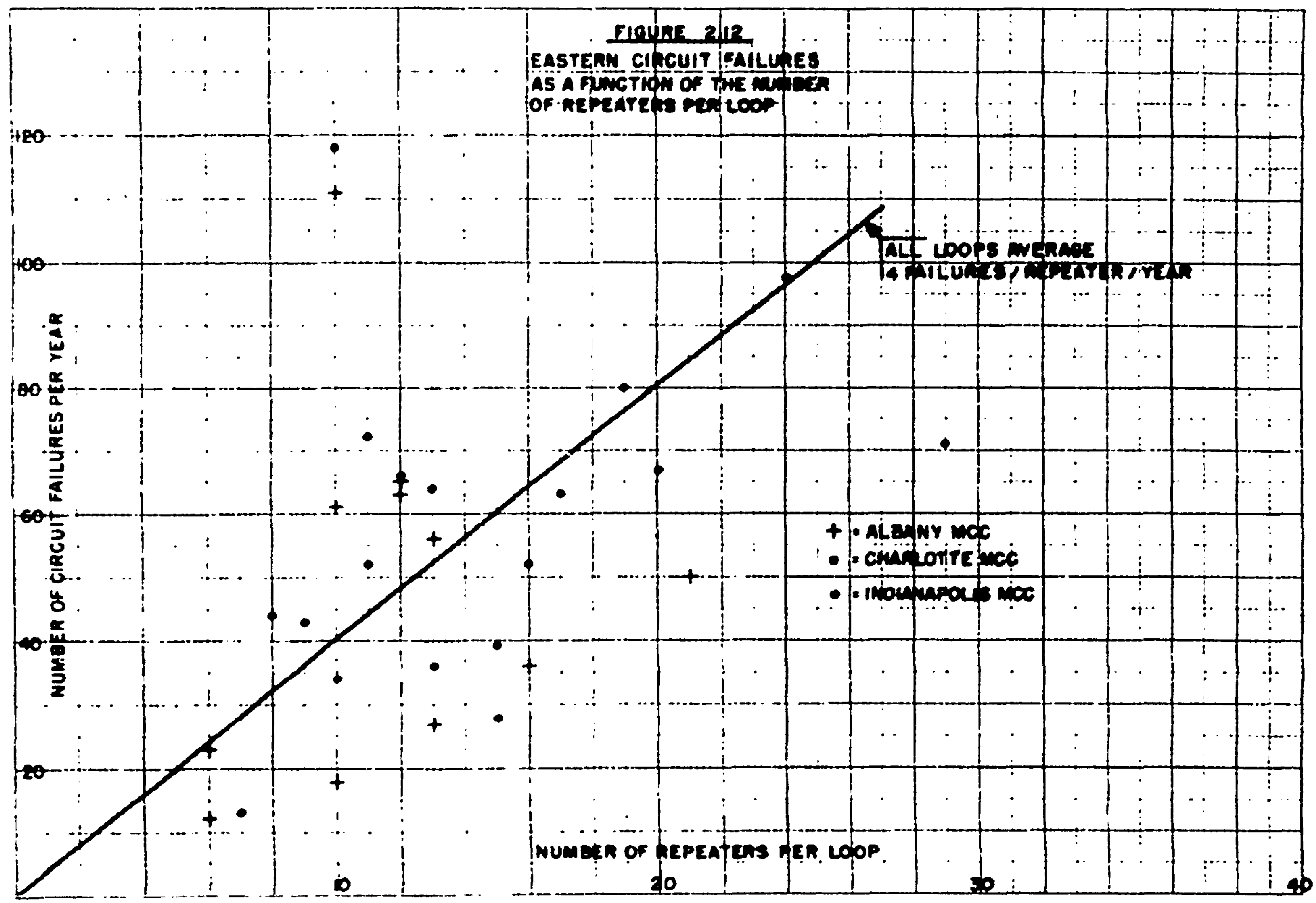


FIGURE 2.12
EASTERN CIRCUIT FAILURES
AS A FUNCTION OF THE NUMBER
OF REPEATERS PER LOOP
ALL LOOPS AVERAGE
4 FAILURES / REPEATER / YEAR
+ = ALBANY MCC
● = CHARLOTTE MCC
● = INDIANAPOLIS MCC
NUMBER OF CIRCUIT FAILURES PER YEAR
NUMBER OF REPEATERS PER LOOP
120
100
80
60
40
20
10
20
30
40

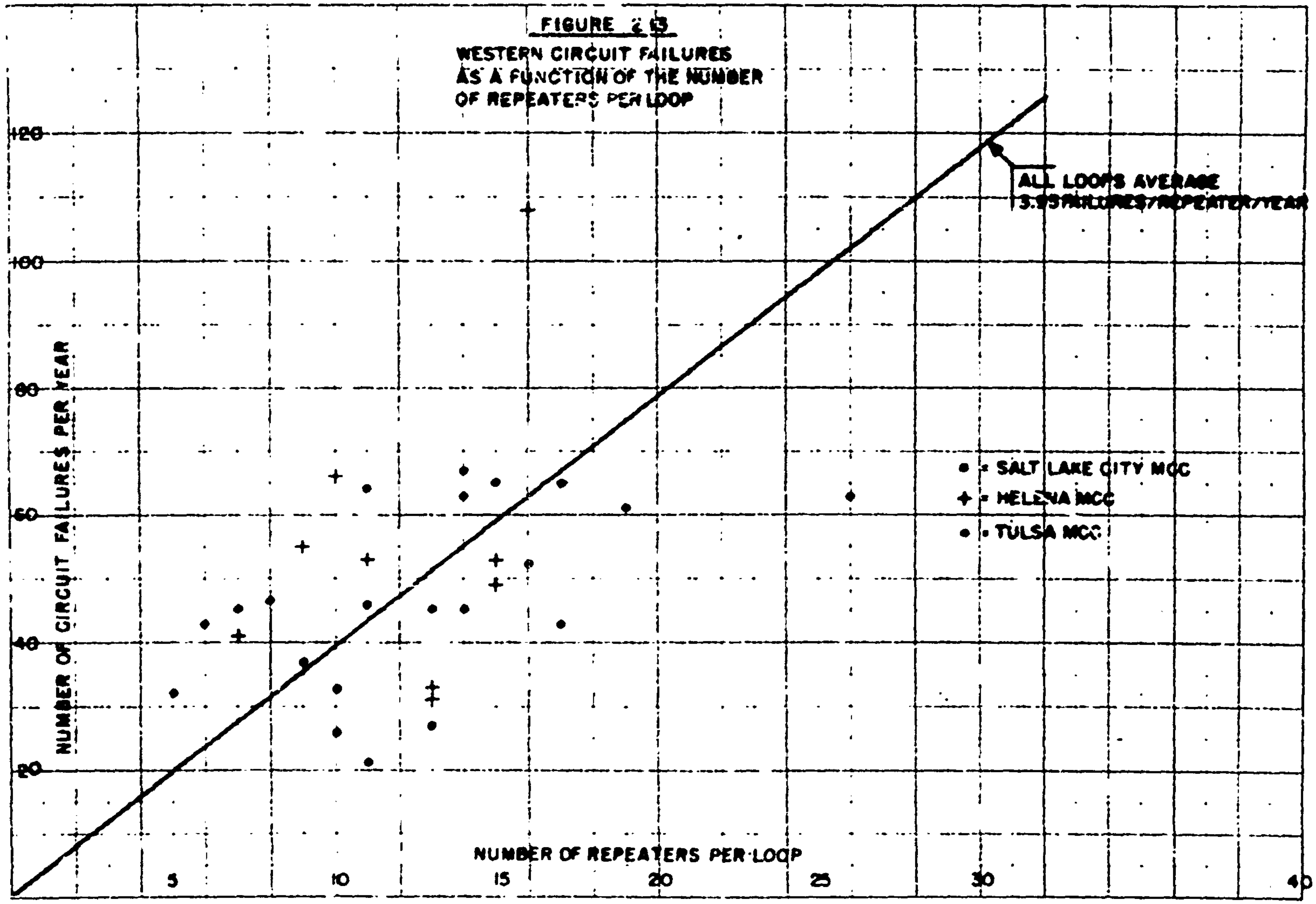


FIGURE 2.3
WESTERN CIRCUIT FAILURES AS A FUNCTION OF THE NUMBER OF REPEATERS PER LOOP
ALL LOOPS AVERAGE 3.93 FAILURES/REPEATER/YEAR
• = SALT LAKE CITY MCC
+ = HELENA MCC
• = TULSA MCC
NUMBER OF CIRCUIT FAILURES PER YEAR
NUMBER OF REPEATERS PER LOOP
120
100
80
60
40
20
5
10
15
20
25
30
40

FIGURE 2.14

EASTERN CIRCUIT FAILURES AS A FUNCTION OF NOMINAL LOOP MILES

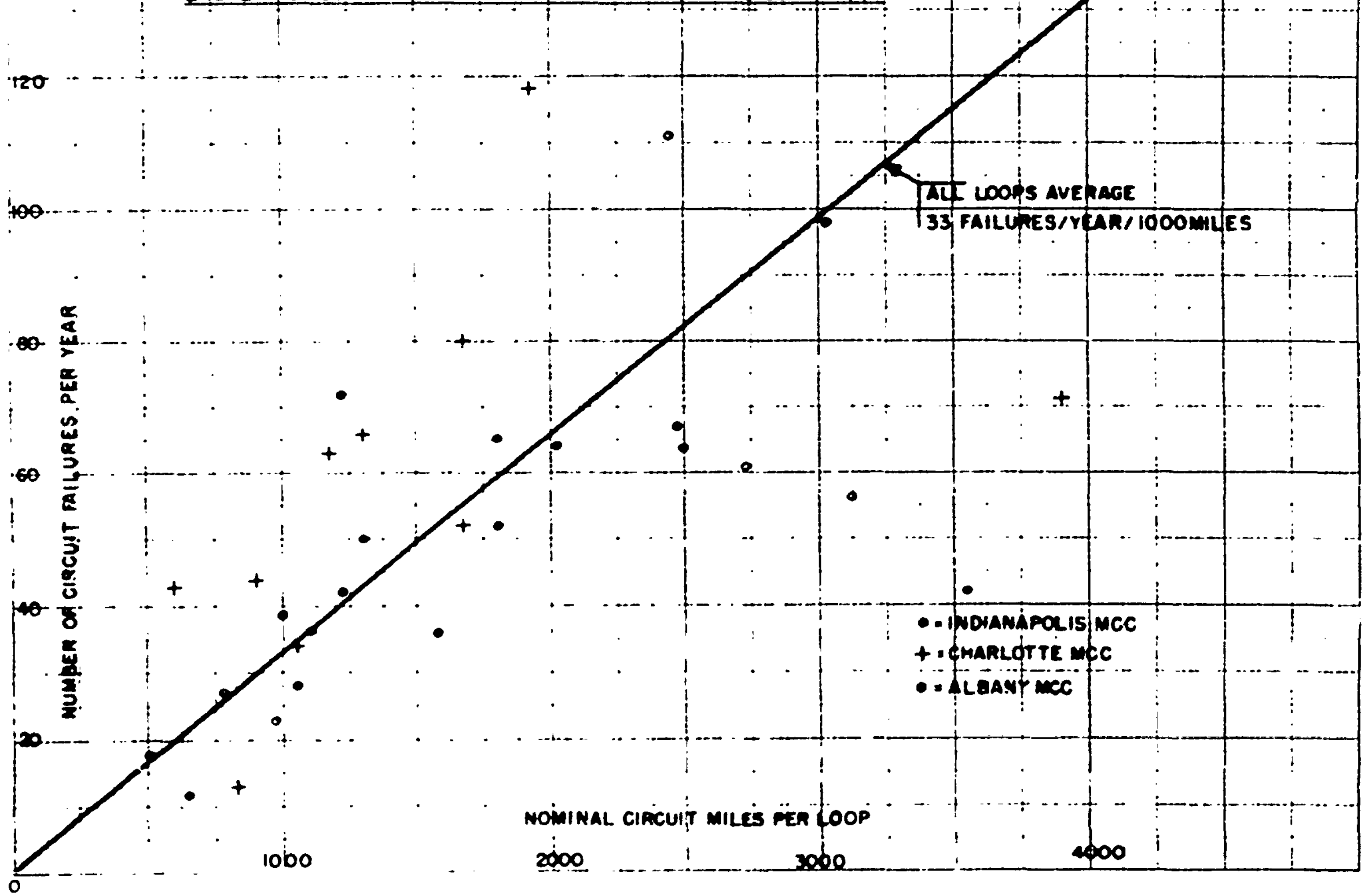


FIGURE 2.15

WESTERN CIRCUIT FAILURES AS A FUNCTION OF NOMINAL LOOP MILES

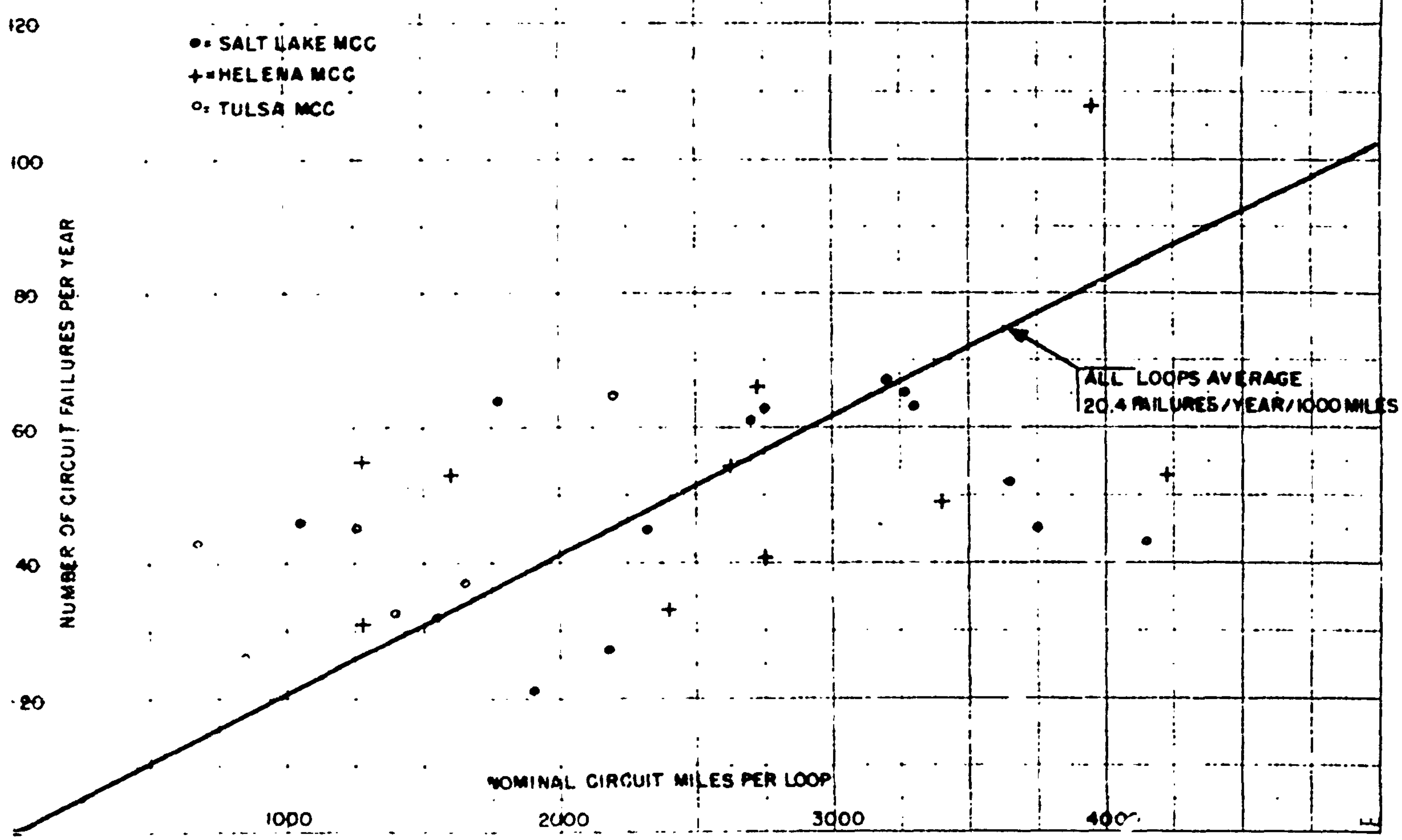


TABLE 2.2

	Power Storms	Personnel	Equipment	Garble	Undet.	Other
Dec. 1962			1			
Jan. 1963						
Feb. 1963	1					
Mar. 1963		1				
Apr. 1963	1	1				
May 1963						
Jun. 1963	1	1				
Jul. 1963						
Aug. 1963						1
Sep. 1963	1	1			1	
Oct. 1963		1	1	1		
Nov. 1963	2			1		

2.1.9.a False Alarms Caused by Storms and Power Failures Occurred as Follows:

(1) 2/19/63 - BX302 - FGB - Winter Park, Florida. One false red was generated during a heavy electrical storm. The power at this station was found to be fluctuating by the maintainer who arrived during the storm. Investigation by engineers revealed that this SGS would send out false red responses when the A-C line voltage was slowly reduced to below 80 volts and also when the SGS was jolted.

Three troubles were found. A broken wire and unsoldered joint were repaired and the delay relay was adjusted to operate properly.

(2) 4/19/63 - BX509 - JCC - Rocky, Oklahoma. One false red was received at all DC's except Richards Gebaur (faulty relay contacts here). Investigation at the SGS revealed maladjusted contacts on the delay relay. Any loss of A-C power would cause the SGS to transmit NY's and occasionally a CY.

As a result of this trouble and the similar trouble at FGB, field personnel were instructed to check and adjust all relays.

(3) 6/12/63 - BX404 - GJP - Brookville, Kansas. One red message was received at all DC's. This station, according to the monitors at the Salt Lake MCC, had transmitted test reds during the idle period between polls twice, at two minute intervals, just prior to transmitting the false red. The Kansas City area engineer found this SGS to have a faulty flip-flop which caused trouble whenever the power was turned off and on. The test red condition could be duplicated but the false red could not be generated in the laboratory.

(4) 9/16/63 - BX601 - MGU - Game Refuge, North Dakota. One false red message was received at all DC's. This alarm message was generated during a severe electrical storm which caused many power dips (21 were recorded by a telephone operator at the game refuge in a one hour period). The false alarm condition could not be artificially duplicated.

(5) 11/9/63 - BX401 - GFM - Ephrata, Washington. A false alarm referred to as "one" red was apparently two, twenty-one minutes apart. Fairly heavy winds and rain were reported in the area. The maintainer found the Sensor loop shorted 20 ohms from the SGS. When the loop was restored, the maintainer reported that the SGS operated normally. It had not been operating properly just prior to the false alarm. The false red could not be duplicated by the engineer who investigated.

(6) 11/20/63 - BX508 - JJJ - Chula Vista, California. A false alarm was transmitted to all DC's and recorded everywhere excepting March Field. The Tulsa monitor recorded "JJCYJJJCY" during the idle time between polls. It was reported lightning had struck and blown out a high-line transformer furnishing A-C power to this section of the state. An emergency power plant restored power in five minutes. It is not known whether the red was transmitted before or after emergency power was applied. The engineer detailed to this investigation could not reproduce the false red during three days of testing.

2.1.9.b <u>False Alarms Caused by Personnel Occurred as Follows:</u>

(1) 3/13/63 - CCJ, BCP, BFJ, JFM, MCC, JMB, BMC Classified Location Only. A Western Union maintainer caused seven single red alarms at the Classified Display Center while working on the DC equipment.

(2) 4/11/63 - Albany, New York. The Albany MCC transmitted five (5) red messages to all DC's during released time obtained from Military Control for the purpose of making his semi-weekly local red test. The transmission was caused by a faulty blinding switch at the MC station. The procedures under which red testing is conducted were tightened in an attempt to reduce this type of failure.

(3) 6/4/63 - BX8 - FMM - Thule, Greenland. One false red was transmitted to all DC's due to a faulty maintenance procedure. Thule had asked for a 15 minute release to repair his SGS. Charlotte MCC was asked to patch this drop off, but because normal signals from the SGS appeared, made a restoration before authorized to do so. The false red arrived just after the premature restoration was made.

(4) 9/21/63 - BX109 - CBJ - Salem, Massachusetts. A false red was generated at Salem and was received at all DC's. A maintainer was working on the SGS without a release. An engineer was sent to talk to the maintainer.

(5) 10/7/63 - BX409 - GJF - Seattle, Washington. One false red was received at all DC's. A Western Union technician was attempting to obtain a part number for a component in the SGS. While attempting to get a close look, he inadvertently pushed the test relay which caused the SGS to transmit a false red to all DC's. No release had been requested or granted for this work.

2.1.9.c <u>False Alarms Caused by Equipment Failures Occurred as Follows:</u>

(1) 12/13/62 - BX409 - GJG - Salt Lake City MCC. A false red was transmitted from the Salt Lake City MCC while the monitor printer showed an incoming circuit garbling due to hits on the line between Seattle and Wenatchee. A faulty component was found on that part of the equipment designed to inhibit such occurrences.

SECRET

(2) 10/16/63 - BX409 - GGU - Salt Lake City MCC. A false red was received at all DC's from the Salt Lake City MCC. This was caused by defective diodes in the MCC decoder. (The defective diodes caused the change of a garbled message to a valid alarm message). A testing procedure to locate defective diodes in decoder equipment is under consideration.

2.1.9.d <u>Alarms Caused by Circuit Garble Occurred as Follows:</u>

(1) 10/17/63 - BX601 - BX603 - Helena MCC. The alarm message MMBCY was transmitted to all DC's by Helena MCC. This false red came in on a loop which did not have station MMB on it. It has been determined that there was a garble somewhere in the circuit during an MMG transmission which added BCY to the first two letters MM giving a legitimate address ahead of the "CY". This false red, therefore, constitutes one of the calculated risk reds appearing during disturbances causing junk on the circuits, and is the first one verified in the 13 months of operation since acceptance of this system.

(2) 11/16/63 - BX508 - JJC - Richards Gebaur DC. A false red was received at Richards Gebaur only during the transmission of junk to all displays from the MCC at Tulsa. The junk was generated when a carrier system failed. The DC at Richards Gebaur somehow decoded a legitimate alarm message out of the incoming garble. Excessive bias on the receiving relay may have been a contributing factor.

2.1.9.e <u>False Alarms from Undetermined and Other Causes Occurred as Follows:</u>

(1) 9/16/63 - BX503 - JJU - Maxwell Air Force Base. Maxwell AFB DC recorded receipt of a false red message for no apparent reason. The appropriate relay module was changed by the maintainer and a complete check of the system was made, but no trouble was found.

(2) 8/27/63 - BX108 - CFB - Booneville, New York. A false red was received at all DC's. The Telco was repairing the cable between the SGS and the Sensor. Most probably, either by a cross in the cable or by application of potential from a test set, the D-C supply current to the Sensor was reversed for a time sufficiently long to initiate the test cycle within the Sensor. Since the current reversal was not under the control of the SGS, the ensuing tone sequence was interpreted as a real alarm.

SECRET

2.2 RESPONSE TO HYPOTHETICAL ATTACK

In order to evaluate the performance of the Bomb Alarm System, the response of the system to part of the first 25 minutes of the hypothetical attack, provided by the Contracting Office, was estimated. This portion (See Table 2.3) included all bursts in the states served by the eastern MCC's and such bursts in Canada as might be visible to Sensors in these states. Bursts west of this area were considered insofar as they affected telegraph circuits between MCC's and SGS's, but are not included in the effectiveness statistics.

TABLE 2.3

Time Minutes	Location	Yield Mt	Elevation Feet	Reports
0.3	Montreal, Quebec	3.0	9200	1
1.0	Jacksonville, Florida	1.0	0	0
2.5	Depot, New York	3.0	0	0
5.0	Redford, New York	3.0	0	1
6.0	Annapolis, Maryland	1.5	3400	3
6.5	Mooers Forks, New York	3.0	0	1
7.4	Swaton, Vermont	3.0	0	1
7.5	Ausable Forks, New York	3.0	0	0
9.1	Keyser, West Virginia	9.0	6200	3
9.5	Pt. Henry, New York	3.0	0	0
9.6	Merrill, New York	3.0	0	0
11.2	Merrill, New York	3.0	0	0
11.3	Sault. Ste. Marie, Mich.	3.0	9200	1
11.4	Norfolk, Virginia	1.5	0	1
11.5	Chazy Lake, New York	3.0	0	0
12.0	Lewis, New York	3.0	0	0
12.3	Essex, New York	3.0	0	1
12.4	Hamilton, Rhode Island	1.5	0	0
13.6	Hamilton, Rhode Island	1.5	0	0
13.9	Keyser, West Virginia	9.0	6200	3
14.1	Alberg, New York	3.0	0	1
15.05	Bath, Maine	1.5	3400	2
15.20	Classified Location	100.0	0	1
15.20	Baltimore, Maryland	1.5	3400	4
15.40	Quonset Pt., R.I.	1.5	0	0
15.40	Elizabeth, New Jersey	1.5	3400	2
15.60	Dayton, Missouri	100.0	0	1
15.70	Eldorado Springs, Mo.	100.0	0	0
15.75	Ft. Bragg, N. Carolina	1.5	3400	1
15.80	Buffalo, New York	1.5	3400	1
15.95	Mobile, Alabama	3.0	0	0
15.95	Newark, New Jersey	3.0	0	1

TABLE 2.3 (Continued)

Time Minutes	Location	Yield Mt	Elevation Feet	Reports
16.00	Saugus, Massachusetts	1.5	3400	2
16.00	California, Missouri	100.0	0	1
16.05	Jersey City, N. J.	1.5	3400	1
16.10	Long Island City, N.Y.	3.0	0	1
16.15	Boston, Massachusetts	1.5	3400	1
16.15	Philadelphia, Pa.	1.5	3400	1
16.20	Griffiss AFB, N. Y.	1.5	3400	0
16.25	Portland, Maine	1.5	3400	0
16.30	Quarles, Missouri	100.0	0	0
16.40	Annapolis, Maryland	1.5	3400	2
16.45	Newport, Rhode Island	1.5	0	0
16.50	Jacksonville, Florida	1.5	3400	0
16.50	Bangor, Maine	1.5	3400	0
16.55	New York, New York	1.5	3400	0
16.60	Atlanta, Georgia	1.5	3400	1
16.60	Savannah, Georgia	1.5	3400	2
16.65	Homestead, Florida	1.5	3400	1
16.65	New London, Conn.	1.5	3400	0
16.70	Frederick, Maryland	1.5	3400	2
16.75	Jacksonville, Florida	1.5	3400	0
16.75	Newark, New Jersey	3.0	0	0
16.85	Eglin AFB, Florida	1.5	3400	2
16.85	Quarles, Missouri	100.0	0	0
16.85	Norfolk, Virginia	1.5	3400	0
16.85	Norfolk, Virginia	3.0	0	0
16.90	Bath, Maine	1.5	3400	0
16.90	Providence, R.I.	1.5	3400	0
16.90	Jersey City, N.J.	1.5	3400	0
16.95	Charleston, S. Carolina	1.5	3400	0
16.95	Eglin AFB, Florida	1.5	3400	2
17.00	Washington, D. C.	3.0	0	1
17.05	Washington, D. C.	3.0	0	1
17.15	Holden, Missouri	100.0	0	0
17.25	Brooklyn, New York	3.0	0	0
17.30	New Orleans, La.	1.5	3400	1
17.30	Virginia, Missouri	100.0	0	0
17.50	Mobile, Alabama	3.0	0	0
17.50	Prairie City, Mo.	100.0	0	0
17.55	Jacksonville, Florida	1.5	3400	0
17.60	Loring AFB, Maine	1.5	3400	0
17.65	Frederick, Maryland	1.5	3400	2
17.75	California, Missouri	100.0	0	0
17.80	Charleston, S. Carolina	1.5	3400	0
17.85	Mobile, Alabama	1.5	3400	0
17.85	Ft. Bragg, N. Carolina	1.5	3400	1

TABLE 2.3 (Continued)

Time Minutes	Location	Yield Mt	Elevation Feet	Reports
17.90	Classified Location	100.0	0	1
18.05	Newport, Rhode Island	1.5	3400	0
18.05	South Norfolk, Virginia	1.5	0	0
18.10	New York, New York	1.5	3400	0
18.30	Norfolk, Virginia	3.0	0	0
18.30	Fort Ritchie, Maryland	100.0	0	0
18.35	Key West, Florida	1.5	3400	0
18.35	Atlanta, Georgia	1.5	3400	1
18.55	Fort Ritchie, Maryland	100.0	0	0
18.60	Jacksonville, Florida	1.5	3400	0
18.65	Brooklyn, New York	3.0	0	0
18.90	Saugus, Massachusetts	1.5	3400	0
18.90	Flushing, New York	1.5	3400	0
18.95	Loring AFB, Maine	1.5	0	0
19.05	Miami, Florida	1.5	3400	0
19.15	Long Island City, N.Y.	3.0	0	0
19.15	Classified Location	100.0	0	1
19.20	Norfolk, Virginia	1.5	0	0
19.25	Ft. Belvoir, Virginia	3.0	0	1
19.40	South Norfolk, Virginia	100.0	0	0
19.40	Griffiss AFB, New York	1.5	3400	0
19.45	Squantum AFB, Mass.	1.5	3400	0
19.50	Jacksonville, Florida	1.5	3400	0
19.55	Homestead, Florida	1.5	3400	0
19.60	Newark, New Jersey	3.0	0	0
19.60	New York, New York	1.5	3400	0
19.65	Newport, Rhode Island	1.5	3400	0
19.70	Mobile, Alabama	3.0	0	0
19.70	Bangor, Maine	1.5	3400	0
19.75	Ft. Belvoir, Virginia	3.0	0	1
19.90	Higginsville, Missouri	100.0	0	0
19.95	Key West, Florida	1.5	3400	0
20.00	Bristol, Pennsylvania	7.0	5700	0
20.10	Jacksonville, Florida	3.0	0	0
20.10	Baton Rouge, La.	3.0	0	0
20.30	Leavenworth, Kansas	7.0	5700	1
20.35	Otis AFB, Massachusetts	1.5	3400	0
20.50	Lockbourne AFB, Ohio	7.0	5700	1
20.50	Clifton, New Jersey	3.0	0	0
20.55	Plattsburg, New York	7.0	5700	0
20.60	Memphis, Tennessee	3.0	0	0
20.85	Jacksonville, Florida	1.5	0	0
20.90	Des Moines, Iowa	3.0	0	0
20.90	Sawyer AFB, Michigan	7.0	5700	1

TABLE 2.3 (Continued)

Time Minutes	Location	Yield Mt	Elevation Feet	Reports
21.00	Albany, New York	3.0	0	0
21.00	Byron, Michigan	3.0	0	0
21.00	Kinchloe AFB, Michigan	7.0	5700	1
21.10	Pease AFB, N. Hampshire	1.5	3400	0
21.10	Wright Patterson AFB, Ohio	7.0	5700	2
21.15	McCoy AFB, Florida	1.5	3400	0
21.25	Seymour Johnson AFB, N.C.	7.0	5700	1
21.50	Albany, New York	3.0	0	0
21.55	Des Moines, Iowa	3.0	0	0
21.60	Jacksonville, Florida	3.0	0	0
21.65	Bristol, Pennsylvania	7.0	5700	0
21.90	Kinchloe AFB, Michigan	7.0	5700	1
21.95	Wurtsmith AFB, Michigan	7.0	5700	1
22.40	Little Rock AFB, Ark.	7.0	5700	1
22.45	Schenectady, New York	3.0	0	0
22.55	Westover AFB, Mass.	7.0	5700	0
22.65	McCoy AFB, Florida	1.5	3400	0
22.65	Sawyer AFB, Michigan	7.0	5700	1
22.70	Richmond, Virginia	3.0	0	0
22.75	Memphis, Tennessee	3.0	0	0
22.90	Leavenworth, Kansas	7.0	5700	0
22.90	Robins AFB, Georgia	7.0	5700	0
23.10	Turner AFB, Georgia	7.0	5700	1
23.10	Baton Rouge, La.	3.0	0	0
23.25	Lockbourne AFB, Ohio	7.0	5700	0
23.30	Pease AFB, N. Hampshire	1.5	3400	0
23.30	Robins AFB, Georgia	7.0	5700	0
23.40	Richmond, Virginia	3.0	0	0
23.55	McGuire AFB, N.J.	7.0	5700	0
23.65	Selfridge AFB, Michigan	7.0	5700	1
23.70	Wright Patterson AFB, Ohio	7.0	5700	0
23.85	Wurtsmith AFB, Michigan	7.0	5700	1
23.90	Seymour Johnson AFB, N.C.	7.0	5700	1
23.90	Westover AFB, Mass.	7.0	5700	0
24.00	Plattsburg, New York	7.0	5700	0
24.05	Centralia RCAFB, Ont.	3.0	9200	1
24.10	Jacksonville, Florida	1.5	0	0
24.20	McGuire AFB, N.J.	7.0	5700	0
24.35	Little Rock AFB, Ark.	7.0	5700	0
24.45	Selfridge AFB, Michigan	7.0	5700	1
24.50	Otis AFB, Massachusetts	1.5	3400	0
24.65	Turner AFB, Georgia	7.0	5700	1
24.95	Clifton, New Jersey	3.0	0	0

2.2.1 Data Presented

The results of the study are shown in three graphs (Figures 2.16, 2.17, 2.18) relating the performance of the system as a function of time.

2.2.1.a Effectiveness of Bomb Alarm System. Figure 2.16 presents the response of the Map alarm function of the system to the hypothetical attack. The heavy line indicates the total number of bursts in the time interval after the beginning of the attack, while the line enclosing the solid cross-hatching indicates the number of these bursts reported. The broken line enclosing the broken cross-hatching indicates the number of excess alarms produced when bursts trigger the Sensors of more than one target area.

2.2.1.b Sensor Availability. This curve (Figure 2.17) shows the number of Sensors remaining effective as a function of time after the beginning of the attack, both without telegraph circuit patching and with immediate patching. To indicate the rate of the attack the total number of weapons is also presented.

2.2.1.c Target Area Availability. This curve (Figure 2.18) indicates the number of Target Area Sensor Complexes remaining capable of reporting a Map alarm as a function of time. The "1 Sensor" curve indicates the number of target areas having only one remaining effective Sensor. These areas are capable of producing a Map alarm on a one-red-and-two-yellow-status basis. The "2 Sensor" curve indicates the number of target areas having two effective Sensors capable of producing the higher credence two-red-status Map alarm. The total attack curve is also included on this chart to indicate the rate of the attack.

2.2.2 Analysis of Results

While the information of the hypothetical attack did not include an exposition of the philosophy of assignment of the Design Ground Zero locations, an analysis of the targets in the portion of the attack included in this study indicates a certain pattern.

The first portion of the attack (0 to 15 minutes) is assumed to be on missile fields, with the majority of the bursts in the east falling in the Plattsburg, New York area. Since Plattsburg AFB is included in the Bomb Alarm System Target Area list, most of these were reported and the performance of the system runs quite high.

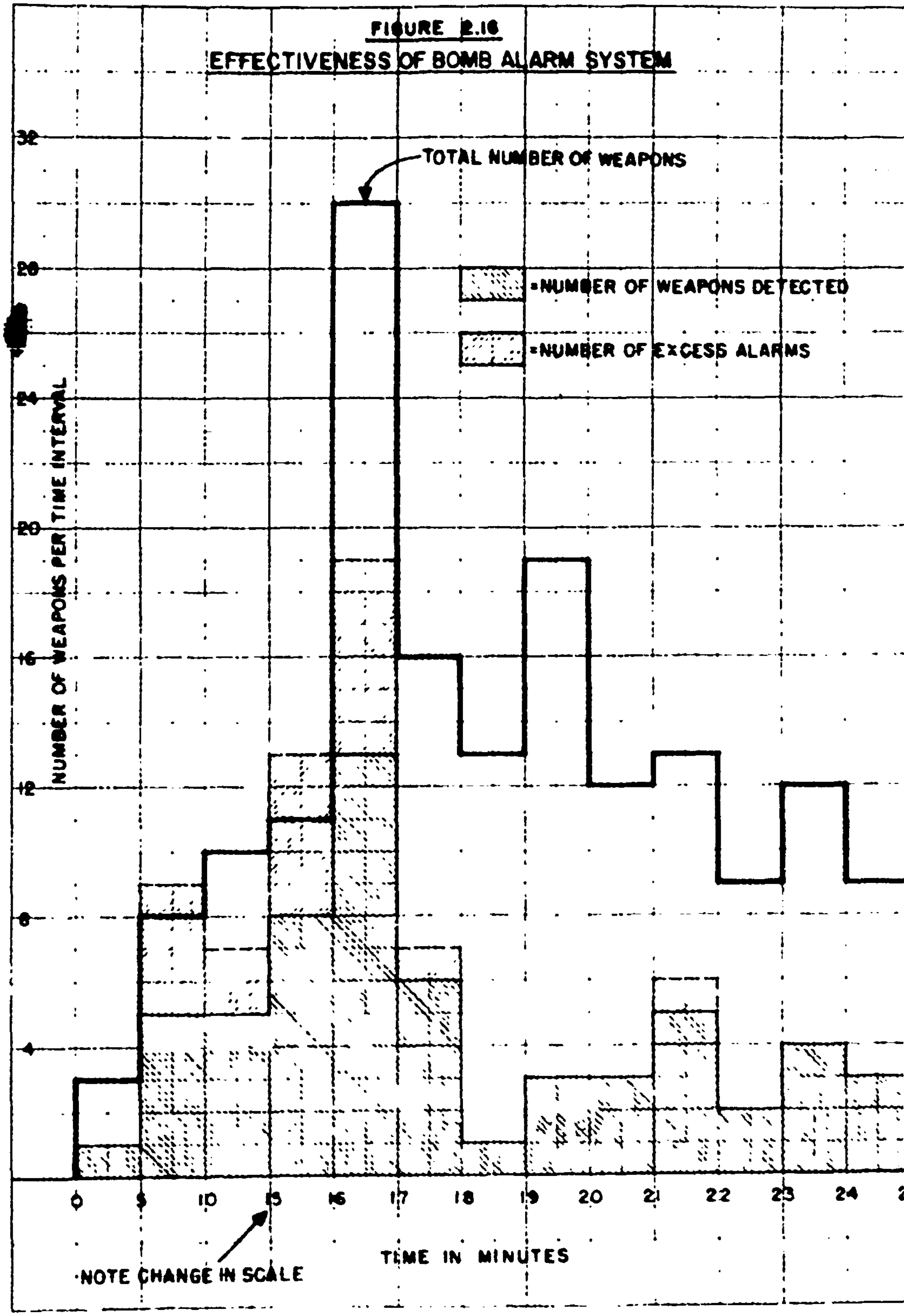


FIGURE 2.16
EFFECTIVENESS OF BOMB ALARM SYSTEM
TOTAL NUMBER OF WEAPONS
=NUMBER OF WEAPONS DETECTED
=NUMBER OF EXCESS ALARMS
NUMBER OF WEAPONS PER TIME INTERVAL
32
28
24
20
16
12
8
4
0
5
10
15
16
17
18
19
20
21
22
23
24
25
TIME IN MINUTES
NOTE CHANGE IN SCALE

FIGURE 2.17

SENSOR AVAILABILITY

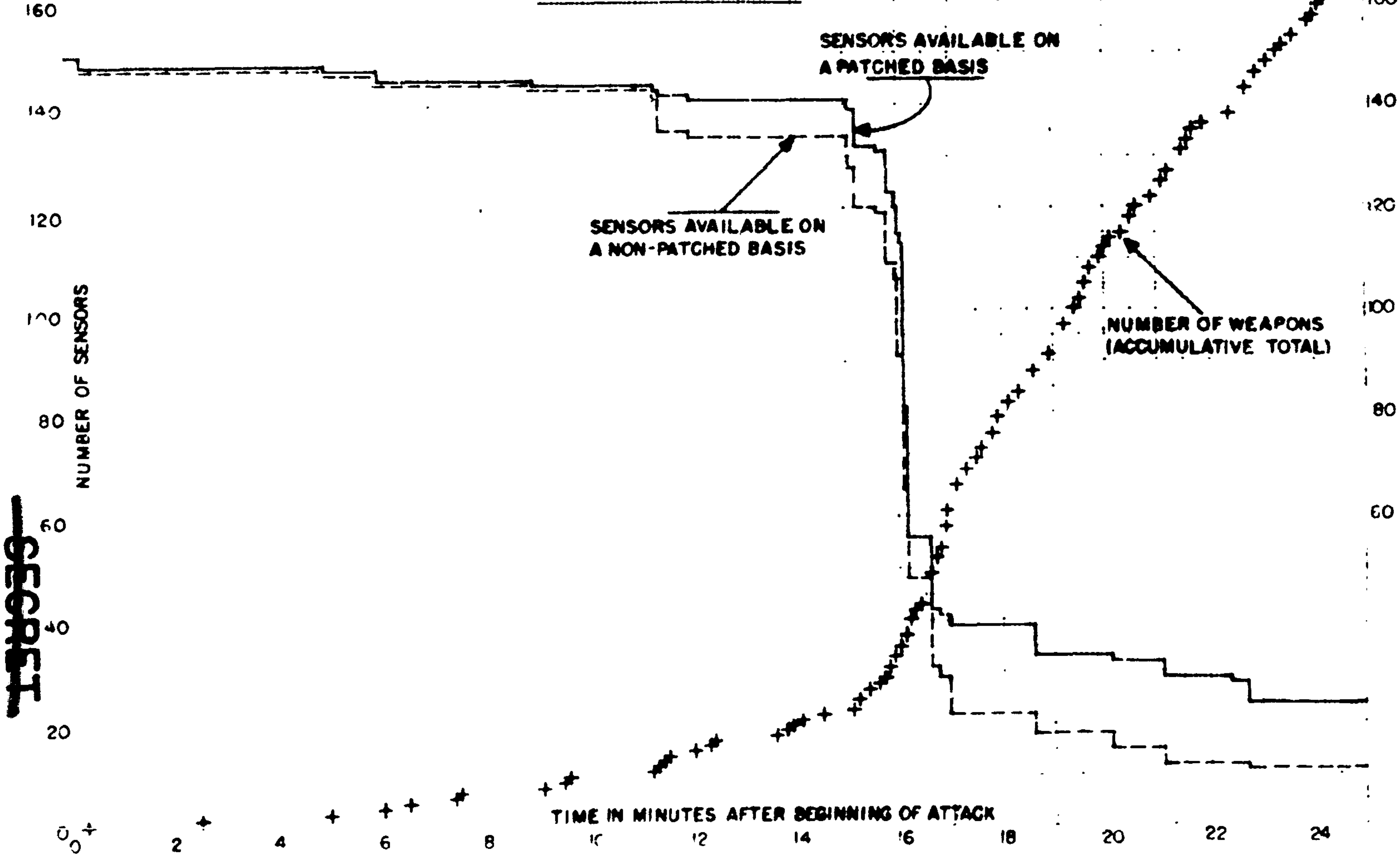
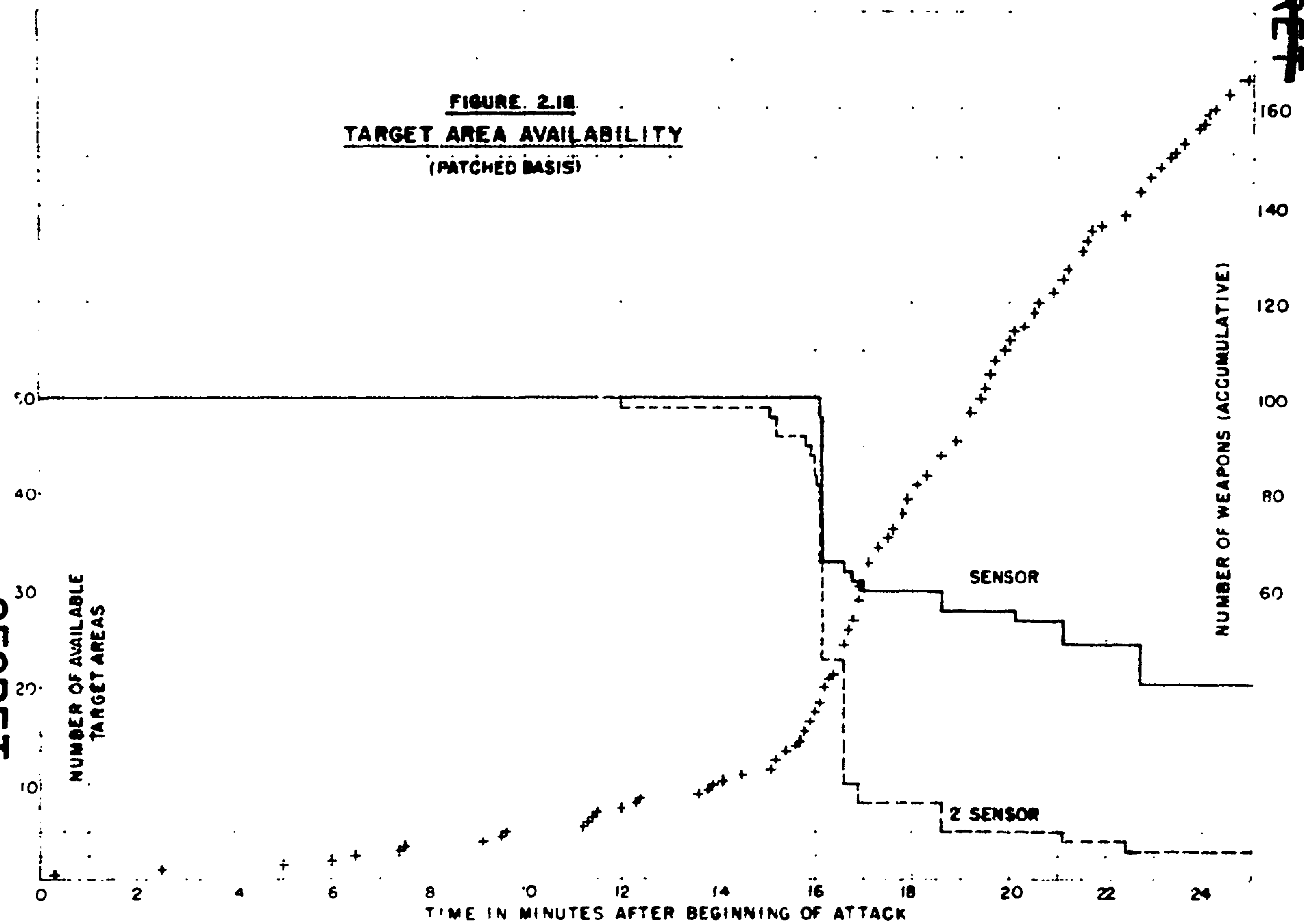


FIGURE 2.18

TARGET AREA AVAILABILITY

(PATCHED BASIS)



The second portion of the attack (15 to 20 minutes) is against population centers, except for a heavy concentration of large weapons in an area of no known significance in western Missouri. The rate of attack is sharply increased starting at this time interval, and the time base of the Effectiveness Chart (Figure 2.16) was changed at this time. The increased rate is reflected as a severely increased slope of the Number of Weapons Curve (Figures 2.17, 2.18). Since the population centers are also major communications centers, this portion of the attack reduced the availability of Sensors sharply. During the first minutes of this period many of the weapons were detected and reported. By minutes 18 and 19, however, facilities to Sensors and SGS located around communications centers were disrupted sufficiently to reduce the reporting rate substantially.

The third portion of the attack (20 to 25 minutes) is centered on Bomb Alarm System target areas. As a result, the proportion of these bursts reported is increased although many of the facilities are destroyed and many of the Sensors are unable to report.

2.2.3 Methods of Response Analysis

2.2.3.a <u>Time Distributions</u>. The times of the bursts were assigned at random within the time intervals designated in the attack document. The minimum time interval used was 0.1 minute for the first 14.9 minutes and 0.05 minute for the balance of the study.

2.2.3.b <u>Detection Criteria</u>. It was assumed that a burst at ground level could be seen at a distance of 40 miles, except where terrain interference was known to exist. Bursts at higher elevations were assumed visible at the horizon distance calculated by the equation:

$$D = 1.23\ (h)^{\frac{1}{2}}$$

where D = distance to horizon in miles

h = elevation in feet.

No weight was given to atmospheric attenuation, effects of cloud cover or other factors affecting detection.

2.2.3.c Loss of Facilities. It was assumed for the study that all facilities lying within the 5 psi overpressure contour will be destroyed and all outside this contour will survive. The travel time of the overpressure front was considered in the reporting capability of Sensors and SGS's, permitting, in appropriate circumstances, a report to be released prior to destruction of the facilities.

In addition to the loss of facilities between the SGS's and MCC's some reporting circuits were lost between the MCC's and various DC's. In the study, all Sensors reporting to an MCC were assumed to be lost if sending from the MCC to all DC's was interrupted on both the main and fallback reporting channels.

2.2.3.d Patching. In the telegraph circuit configuration employed for the SGS loops, it is possible to by-pass an inoperative SGS circuit by manual patching or re-routing of the telegraph circuit at a communications center. This will restore to service other SGS's sending through the faulty facility to the MCC. In the effectiveness study it was assumed that a patch was made in two minutes to restore SGS's cut off by interruption of the facilities.

2.3 BOMB ALARM SYSTEM REPEAT CAPABILITY

The BAS was designed to be a system for the purpose of reporting, with highest reliability, the first alarm of a nuclear detonation at any of a number of selected target areas. As such, it has a definite but limited capability to detect and report successive detonations. The following discussion will evaluate the repeat capability of the system in terms of (1) its inherent capability and (2) its capability as related to the hypothetical attack considered.

2.3.1 Present System Philosophy

Each of the selected target areas is covered by a triad of optical Sensors. Each of the Sensors is connected to a SGS which contains the circuitry necessary to store and transmit the Sensor status in telegraphic code. Each of the three SGS's is connected to one of three MCC's to which it reports the status of the Sensor either on command (Poll) or immediately following a detected nuclear detonation (Event). The MCC's collect data from the SGS's both serially and in parallel and repeat this data to the DC's serially with a parallel output for each DC.

The country is divided into two geographic areas. Within each of the areas there is an autonomous system of three MCC's as described above. All of the MCC's operate asynchronously.

The data transmission speed is 60 words per minute and is constant for the entire system. The code employed is 7.5 unit with bit width of 22 ms. The duration of one character is, therefore, 165 ms.

All intelligence is transmitted as five-character code groups, the first three characters being the address of the SGS (and Sensor) and the last two being the status. The first character is unique to one of the MCC's while the second and third characters are unique to one target area in each of the two geographic areas. The transmission time of the standard five-character message is 825 ms.

The reporting order is from the Sensor to the SGS to the MCC to the DC. Each of these points in the system has its own measure of repeat capability and each is subject to variation by a different set of conditions. The reporting system presently imposes more severe limitations on repeat capability than the Sensor.

The optical Sensor completes its detection cycle in two seconds. This is a minimum figure based upon its designed range of weapon yields.

The SGS registers the alarm at the end of approximately one and one-half seconds but requires additional time to transmit the alarm to the MCC. It cannot register a second alarm from its Sensor until the first one has been transmitted. Various numbers of SGS's are connected together serially and the data transmission rate of the entire serial string is limited to 60 words per minute. Under certain conditions of multiple alarms, or alarms coincident with a poll, loop traffic is generated much faster than it can be transmitted to the MCC. Each SGS has a seven-character storage and excess loop traffic is diverted to the storage of one or more SGS's to await its turn for transmission.

The MCC collects data, serially, from a number of parallel inputs and repeats this data, serially, to each of the DC's. The MCC polls all of its loops, in parallel, to determine availability for each of the two following conditions:

2.3.1.a Standby - two sequential polls are conducted in each two minute interval.

2.3.1.b Attack - a poll (yellow search) is conducted immediately after repeating all alarm messages to the DC if all the SGS loops are idle.

For the condition of multiple events in rapid sequence at multiple target areas, the rate of data into the MCC may exceed its output capability. Therefore, it has a limited repeat capability which may impose further restrictions on the system in addition to those of the SGS.

The DC receives from a number of MCC's in parallel and displays the information in the form of lighted lamps on either the Communicator's Panel or Map. The alarms remain displayed until a manual reset is performed. Therefore, any repeat capability of the system reporting to the DC can only be realized by a manual reset at the DC.

In order to optimize the original system concept of reporting the first alarm with highest reliability, two alarm messages are sent for each detected event. Inclusion of the redundant message effectively halves the repeat capability of the reporting system. In addition, neither the MCC nor the DC can differentiate between the redundant alarm of one event and the alarm of a succeeding event reported by a common SGS.

2.3.2 SGS Repeat Capability

The two factors, other than data transmission rate, which limit the repeat capability of the SGS are: They are connected together serially, in varying numbers, each acting as a regenerative repeater for the preceeding one. They send two alarm messages for each event, the second being redundant.

2.3.2.a Circuit Configuration of SGS's. SGS's are "looped" together serially to each of the MCC's as indicated (Figure 2.19). The loop shown contains seven SGS's, which is the maximum number per loop presently within the system. A breakdown of all the loops in accordance with the number of SGS's on each is:

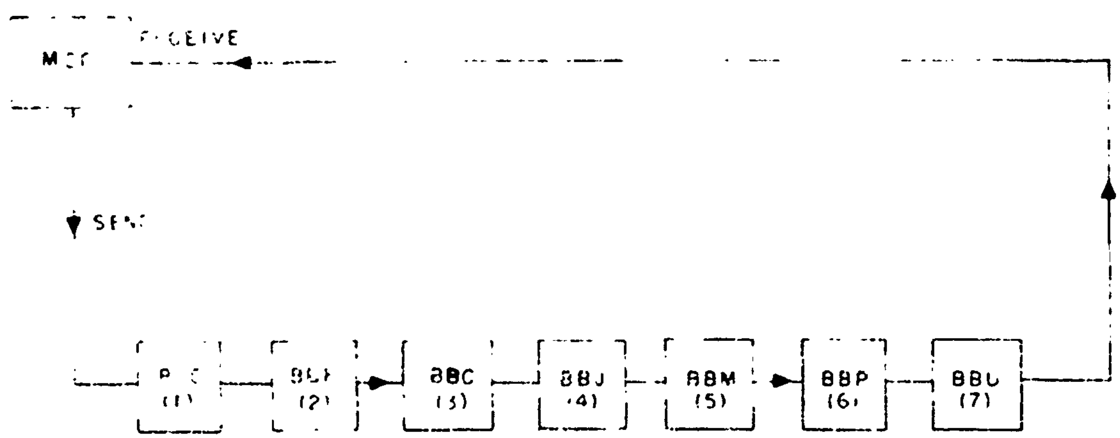


FIGURE 2.19
SGS LOOP DIAGRAM

TABLE 2.4

Number of Loops	SGS's per Loop
6	1
3	2
7	3
17	4
11	5
19	6
4	7
67	

Each of the MCC's checks the availability of its SGS's twice in each two minute interval and makes a single composite report to the DC. To do this the MCC sends a poll message to all its loops, in parallel, twice in each two minute interval. As each of the SGS's receives the poll message, it regenerates it and adds its status message immediately behind on the idle line condition. It adds a status message only if the Sensor is operating normally (green). If a Sensor or SGS is not operating, no response is made by the SGS and the MCC later sends a yellow status message to the DC. Assuming all Sensors are operating normally, a polling sequence for the loop illustrated, as received by the MCC, would be as follows: BBBG(space), BBCW(space), BBFW(space), BBGW(space), BBJW(space), BBMW (space), BBPW(space), BBUW(space), where BBBG(space) is the poll message (request) and W(space) is the green status (answer). It will be noted that the #1 SGS, BBC, has only to regenerate the poll message and its own response whereas the #7 SGS, BBU, regenerates the poll message together with all the responses from the preceding SGS's and then adds its own response. The probability of there being incoming traffic at any SGS under routine conditions of standby polling is, therefore, related to its position on the loop.

TABLE 2.5

SGS Position on Loop	Probability of Incoming Traffic
1	1.4%
2	2.8
3	4.1
4	5.5
5	6.9
6	8.2
7	9.6

When a SGS finishes responding to an event, at approximately 1.5 seconds of the sensor cycle, it will report it as two identical five character alarm messages to the MCC. Transmission of the first alarm must be completed and the second initiated (programmed in storage) before the SGS can register a succeeding event. The SGS will transmit under one of the following two conditions:

(1) Idle Line: If there is no traffic on the line (loop), between the send side of the MCC and the SGS responding, the two alarm messages are sent immediately. Each requires a transmission time of 825 ms or 1.65 seconds total.

(2) Busy Line: If there is traffic on the line, normal polling or additional alarm messages, the first alarm is sent immediately following the end-of-message character of the status message being regenerated. The second (redundant) alarm is sent when the line is idle. Therefore, start of transmission of the first alarm message can be delayed an additional 825 ms maximum but the second (redundant) alarm can be delayed up to 8 message lengths or 6.6 seconds.. This would be true of the #7 SGS for an alarm just after start of poll.

To illustrate the above, assume that the #1 SGS is ready to report an event just after start of poll. Its response would be: BBBG(space), BBCCY, BBCCY, where CY is the red status. The event would have just been registered when polling began and the first alarm would be delayed 825 ms (duration of poll message). The time for the SGS to be ready to repeat would be 1.65 seconds as measured to the start of transmission of the second alarm message.

If an event is detected by the #7 SGS, its response would be (poll), (#7 alarm 1), (#1 green), (#2 green), (#3 green), (#4 green), (#5 green), (#6 green), (#7 alarm 2). Again, the first alarm is delayed only 825 ms but the elasped time to start of transmission of the second alarm message (ready to repeat) is 6.6 seconds.

It will be noted that transmission of the first alarm message is never delayed more than 825 ms maximum. Also, the above are worst case conditions which assume that the poll has just begun. For the intermediate SGS's between #1 and #7, their times to be ready to repeat are proportional to their positions on the loop.

The above are the ranges of ability to detect a second event following the first event of an attack. Because of present system philosophy, the probability of traffic on the loop is high following the first event. This is true because the MCC is programmed to poll all its loops after an alarm is received as soon as all its incoming lines are idle. It does this for the purpose of determining possible additional damage by ascertaining which of the SGS's are not reporting. All yellow reports only are sent to the DC where they may be combined with the red report (alarm) to light Map Display lamps. Polling after an alarm has the effect of limiting the repeat capability of the SGS's for subsequent events as described above.

2.3.2.b Interdependence of SGS's. Repeat capability is also impaired for the condition of simultaneous detection of one or more events by some or all of the SGS's on a loop. The time required for each of the SGS's is again related to its position on the loop and the worst repeat capability is that for the #7 SGS on a 7 SGS loop. Assuming the worst case where all SGS's on a loop detect event(s) simultaneously, the times for the SGS's to be ready to repeat are:

TABLE 2.6

Position and Total Number of SGS on Loop	Time (Sec.) Ready to Repeat
1	.825
2	2.5
3	4.1
4	5.8
5	7.4
6	9.1
7	10.7

The above times assume no traffic on the loop. If there is traffic, the times are increased by a maximum of 825 ms and the worst repeat capability is then 11.5 sec.

2.3.2.c Summary. The time required for a SGS to be ready to repeat can vary between .825 sec. minimum and 11.5 seconds maximum and is dependent upon:

(1) The position of the SGS on the loop.

(2) The probability of traffic on the loop, either normal polling or additional alarms, at the time of an event.

The BAS is divided into two geographic areas. Within each geographic area, each of the target areas is monitored by each of the three MCC's. Each of the MCC's controls a number of loops with varying numbers of SGS's on each.

TABLE 2.7

Master Control Center	Total Loops
B	12
C	10
F	11
G	11
J	12
M	11
	67

Since the loops are connected in a random manner, the repeat capability of each of the SGS at any target area is generally different. The table below indicates repeat capability of numbers of target areas in terms of one, two and three SGS repeat capability. The SGS repeat capability is proportional to its location on the loop as discussed above.

TABLE 2.8

SGS Location on Loop	Numbers of Target Areas Having: 1 SGS	2 SGS	3 SGS
1	47	17	3
2	35	17	9
3	11	33	13
4	6	22	25
5		8	24
6		2	21
7			4

For two SGS repeat capability, the location (time) given is a maximum for one; it may be the same or less for the other. For three SGS repeat capability, the location (time) given is a maximum for one; it may be the same or less for the other two.

Forty-seven target areas have one SGS with the highest repeat capability and these are scattered randomly through the system. They can detect and report successive weapons at minimum intervals of 2.3 seconds corresponding to the 1.5 second SGS response time plus the .825 second for the alarm message. This is increased by a maximum of 825 ms additional with traffic on the line. Thirty-five additional target areas have a single SGS repeat capability equal to the above plus 2.5 seconds if the #1 SGS simultaneously reports an alarm coincident with a start of poll, or 4.8 seconds maximum.

The single SGS repeat capability is useful for alarming the Communicator's Panel. The two and three SGS repeat capabilities are more significant in terms of present system philosophy which dictates that a "true" alarm is a Map alarm corresponding to alarm reports from a minimum of two out of three Sensors at a target area.

The SGS's with the best repeat capability have the least probable availability and survivability. This is true since any break in the serial loop prevents SGS's between the send side of the MCC and the break from reporting. The probability of isolation is greatest for those SGS's nearest the send side of the MCC.

2.3.3 MCC Repeat Capability

The MCC's receive from their SGS's in parallel and send to the DC's serially, at the same transmission rate, and therefore have a limited repeat capability. In the present system the MCC's receive from a maximum of 12 loops with the result that they may accept information 12 times faster than they send it. The MCC storage will accommodate one message from each of the SGS's and the MCC is programmed to search through and read out of storage in a fixed order. Therefore, when simultaneous alarms are received from several SGS's on several loops, there will be an interval whereby a second alarm from a common SGS can be received on top of the first one before it is read out. The maximum repeat capability of a Sensor and SGS is 1.5 plus .825 or 2.3 seconds. This corresponds to a maximum of two simultaneous alarms at the MCC to realize the best repeat capability of the Sensor and SGS. The probability of simultaneous responses, followed by another response in 2.3 seconds, at two target areas with the highest SGS repeat capability reporting to one MCC is considered remote, but it represents the limiting conditions.

It is important to note that the concept of repeat capability of the MCC has little meaning in the present system due to the redundant alarm message for each event. The redundant alarm message is delayed by the SGS until the loop is idle and this delay can be as long as 13 message lengths (10.7 sec) for a saturated 7 SGS loop. Regardless of the delay, the MCC cannot differentiate between the redundant alarm of one event and the alarm of a succeeding event.

2.3.4 DC Repeat Capability

The DC receives from all the MCC's, in parallel, and displays the alarms serially on the Communicator's Panel and Map. Each individual Sensor status is displayed on the Communicator's Panel. An alarm is displayed on the Map only for the conditions of (1) two or more red reports from a target area or, (2) 1 red report and two yellow reports from a target area. Since the reports are processed serially, it is necessary to store them in order to combine them for the two conditions described. The Map alarm is generally regarded as the "true" alarm since it provides additional credence.

Of all the system equipment, the DC is most limited in repeat capability. A Map alarm could be noted and a manual reset quickly performed, but this would result in a very low credence level for an additional alarm at that target area. For example, the transmission of three simultaneous alarms from a target area involves three transmission paths and three different delays. Since they are posted serially, the first two are sufficient to actuate the Map Display. If they are then reset, the third alarm arriving at a later time is left to combine with additional possible alarms from a succeeding event or yellows resulting in a false Map alarm. This is compounded by the redundant alarm message. The MCC, as a function of its repeat capability, may or may not transmit the redundant alarm to the DC. If it does, the number of possible combinations available to post a false Map alarm is increased still further.

2.3.5 Repeat Capability as Related to Hypothetical Attack

The repeat capability of the system, except for the DC, is not generally a significant factor in light of the hypothetical attack considered. When successive events did occur, they occurred in areas where the density of Sensors was small and saturation of the reporting system in that area did not occur. Conversely, there are high altitude events over areas with a high density of Sensors, but the time spacing of successive events is within the repeat capability of the system in that area. As examples of each of the above, the most exacting periods of the attack are as follows:

2.3.5.a Target Area JB. A high concentration of weapons occurred in the vicinity of this target area. Their times and the BAS responses are as follows:

TABLE 2.9

Time of Event (Min.)	Interval (Sec.)	SGS's Responding	Alarm
0.3	-	BJB,CJB,FJB	Map
2.5	132	BJB	C.P.
5.0	150	BJB,CJB(FJB lost)	Map
6.5	90	BJB,CJB	Map
7.4	54	BJB,CJB	Map
7.5	6	BJB,CJB	Map
9.5	120	CJB	C.P.
11.5	120	BJB	C.P.
12.0	30	CJB(BJB lost)	Map
12.3	18	CJB	Map
14.1	108	CJB	Map

The shortest time interval between successive events is six seconds, well within the repeat capability of the Sensor. The SGS's BJB, CJB and FJB occupy positions 1, 2 and 3 respectively, on their loops and have ample time to clear the alarm for the event at 7.4 before the event at 7.5, even for the condition of prior traffic on the loop. The MCC can process all the reports including the redundant alarms and repeat them to the DC. Manual reset at the DC would, for the time spacing involved, give a fairly reliable picture of successive events. A fallacy of the "Map Alarm" concept is revealed by events at 9.5 and 11.5. CJB, reporting the event at 9.5 would not actuate a Map lamp. If left stored, however, it will combine with BJB reporting the event at 11.5 and only one Map alarm will result from two widely spaced events. A similar combination is possible at any stage of an attack.

2.3.5.b A Series of High Altitude Events Over a Large Geographic Area with Multiple Sensors and Target Areas Responding. The analysis is with respect to repeat capability and assumes that the system survives, whereas much of the system does not survive as illustrated in another section of this study. The additional assumption is made that all MCC loops are idle just prior to the attack interval. This is probably not true but, short of considering the complete attack, this interval is considered as a "worst case" sample.

The following additional assumptions are made: (1) Aggregate reporting times to the MCC's and to the DC's are taken as the sum of integral message lengths without regard to additional small timing delays incurred by regeneration and transmission. (2) For those cases where several loops are reporting "simultaneously" to a MCC, the address first alphabetically will be assumed to arrive first. (3) When polled, each of the SGS's will respond green unless in the red mode.

For the listed data (Table 2.10) numbers in parenthesis indicate the positions of the SGS's on the loops involved during the attack interval.

TABLE 2.10

Time Of Event (Min)	Interval (Sec)	SGS's Responding	Loop No.	Total SGS's On Loop	MCC
16.40	-	BMB(4),BFF(3),BBF(2),BCJ(1)	209	4	B
		BCW(1)	207	2	B
		CCJ(2),CBF(1)	106	6	C
		CFF(3),CMB(2),CCW(1)	107	6	C
		FCW(6)	304	6	F
		FMB(2),FFF(1)	306	4	F
		FCJ(2),FBF(1)	308	3	F
16.50	6	BCM(6)	211	7	B
		CCM(5)	109	7	C
		FCM(4)	309	7	F
16.55	3	BGG(1)	210	5	B
		CGG(5)	107	6	C
		FGG(1)	304	6	F
16.60	3	BBC(4),BFJ(2),BBP(1)	206	6	B
		CBP(6)	103	6	C
		CFJ(5)	105	6	C
		CBC(6)	106	6	C
		FBC(1)	301	6	F
		FFJ(3),FBP(2)	305	3	F

TABLE 2.10 (Continued)

Time Of Event (Min)	Interval (Sec)	SGS's Responding	Loop No.	Total SGS's On Loop	MCC
16.65	3	BFG(3)	205	5	B
		BJP(4)	210	5	B
		BMC(4)	211	7	B
		CFG(3)	103	6	C
		CJP(6)	107	6	C
		CMC(3)	109	7	C
		FFG(2)	302	6	F
		FJP(7),FMC(3)	309	7	F
16.70	3	BMB(4),BFF(3),BBF(2)	209	4	B
		BCW(1)	207	2	B
		CBF(1)	106	6	C
		CFF(3),CMB(2),CCW(1)	107	6	C
		FCW(6)	304	6	F
		FMB(2),FFF(1)	306	4	F
		FBF(1)	308	3	F
16.75	3	BGG(1)	210	5	B
		CGG(5)	107	6	C
		FGG(1)	304	6	F

Location of burst together with target areas and numbers of Sensors responding are listed in Table 2.11. All alarms are Map alarms.

Target Area Responding		Annapolis Maryland HOB 3400'	Bangor Maine HOB 3400'	New York City, N.Y. HOB 3400'	Atlanta & Savannah Georgia HOB 3400' (2)	Homestead, Fla. New London, Conn. HOB 3400' (2)	Frederick Maryland HOB 3400'	Newark New Jersey HOB 0'
		16.40	16.50	16.55	16.60	16.65	16.70	16.75
Washington, D. C.	(MB)	3					3	
Baltimore, Md.	(BF)	3					3	
Dover AFB, Del.	(CJ)	3						
Classified Location	(FP)	3					3	
Ft. Ritchie, Md.	(CW)	3					3	
Dow AFB, Ohio	(CM)		3					
New York, N. Y.	(GG)			3				3
Atlanta, Georgia	(BC)				3			
Hunter AFB, Ga.	(FJ)				3			
Charleston AFB, S.C.	(BP)				3			
Homestead AFB, Fla.	(FG)					3		
Suffolk Co. AFB, N.Y.	(JP)					3		
Westover AFB, Mass.	(MC)					3		

The following points are noted:

(1) Nine events occur, two simultaneously at 16.6 and again at 16.65, within a total time interval of 21 seconds.

(2) The maximum number of Sensors responding simultaneously is fifteen, for the event at 16.40.

(3) Common Sensors see successive events in two cases. One group sees events at 16.40 and again at 16.70, a time interval of 18 seconds. Another group sees events at 16.55 and again at 16.75, a time interval of 12 seconds.

(4) The maximum number of SGS's responding on a loop is four.

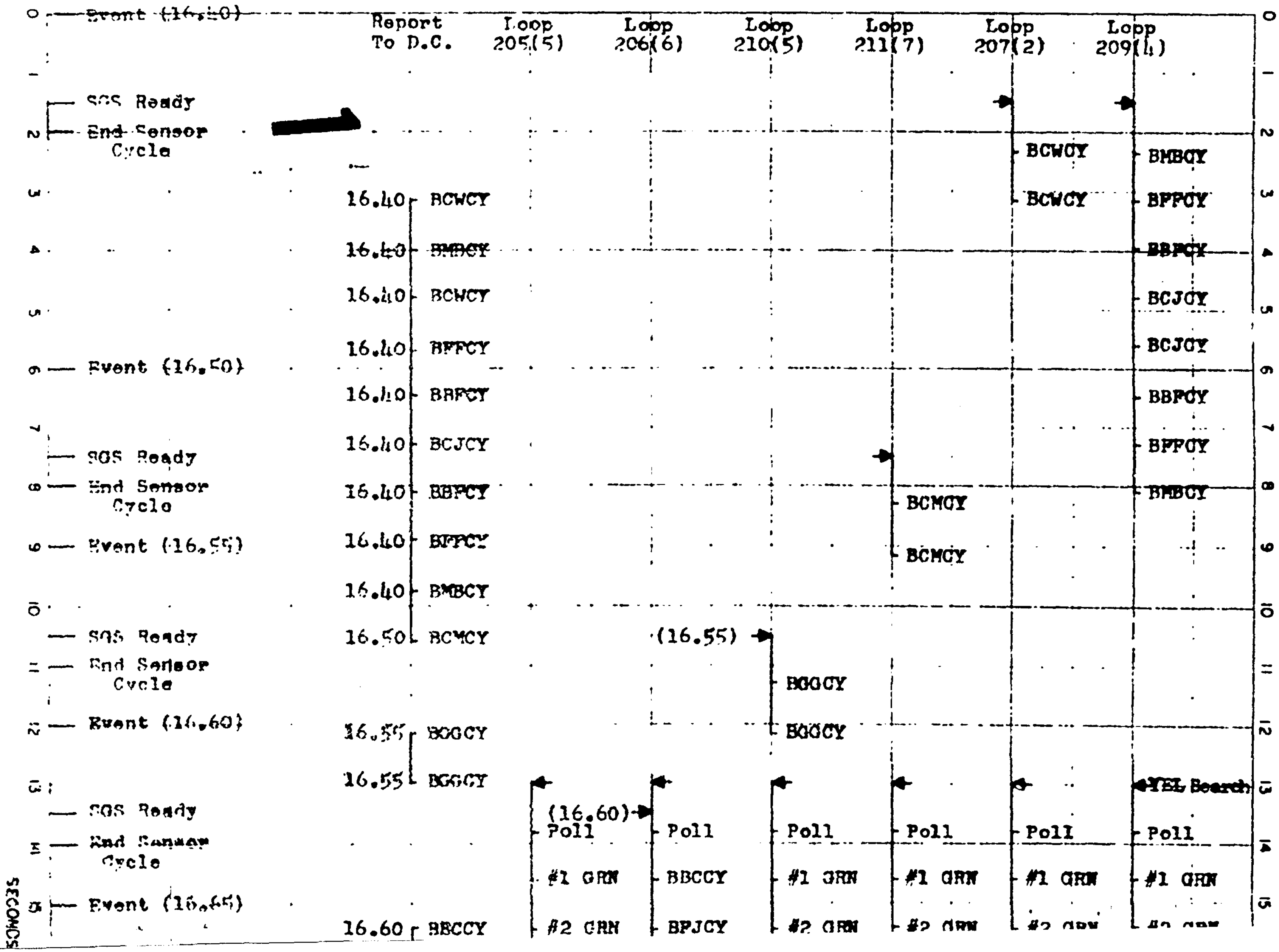
(5) Successive events are seen by different Sensors on the same loop.

(6) The maximum number of loops simultaneously reporting to one MCC is four.

A series of timing diagrams illustrates the operation of the system during the attack interval. Figures 2.20, 2.21 and 2.22 show the sequence of traffic to each of the MCC's from the loops responding and the subsequent traffic from each of the MCC's to the DC's. Figure 2.23 indicates the clearing (of traffic) times of the SGS's responding. They can register another event one message length or 825 ms less than their times to clear. This time corresponds to placing the second alarm in the storage register and start of transmission. Figure 2.24 indicates the order in which alarm messages are received by the DC's together with the time and order of posting "Map" alarms.

It is to be noted that the order in which the SGS's clear does not correspond to the reporting order as received by the MCC. For the condition of simultaneous response by multiple Sensors on the same loop, it is most probable that the SGS's will report their first alarm message, in order, from the receiving side of the MCC. This is due to small transmission delays "up the line" from the receiving side of the MCC. Therefore, the SGS nearest the receiving side will be the first to report, the last to be ready to repeat and the last to clear.

The timing and pattern of the attack is within the repeat capability of the Sensors and SGS's responding. Times to clear are extended, in many cases, because of both simultaneous detection by SGS's on the same loop and by the yellow search. An example of the former is seen in loop 209 on which all four SGS's respond to the event


Event (16.40)
SOS Ready
End Sensor Cycle
Event (16.50)
SOS Ready
End Sensor Cycle
Event (16.55)
SOS Ready
End Sensor Cycle
Event (16.60)
SOS Ready
End Sensor Cycle
Event (16.65)
SECONDS
Report To D.C.
Loop 205(5)
Loop 206(6)
Loop 210(5)
Loop 211(7)
Loop 207(2)
Loop 209(4)
16.40 BCWCY
16.40 BMBCY
16.40 BCWCY
16.40 BFFCY
16.40 BBFCY
16.40 BCJCY
16.40 BBFCY
16.40 BFFCY
16.40 BMBCY
16.50 BCMCY
16.55 BGGCY
16.55 BGGCY
16.60 BBCCY
BCWCY
BCWCY
BMBCY
BFFCY
BBFCY
BCJCY
BCJCY
BBFCY
BFFCY
BMBCY
BCMCY
BCMCY
(16.55)
BGGCY
BGGCY
YEL Search
(16.60)
Poll
Poll
Poll
Poll
Poll
Poll
#1 GRN
BBCCY
#1 GRN
#1 GRN
#1 GRN
#1 GRN
#2 GRN
BFJCY
#2 GRN

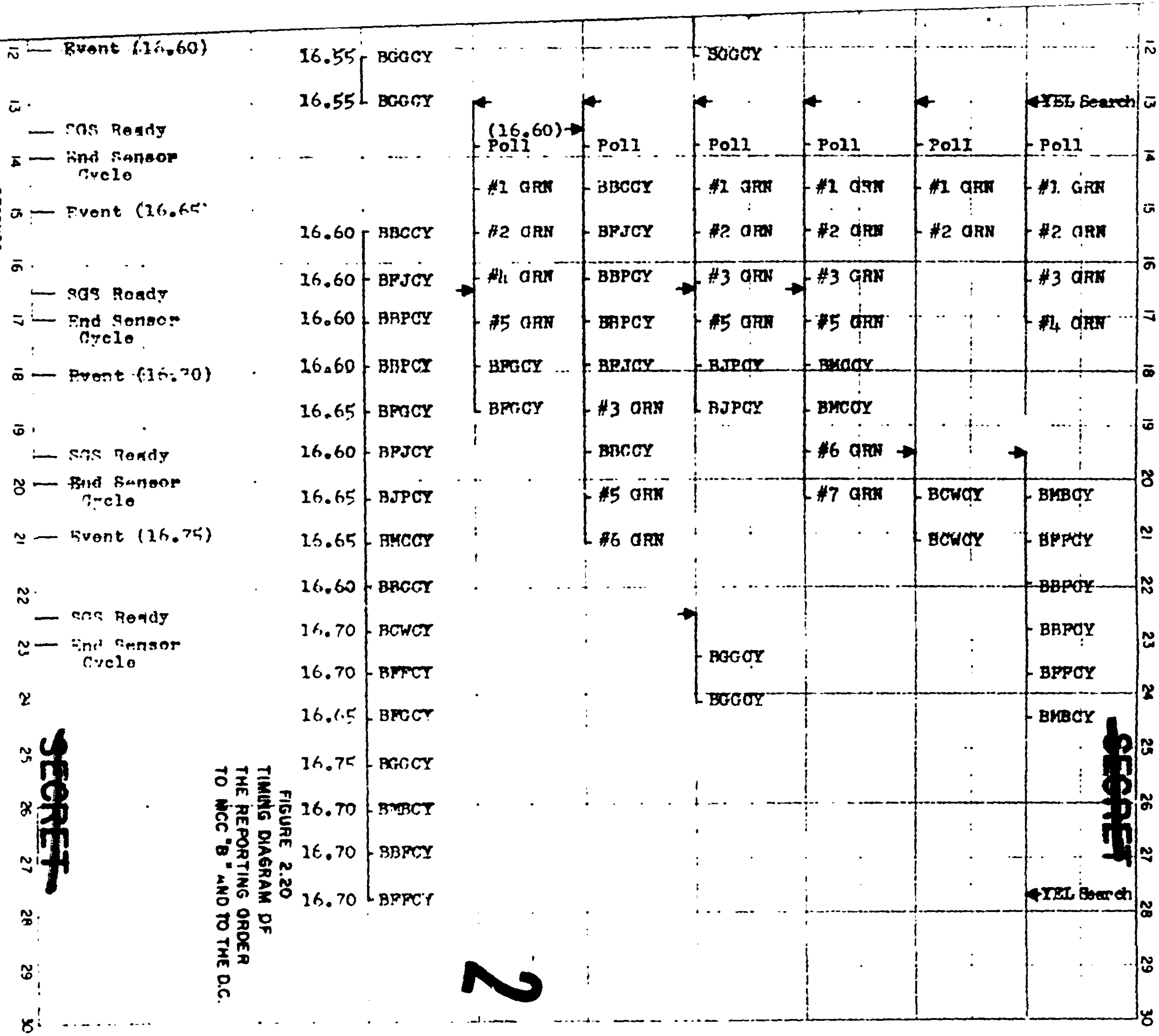


FIGURE 2.20
TIMING DIAGRAM OF THE REPORTING ORDER TO NCC "B" AND TO THE D.C.

SECONDS	Event	Report To D.C.	Loop 105(6)	Loop 103(6)	Loop 109(7)	Loop 107(6)	Loop 106(6)
0	Event (16.40)						
1	SGS Ready						
2	End Sensor Cycle					CFFCY	CCJCY
3		16.40 CCJCY				CMBCY	CBFCY
4		16.40 CFFCY				CCWCY	CBFCY
5		16.40 CMBCY				CCWCY	CCJCY
		16.40 CBFCY				CMBCY	
6	Event (16.50)	16.40 CCJCY				CFFCY	
7		16.40 CCWCY					
	SGS Ready						
8	End Sensor Cycle	16.40 CFFCY			CCMCY		
9	Event (16.55)	16.40 CMBCY			CCMCY		
		16.50 CCMCY					YBL Search
10	SGS Ready		Poll	Poll	Poll	Poll	Pcll
11	End Sensor Cycle		#1 GRN	#1 GRN	#1 GRN	CGGCY	#1 GRN
12	Event (16.60)	16.55 CGGCY	#2 GRN	#2 GRN	#2 GRN	#1 GRN	#2 GRN
13			#3 GRN	#3 GRN	#3 GRN	#2 GRN	#3 GRN
	SGS Ready						
14	End Sensor Cycle		#4 GRN	#4 GRN	#4 GRN	#3 GRN	#4 GRN
			CFJCY	CBPCY	#5 GRN	#4 GRN	CBCCY
15	Event (16.65)	16.60 CBCCY	CFJCY	#5 GRN	#6 GRN	CGGCY	#5 GRN
16	SGS Ready	16.60 CBPCY	#6 GRN	CBPCY	#7 GRN		CBCCY

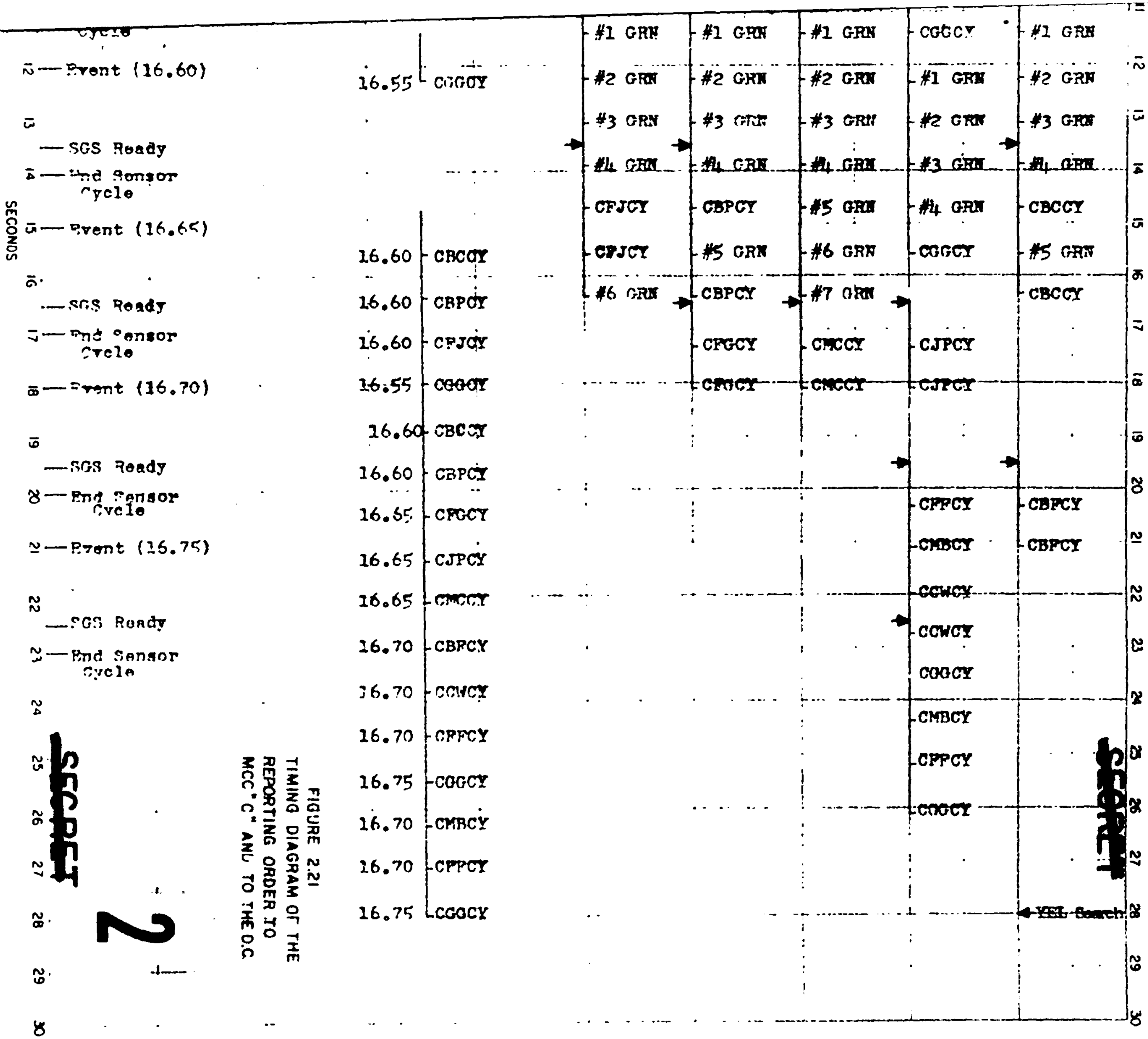


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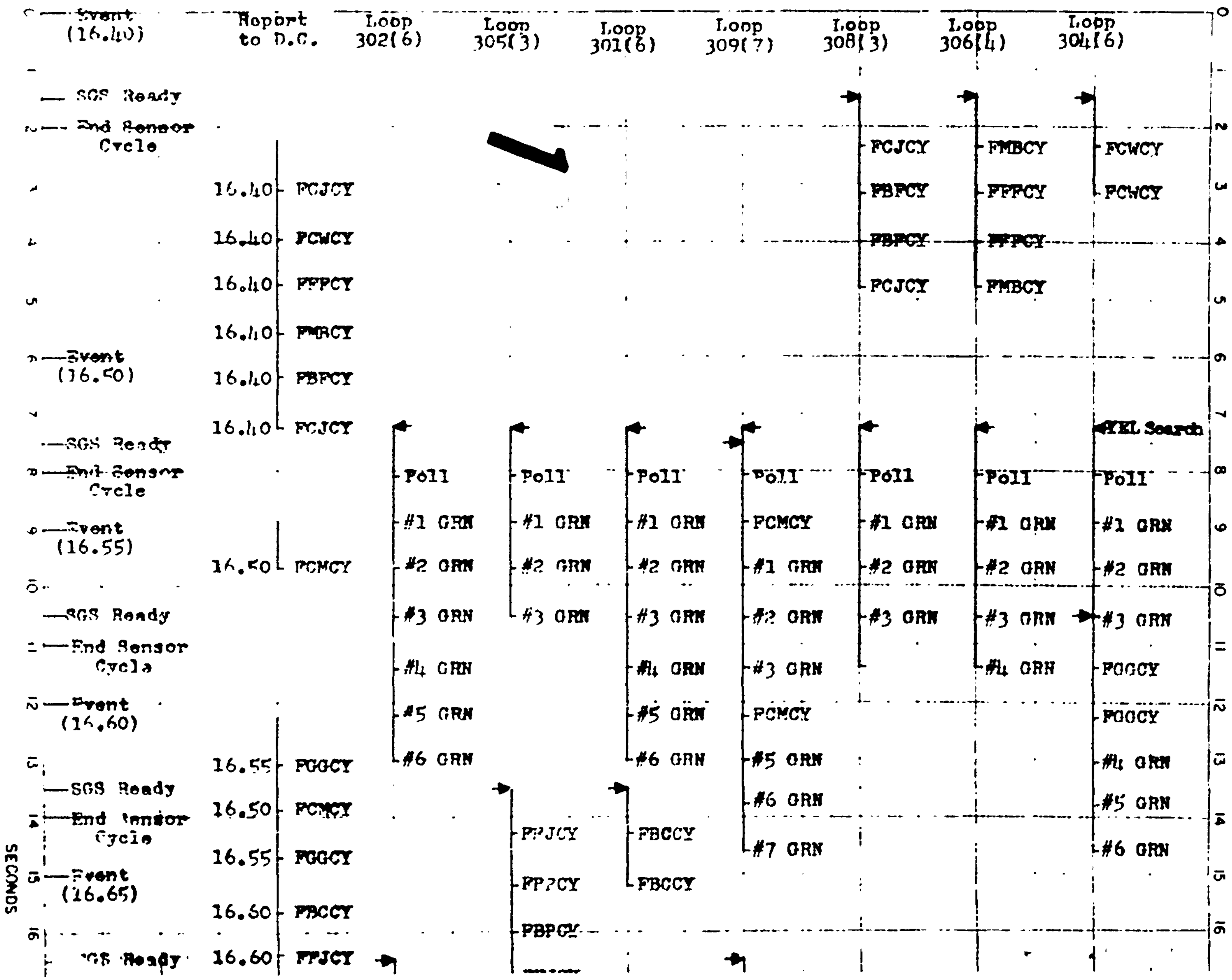
FIGURE 2.21
TIMING DIAGRAM OF THE REPORTING ORDER TO MCC"C" AND TO THE D.C

SECRET


Event (16.40)
Report to D.C.
Loop 302(6)
Loop 305(3)
Loop 301(6)
Loop 309(7)
Loop 308(3)
Loop 306(4)
Loop 304(6)
SGS Ready
End Sensor Cycle
Event (16.50)
SGS Ready
End Sensor Cycle
Event (16.55)
SGS Ready
End Sensor Cycle
Event (16.60)
SGS Ready
End Sensor Cycle
Event (16.65)
SGS Ready
16.40 FCJCY
16.40 FCWCY
16.40 FFPCY
16.40 FMBCY
16.40 FBFCY
16.40 FCJCY
16.50 FCMCY
16.55 FGGCY
16.50 FCMCY
16.55 FGGCY
16.60 FBCCY
16.60 FPJCY
FCJCY
FBFCY
FBFCY
FCJCY
FMBCY
FFPCY
FFPCY
FMBCY
FCWCY
FCWCY
YEL Search
Poll
#1 GRN
#2 GRN
#3 GRN
#4 GRN
#5 GRN
#6 GRN
#7 GRN
FCMCY
FGGCY
FPJCY
FBCCY
FBPCY
SECONDS
0
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16

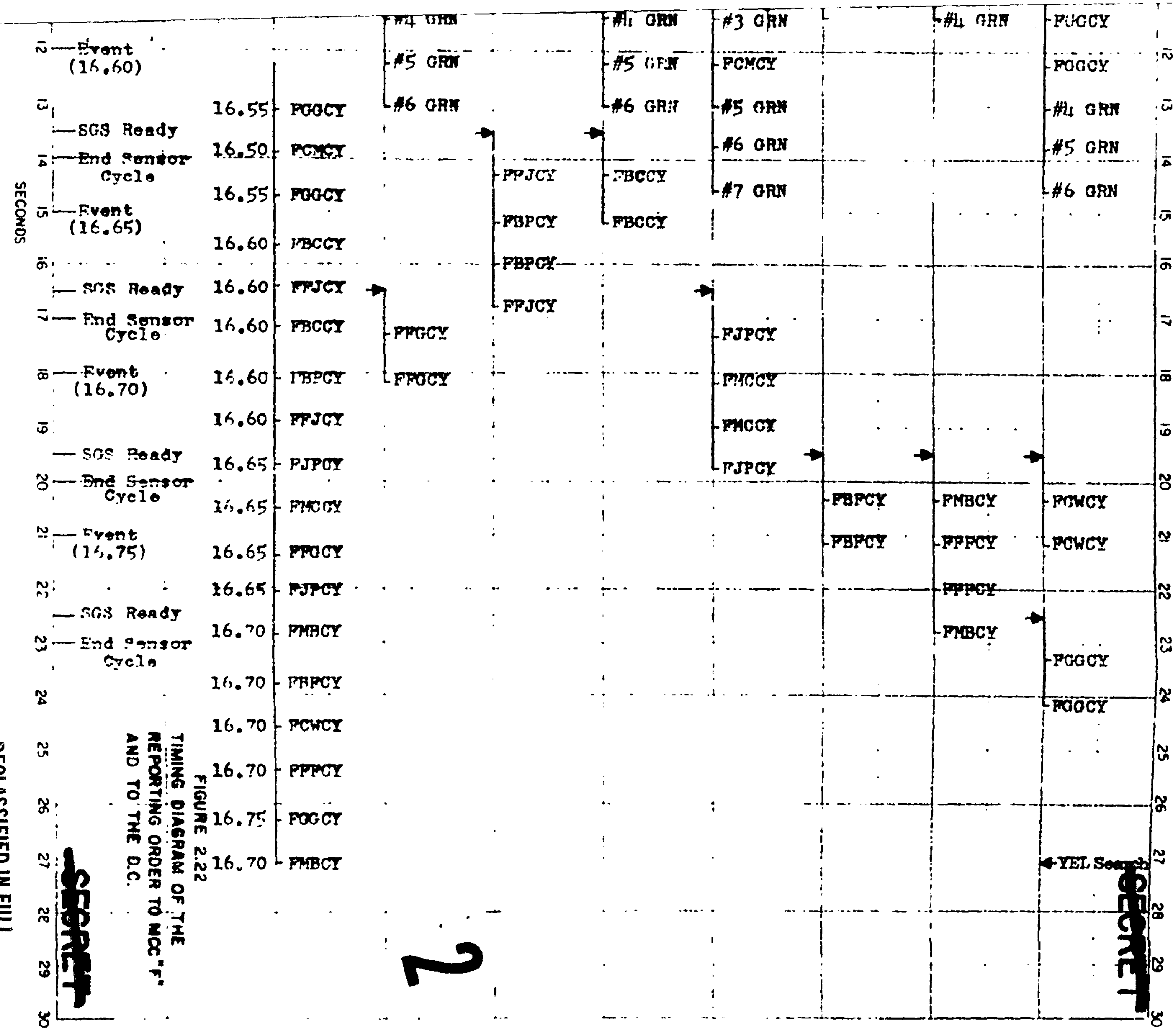
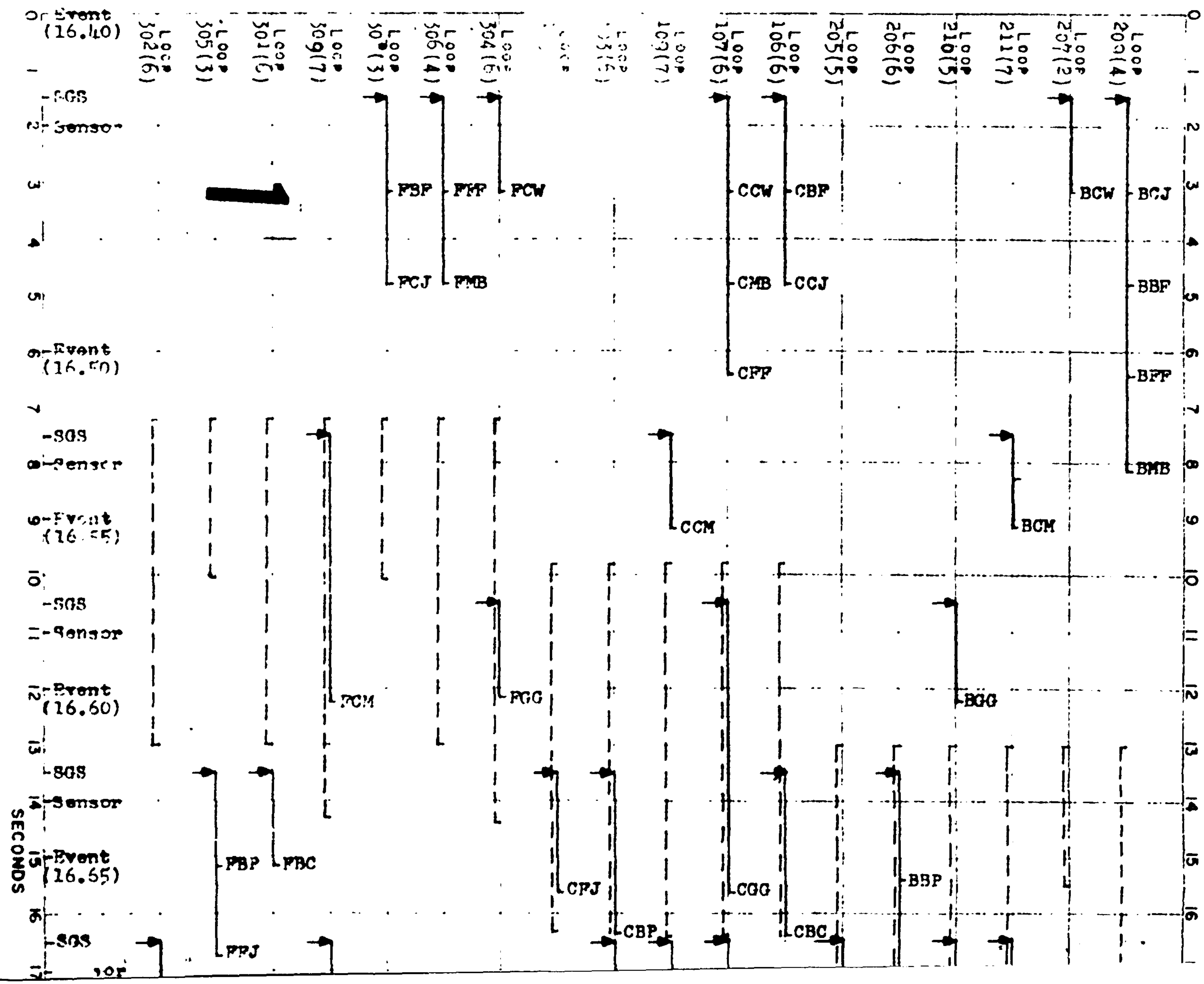


FIGURE 2.22
TIMING DIAGRAM OF THE REPORTING ORDER TO MCC "F" AND TO THE D.C.


Event (16.40)
SGS
Sensor
Event (16.50)
SGS
Sensor
Event (16.55)
SGS
Sensor
Event (16.60)
SGS
Sensor
Event (16.65)
SGS
SECONDS
Loop 302(6)
Loop 305(3)
Loop 301(6)
Loop 309(7)
Loop 306(4)
Loop 304(6)
Loop 107(6)
Loop 106(6)
Loop 205(5)
Loop 206(6)
Loop 210(5)
Loop 211(7)
Loop 207(2)
Loop 209(4)
FBF
FMF
FCW
FCJ
FMB
CCW
CBF
CMB
CCJ
CFF
BCW
BCJ
BBF
BFF
BMB
CCM
BCM
FCM
FGG
BGG
FBP
FBC
FFJ
CFJ
CBP
CGG
CBC
BBP

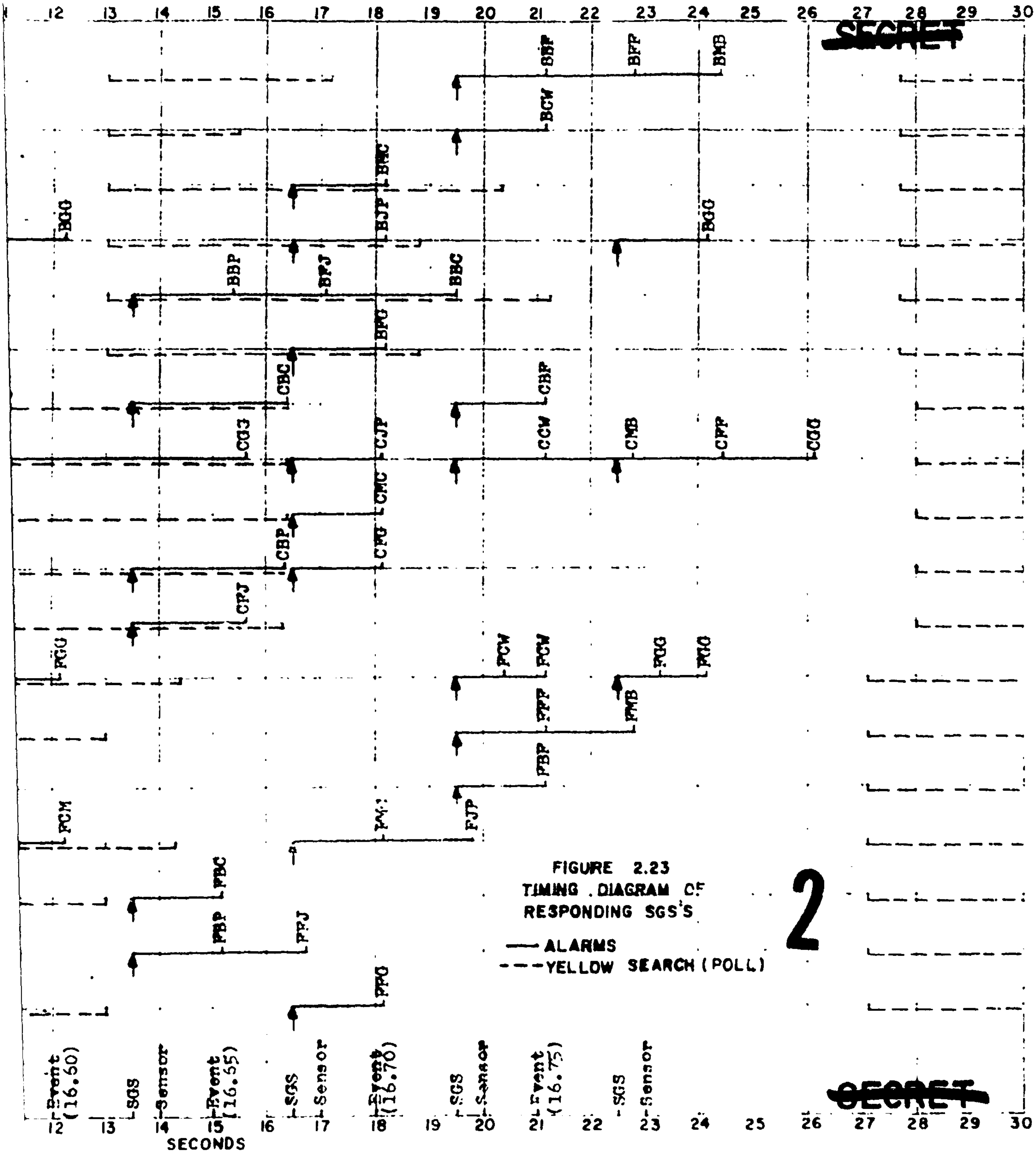


FIGURE 2.23
TIMING DIAGRAM OF
RESPONDING SGS'S

2

Page determined to be Unclassified
Reviewed Chief, RDD, WHS
IAW EO 13526, Section 3.5
Date: OCT 1 1 2011

SECONDS	Event	Display Event	Map Alarm No.	Location	MCC "F"	MCC "C"	MCC "B"
0	Event (16.40)						
1							
2							
3	[redacted]				FCJCY	CCJCY	BCWCY
4		16.40	1	Dover AFB, Del. (CJ)	FCWCY	CFFCY	BMBCY
5		16.40	1	Ft. Ritchie, Md. (CW)	FFFCY	CMBCY	BCWCY
		16.40 16.40	1 1	Classified Location (FF) Washington, D.C. (MB)	FMBCY	CBPCY	BFFCY
6	Event (16.50)						
					FBFCY	CCJCY	BBFCY
7		16.40	1	Baltimore, Md. (BM)	FCJCY	CCWCY	BCJCY
8		16.40 16.40	2 2	Ft. Ritchie, Md. (CW) Dover AFB, Del. (CJ)		CFFCY	BBFCY
9	Event (16.55)					CMBCY	BFFCY
		16.40	2	Classified Location (FF)	FCMCY	CCMCY	BMBCY
10							
		16.40 16.50	2 1	Washington, D.C. (MB) Dow AFB, Maine (GM)			BCMCY
11							
12	Event (16.60)					CGGCY	BGGCY
13		16.55	1	New York, N.Y. (GG)	FGGCY		BGGCY
14		16.55	2	New York, N.Y. (GG)	FCMCY		
		16.50	2	Dow AFB, Maine (GM)	FGGCY		
15	Event (16.65)				FBCCY	CBCCY	BBCCY
16		16.60	1	Atlanta Ga. (BC)	FFJCY	CBPCY	BFJCY
17							

SECRET

Seconds	Event	Time	No.	Location	F	C	B
12	Event (16.60)					CGGCY	BGGCY
13		16.55	1	New York, N. Y. (GG)	FGGCY		BGGCY
14		16.55	2	New York, N.Y. (GG)	FGMCY		
15	Event (16.65)	16.50	2	Dow AFB, Maine (GM)	FGGCY		
					FBCCY	CBCCY	BBCCY
16		16.60	1	Atlanta Ga. (BC)	FPJCY	CBPCY	BPJCY
17					FBCCY	CPJCY	BBPCY
18	Event (16.70)				FBPCY	CGGCY	BBPCY
19		16.55 16.60	3 1	New York, N.Y. (GG) Charleston AFB, S.C. (BP)	FPJCY	CBGCY	BPGCY
20		16.60 16.60	1 2	Hunter AFB, Ga. (PJ) Atlanta, Ga. (BC)	FJPCY	CBPCY	BPJCY
					FMCCY	CPGCY	BJPCY
21	Event (16.75)						BMCCY
		16.65 16.65	1 1	Homestead AFB, Fla. (PG) Suffolk Co. AFB, N.Y. (JP)	FPGCY	CJPCY	
22		16.65	1	Westover AFB, Mass. (MC)	FJPCY	CMCCY	BBCCY
23		16.65	2	Suffolk Co. AFB, N.Y. (JP)	FMBCY	CBPCY	BCWCY
24					FBPCY	CCWCY	BPPCY
25		16.70 16.70	1 1	Ft. Ritchie, Md. (CW) Baltimore, Md. (BP)	FCWCY	CPPCY	BPGCY
		16.70 16.65	1 2	Classified Location (PP) Homestead AFB, Fla. (PG)	FPPCY	CGGCY	BGGCY
26		16.75	1	New York, N.Y. (GG)	FGGCY	CMBCY	BMBCY
27		16.70	1	Washington, D. C. (MB)	FMBCY	CPPCY	BBPCY
28		16.70	2	Classified Location (PP)		CGGCY	BPPCY
29		16.75	2	New York, N. Y. (GG)			
30							

SECONDS

FIGURE 2.24
TIMING DIAGRAM OF DISPLAYED "MAP" ALARMS AT THE D.C.

2

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at 16.40. The time required for the 4th SGS (BMB) to clear is 6.6 seconds after it is first ready to report. An example of the latter is seen in loop 107 on which the 5th SGS (CGG) responds to the event at 16.55 just after start of poll. The time to clear this SGS is extended an additional 3.3 seconds while it regenerates the green responses from up the line. The difference between "clearing time" and "reporting time" is revealed by the operation of loop 211 on which SGS BMC responds to the event at 16.65 during a yellow search. This SGS is #4 on the loop and does not respond green when polled since it is in the red mode. It is not yet ready to report the alarm, however, and #5 begins its green response. Approximately 200 ms later, #4 is ready to report its alarm and does so, with the alarm traffic diverted to the storage of #5 while it finishes its green response. A similar operation is found on loop 210 for SGS #4 (BJP) responding to the same event.

Some idea of the repeat capability of the MCC is revealed by the traffic to each of the three MCC's following the first event at 16.40. MCC "B" receives in parallel on two loops with the bulk of the traffic on one of them. The input rate is only slightly greater than the output and only the redundant BCJ is lost. MCC "C" receives the same quantity of traffic on two loops but with the traffic almost equally divided. Two of the redundant alarms (CBF and CCW) are lost. MCC "F" receives the same quantity of traffic on three loops and the input rate is substantially greater than the output. Of the five redundant alarms received, only one (FCJ) is repeated to the DC.

The series-parallel pattern of traffic to the MCC determines how long it will remain busy sending to the DC and, therefore, how long before a yellow search is initiated. Yellow searches are initiated at 13, 9.8 and 7.2 seconds of the attack interval by MCC's "B", "C" and "F" respectively.

The series-parallel pattern of traffic together with asynchronous yellow searches, alphabetical storage register at the MCC and the redundant alarm message makes any repeat capability at the DC's highly ambiguous. For example, Figure 2.24 reveals that the first and redundant Map alarms for Dover AFB, responding to the event at 16.40, are received 4.5 seconds apart. If a manual reset was performed following the first Map alarm for this target area, the following redundant alarm would appear as another event. Worse yet is the report from Dow AFB, responding to the event at 16.50. The redundant alarm follows reports from target areas responding to the event at 16.55.

It is to be noted that information derived from the yellow searches and stored at the MCC's is not transmitted to the DC's. This is true since each of the MCC's receives an alarm during the course of its yellow search and returns to the alarm mode, reporting alarm messages and ignoring yellow reports. Since the MCC always sends alarm reports on a priority basis, the density of the attack may prevent the MCC from making yellow searches or, having made them, from reporting the results to the DC.

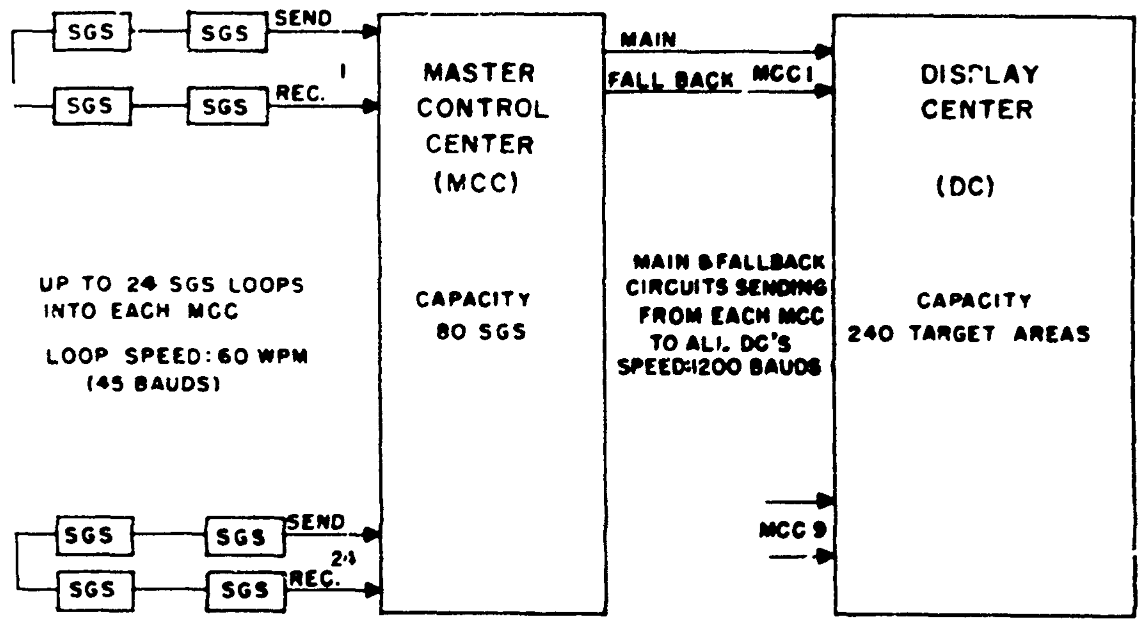
The repeat capability of the present BAS is sufficient to report much of the hypothetical attack considered. The value of repeat capability is severely restricted, however, by multiple detection of events, redundant reports and inability to sort and display the reports beyond the first one from each target area.

3.0 DESCRIPTION OF AUGMENTED BOMB ALARM SYSTEM

3.1 GENERAL

The Augmented Bomb Alarm System (See Figure 3.1) is organized along the same lines as the present system in that an MCC receives messages from a group of SGS's and forwards the information from them to all DC's. The MCC periodically sends out poll messages to the SGS which reply with a green status message if the Sensors and equipment at the station are operating properly. When the Sensors associated with a SGS detect a nuclear detonation, the station sends out an alarm message which is processed through the MCC to the DC's with a minimum of delay. An operator at the MCC may initiate a test of the SGS by sending a message which causes test equipment in the Sensors to cycle. If the Sensors detect the test signals properly, a test response, differing only slightly from an alarm message, is sent to the line by the SGS. The MCC normally will intercept these messages, but for a system test the MCC may be programmed to send them on to the DC's as alarm messages.

As in the present system each target area is covered by three Sensors. Each of the SGS reports to a different MCC so that the loss of one MCC facility will still leave two Sensors in operation. The target areas are divided into geographical groups of not more than 80 per group, each group reporting to three MCC's.



AUGMENTED BOMB ALARM SYSTEM BLOCK DIAGRAM

FIG. 3.1

The Electromagnetic pulse Sensor is a high threshold device, possibly weighted for increased sensitivity to high frequencies. This weighting and the high threshold features will reduce the sensitivity of the system to sferics. In any event, an alarm is not generated on the basis of an EM pulse alone; the pulse provides localization of an optically detected detonation and may be used to determine time zero of any event.

The Yield determination is made from an optical device, with the measurement made on the basis of the time interval from the arrival of the EM pulse to the first peak or to the minimum inflection point after the first peak. A device designed to measure time to the second peak would severely restrict the system's repeat capability. (See Figure 3.2). The yield is evaluated to a $(10)^{1/2}$ accuracy with outputs of 0.3, 1, 3, 10, 30 and 100 megatons.

The Elevation determination will be made on the basis of a two sector optical device capable of differentiating between air and ground bursts (See Figure 3.3). The division line between the two levels must be established arbitrarily. Under certain conditions the optical Sensor range is such that a remote air burst may be seen by the ground burst sector. To resolve this ambiguity an elevation report will be made only if EM localization of the optical report has been received. Ideally the determination will be made early in the burst cycle, when the fireball is relatively small, using only first peak thermal energy.

3.2 DETAILED DESCRIPTION OF SIGNAL GENERATING STATION

The SGS in the augmented system operates in the same manner as in the present Bomb Alarm System, but is also capable of reporting yield and differentiating between air and ground bursts. A high threshold electromagnetic (EM) pulse Sensor is included for localization of the event reported by the optical Sensor. A second fallback optical Sensor is provided at the SGS to give alarms if the Sensor nearer the target area is destroyed or inoperative.

A typical target area complex is shown in Figure 3.4. The optical Sensors 11 miles from ground zero are the present Sensors, unchanged in operation or function. The SGS's are located further radially from the target area with additional Sensors in the immediate vicinity of the SGS. Locating the new Sensors at the SGS simplifies the problem of providing power to the Sensors and receiving signals from them. Because of the addition of sensing elements to SGS sites, SGS sites would have to be more rigorously defined than in the present configuration.

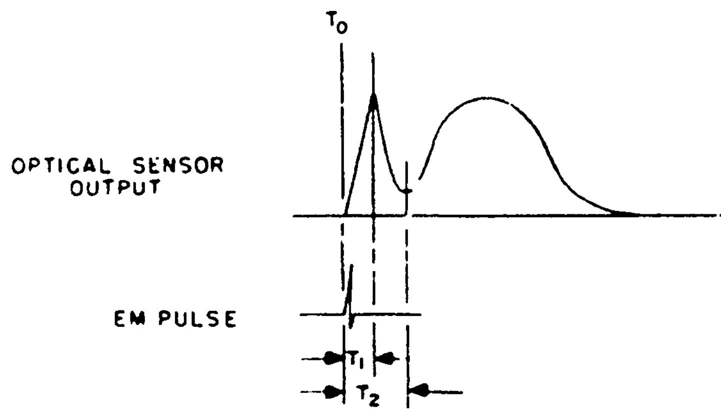
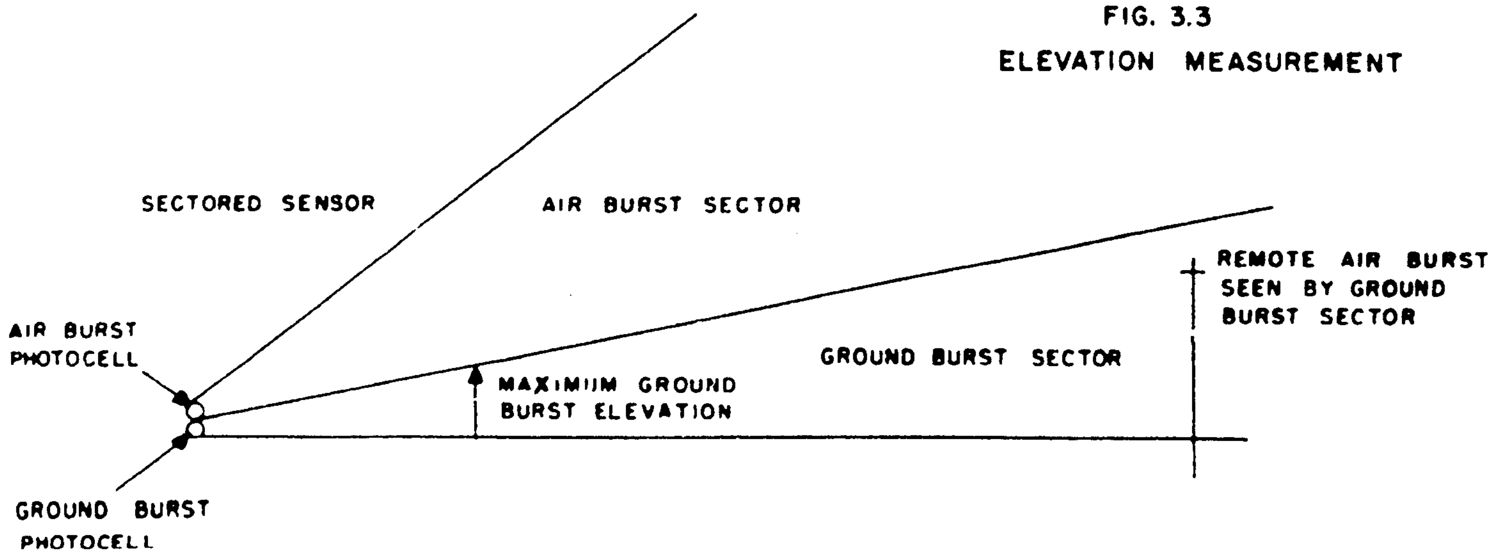


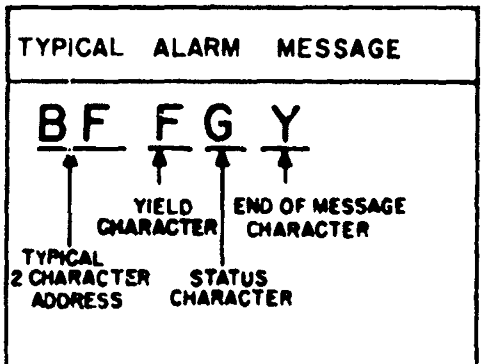
FIG. 3.2
YIELD MEASUREMENT

EITHER T_1 OR T_2 MAY BE USED FOR MEASUREMENT

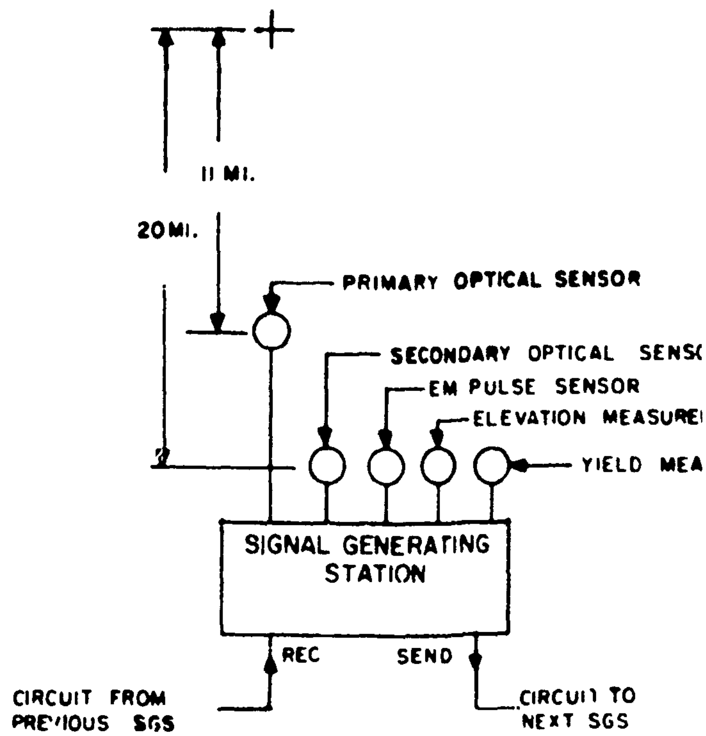
T_2 MAY BE DERIVED FROM EM PULSE OR FAST-RISE OPTICAL SENSOR

FIG. 3.3
ELEVATION MEASUREMENT





VARIABLE INFORMATION			
CHARACTER	YIELD M.T.	STATUS EM	STATUS ELEV.
B	0.	—	—
C	0 3	NO	NO
F	1.0	YES	NO
G	3.0	YES	AIR
J	10.0	YES	GND
M	30.0	—	—
P	100	—	—



POLL MESSAGE BB□
GREEN RESPONSE BF□
TEST MESSAGE II□
TEST RESPONSE BFFGZ (TYPICAL)

AUGMENTED
TARGE

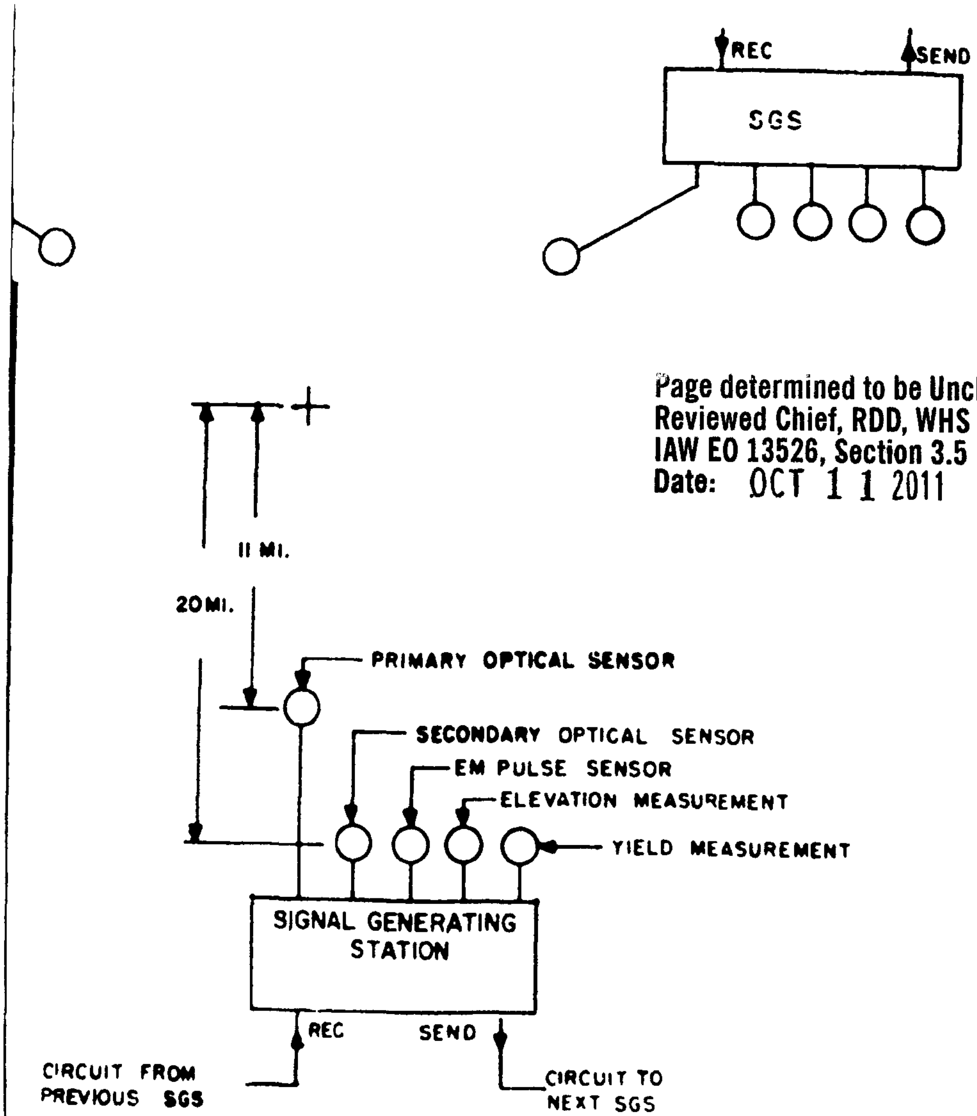


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FIG 3.4

AUGMENTED BOMB ALARM SYSTEM
TARGET AREA COMPLEX

3.2.1 Sensors

The Primary Optical Sensor is the one presently installed and working in the Bomb Alarm System. In the augmented system it is unchanged.

The Secondary Optical Sensor is located in a Sensor complex near the SGS. It is identical in operation to the Sensor in the present system, although the output signals may differ since a telemetering system to report signals is not necessary with the Sensor located near the SGS.

3.2.2 Signalling

The signalling arrangement between the MCC's and the SGS is the same as in the present Bomb Alarm System. The SGS are arranged in series loops from the MCC. The output, of the SGS nearest the sending side of the MCC, is regenerated and passed through subsequent SGS on the way to the receive side of the MCC.

The characters used for signalling in the augmented system are the same as those used in the present system. All characters used for address and status information have three pulses marking of the five pulses in the telegraph code as does the character Y, the alarm end-of-message character. The spaco character used for EOM status character for green messages has only one of the five pulses marking. For an error to pass undetected while using this three out of five code, transmission distortions must convert as many pulses in a character from marking to spacing as are converted from spacing to marking. This double conversion is much less probable than the more common systematic addition or subtraction of pulses.

In normal operation the MCC sends a poll message to all loops in parallel. This message is read in the SGS as it is passed through the loop. If either of the optical Sensors connected to a SGS are working, the SGS inserts a green response message when the receive line goes idle. This message consists of the two address characters followed by the character space. The reduction in the number of the address characters from three to two allows the reporting of the additional yield information without extensive modification of the SGS.

When either of the optical Sensors reports a burst, an alarm message is prepared. Depending on the additional information received, any one of seven yield characters and four status characters may be included in the message.

The alarm message is sent at once if the send and receive lines are idle or at the end of the message going through the SGS if there is traffic on the lines. As in the present system, traffic coming in while an alarm message is being sent is stored for transmission at the end of the alarm message.

In the present system two alarm messages are sent; one as described above and another when the receive line goes idle. In the augmented system this second message is eliminated to increase the repeat capability of the system and to eliminate the ambiguity caused by the second report.

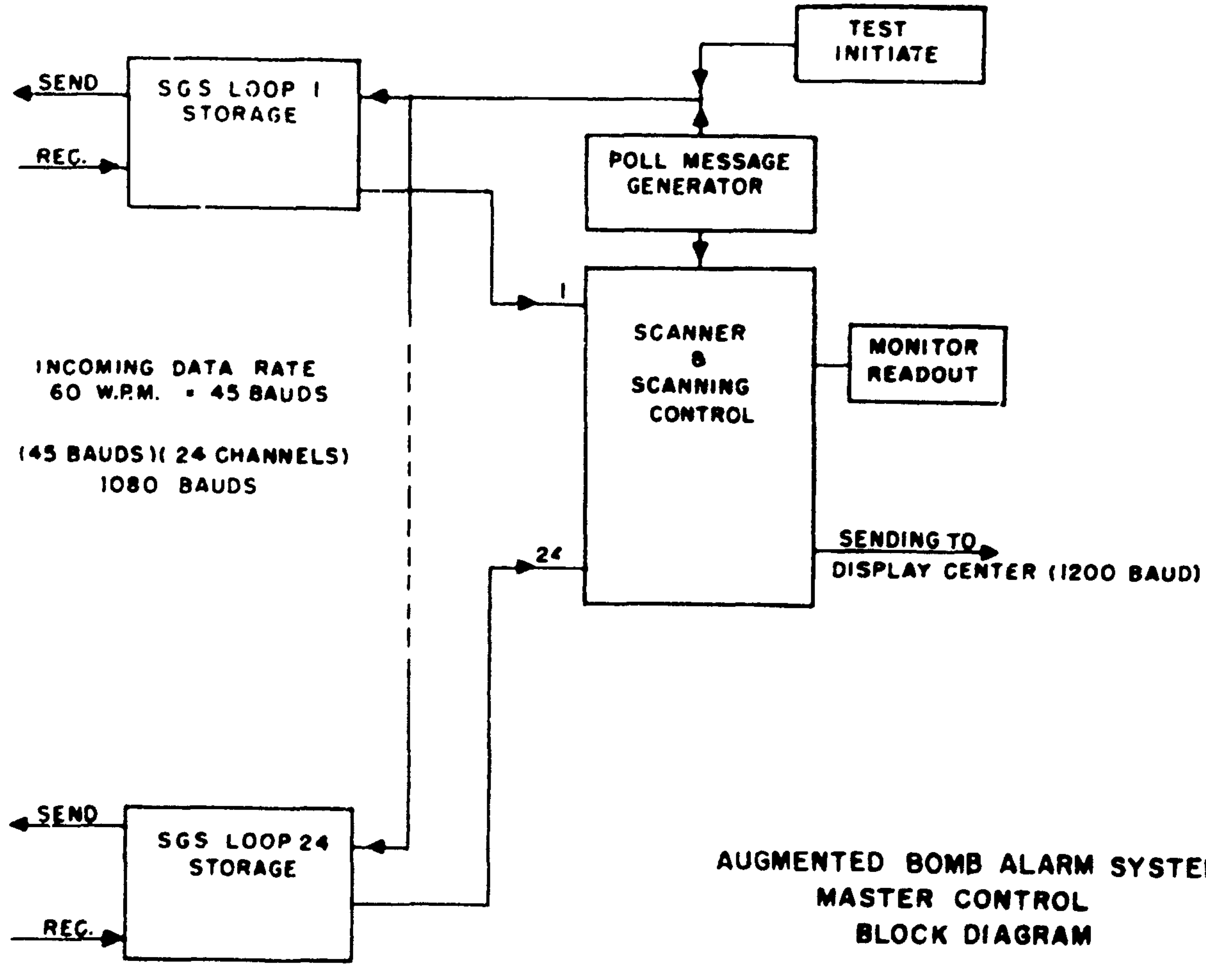
A facility is included in the MCC to generate a message to be sent to the SGS to initiate burst simulation devices in the Sensors and test the response of the Sensor and SGS. An alarm response to this test message is altered from a regular response to reduce the probability of generating a false alarm during the course of testing. In order to generate a test response, it is required that both of the optical Sensors report the burst simulation. For test purposes they must function on an AND basis; to report alarms only the OR function is required.

3.3 DETAILED DESCRIPTION OF MASTER CONTROL CENTER

The MCC (See Figure 3.5) is essentially a time-division multiplexing device which receives messages from an many as 80 SGS's, connected serially in up to 24 low speed circuits, and relays the information received to the DC's at high speed.

The SGS loops sending into the MCC work at a speed of 60 words per minute or 45 bauds (bits per second). The total incoming data rate then is 24 times 45 bauds or 1080 bauds. The messages are relayed to the DC's serially at a speed of 1200 bauds which is more than adequate to handle the data.

The loop-storage block includes a serial-to-parallel converter, a groen message storage, an alarm message storage and control circuits to check the incoming messages and regulate access to the sending circuit. The address and status characters are limited to those having three marking pulses of the five in the telegraph code. As each character is received, its marking bits are counted and if any character of a message should fail in its count, the message is not stored for transmission to the DC. This check provides protection against the most common of transmission distortions; the simple addition or subtraction of pulses. For an error to pass through the MCC the same number of pulses must be added and subtracted in one character.



AUGMENTED BOMB ALARM SYSTEM
MASTER CONTROL
BLOCK DIAGRAM

FIGURE 3.5

Two storages are provided to receive the message when the end-of-message (EOM) character has been received and the parity check requirement is met. The first of these stores the three characters of the green message; the second stores the five characters of the alarm messages.

When a message is transferred to a storage, a request for access to the circuit sending to the DC's is made. The scanner is continually probing the loop storages to determine if a request is present. When a message is waiting it is shifted directly out of the storage unit to the sending circuit.

In the normal polling sequence, the block of green status messages relayed to the DC's is framed between start-of-transmission and end-of-transmission messages which are required for DC control. The start-of-transmission message is sent when the loops are polled and the end-of-transmission is sent after the last message received from the loops has been relayed through the MCC.

Immediately following receipt and re-transmission of an alarm sequence, a poll message is sent to the loops and the messages received are forwarded to the DC's. This MCC, unlike the present MCC, is capable of handling and re-transmitting a mixture of red and green incoming reports. This process permits more rapid reporting of inoperative SGS to the DC's to allow more rapid evaluation of one red and two yellow alarms. At the same time this special poll message is sent to the loops, a control message is sent to the two other MCC's in the same geographical area. This control message will initiate the special polling sequence at the other MCC's.

A monitoring readout of the status of the SGS reports to the DC's is required to facilitate maintenance dispatching. This readout could be in the form of a page printer with a single line of characters per poll, one character per SGS, to indicate which had responded green.

3.4 DESCRIPTION OF DISPLAY CENTER

3.4.1 General

The DC receives reports from all MCC's and presents Availability and Alarm Displays and a printed readout of burst data. The Availability Display is similar in function and appearance to the present Communicator's Panel, with green and yellow availability lights and a red alarm light for each Sensor-SGS combination. The Alarm Display shows target area name and distinguishes between air or ground bursts for localized events. A third indicator, for each target area, counts those events outside of, but unique to, a particular target area.

The Alarm Display is capable of recording a limited number of bursts at each target area. The printed readout shows the target area name, the time of the burst, the yield, localization and whether an air or ground burst was recorded.

As in the present Bomb Alarm System, an alarm will be displayed only if alarm reports have been received from two Sensors, or from one Sensor if the other two in the target area are not available.

3.4.2 Display Description

3.4.2.a Availability Display. This display shows the availability or alarm status of each Sensor as reported by the last message from its MCC. When an MCC starts transmission of a poll, all green (Sensor available) lights associated with that MCC are turned off, while yellow (Sensor unavailable) and red (alarm) lights are left on. As green status reports are received, green lights are turned on, either from the blank state or from the yellow condition. At the end of the transmission from the MCC, lights associated with SGS's which fail to report green are turned yellow.

When an alarm message is received, the red light associated with the Sensor sending the alarm message is lighted and remains lit until manually extinguished. The green or yellow light preceeding the red is extinguished. The appropriate green or yellow indicator is, however, relighted on the first poll following the alarm.

3.4.2.b Alarm Displays.
(1) Visual Display. The Visual Display consists of an illuminated panel displaying the name of the target area and three rows of lights (See Figure 3.6). The upper row indicates that a local air burst was detected; the center row indicates that at least two optical Sensors detected a burst without an accompanying EM localization signal and the bottom row indicates that a local ground burst was detected. The name panel is dark until the first report for the area is received.
(2) Readout Printer. The printed readout lists the target area name, the time of arrival of the report at the DC, the yield, an indication of the presence of a localizing EM pulse and a differentiation between air or ground burst. Typical report readouts are shown in Figure 3.7.

3.4.3 Display Control Description

2.4.3.a Buffer Storage. See Figure 3.8. There are two circuits carrying the same information to each DC to provide redundant and diversified service. The DC is

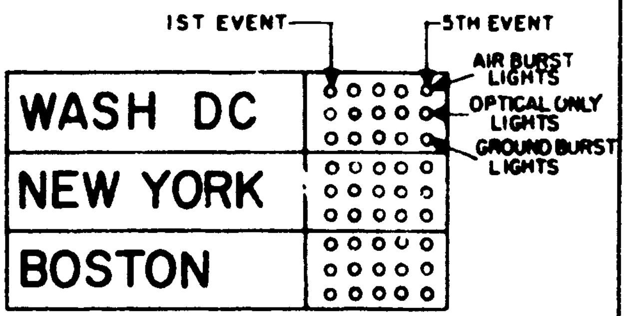


FIG. 3.6

VISUAL ALARM DISPLAY

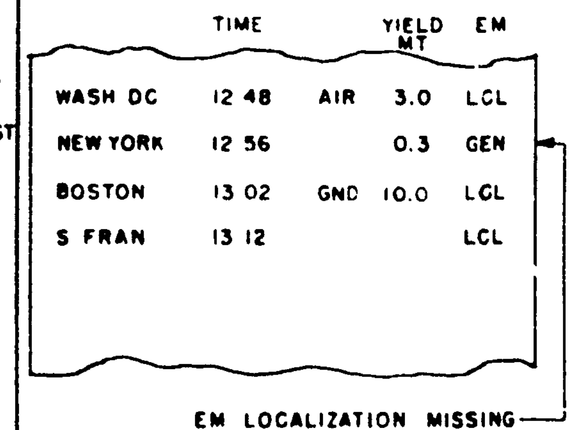
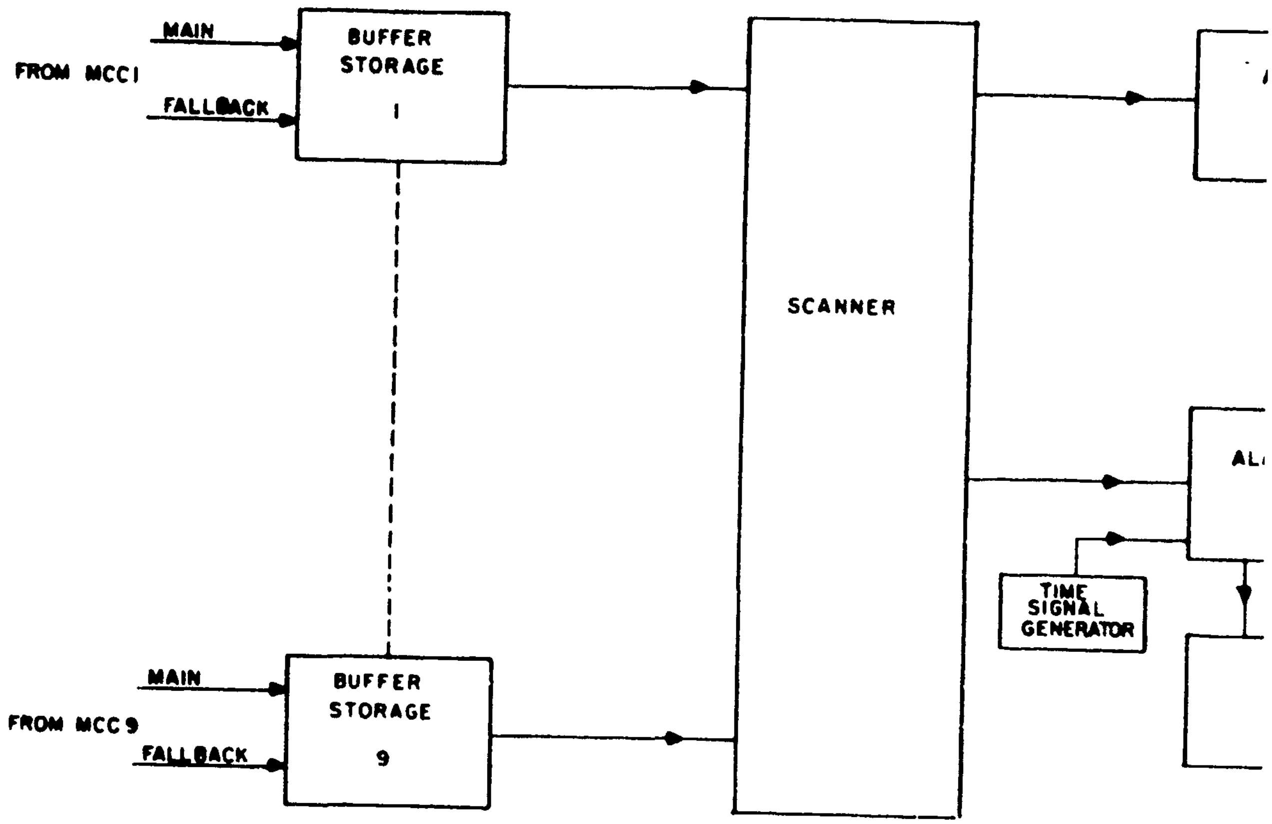


FIG. 3.7

PRINTED READOUT


MAIN
FROM MCC1
FALLBACK
BUFFER STORAGE 1
MAIN
FROM MCC9
FALLBACK
BUFFER STORAGE 9
SCANNER
TIME SIGNAL GENERATOR

1

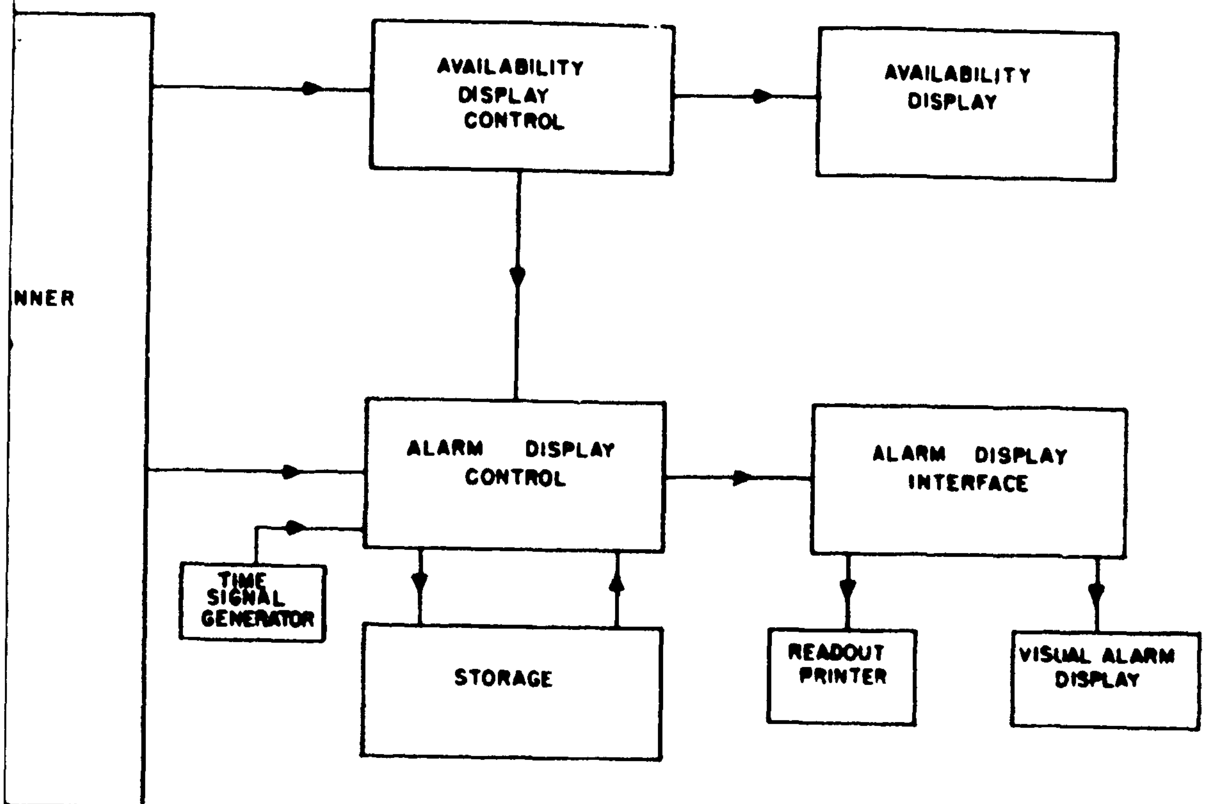


FIG. 3.8
AUGMENTED BOMB ALARM SYSTEM
DISPLAY CENTER

2

capable of receiving from both circuits simultaneously, acting on the first good message to be received from either. The confirmation received on the other channel is ignored. Each of these inputs is terminated in a serial-to-parallel converter to store the message as it is received. A parity check is applied to each character as it is received as described in the section on the MCC receiving circuits. When a good message is received, a request for access to the display controls is made.

Each Buffer Storage is equipped to decode start and end-of-poll messages for input to the Availability Display control equipment.

Each Buffer Storage is able to detect an idle line character sent periodically by the MCC. If the equipment should fail to detect this character, a sending stopped signal is generated and passed to the Availability Display control.

3.4.3.b Scanner. The scanner is continuously probing the Buffer Storage units to determine if a message is waiting for processing. If a message is waiting, it is transferred to the display controls. The scanner operates at sufficient speed to permit transfer of the messages received to the Buffer Storage before other messages start arriving.

3.4.3.c Availability Display Control. This control provides status storage and lamp driver circuits. When a Buffer Storage receives a start of poll message from the MCC, the green status storages for SGS's associated with that MCC are reset to a blank state and the associated green lamps are extinguished. As green response messages are received, the corresponding green lamps are turned on. When the end-of-poll message is received in the Buffer Storage, a signal is sent to cause all control storage elements, associated with that MCC, remaining in the blank state to be set to yellow.

When an alarm message is received, the corresponding red lamp is lighted. This lamp will remain lit until a manual switch is operated to reset the control storage element to the blank state and extinguish the light until further status reports are received.

When both facilities from a MCC are interrupted, a sending stopped signal is sent from the Buffer Storage to the Availability Display control to indicate that it is no longer possible to receive reports from that MCC. When the control receives this signal, all lights associated with Sensors relaying through that MCC are turned yellow and remain in this state until green responses are received.

At either the end-of-poll or the sending stopped signals from a Buffer Storage, all yellows generated are passed to the Alarm Display control and stored for future alarm evaluation.

3.4.3.d Alarm Display Control. Since the amount of information to be displayed and the rate at which the information is presented to the DC is much greater than in the present BAS, the Alarm Display control equipment is far more complex in the augmented system. In addition to reading out more extensive data, the augmented system is designed to report a limited number of bursts in each target area and to reduce the number of excess alarms; i.e., those from an area considerably removed from an air burst over another area.

The Alarm Display control is a computer-like device with information storage capacity and central logic program for evaluating the reports received from the Buffer Storages and the Availability Display control. The Display Interface converts the information to levels and codes compatible with the displays used.

The system is designed to display an alarm if two Sensors in a target area transmit alarm reports, or if one Sensor transmits an alarm report while the other two Sensors in the area are in the yellow, or unavailable, state. Since the SGS is capable of localizing an optical detection with an associated detection of an EM pulse, several levels of localization of the reports for a target are possible. The various types of alarm reports possible from an area are indicated in Table 3.1.

In areas of heavy target area concentration, it is highly probable that one event, especially an air burst, will produce optical detections at Sensors well removed from ground zero. The EM pulse detection was added to the SGS output to provide localization of the burst area. For these complexes of high target area concentration, the target areas are grouped, and when an alarm determination has been made, the localization levels of all target areas in the complex are checked. The target area with the highest level is displayed. The reports for all other target areas in the complex with lower localization levels are erased from the storage. If two target areas have alarms consisting of two or more reports consisting of optical plus EM, both are displayed.

TABLE 3.1

REPORT RELIABILITY LEVELS

Localization Level	Sensor Reports
1	1 Optical without Localization and 2 Yellow Sensors indicates a probable burst near the target area
2	2 Optical without Localization indicates a definite burst near the target area
3	1 Optical with Localization and 1 Optical without Localization indicates a definite burst, possibly within, but definitely close to the target area
4	1 Optical with Localization and 2 Yellow Sensors indicates a probable target area burst
5	2 Optical with Localization indicates a definite burst within the target area.

When Sensors from two or more target areas in a complex give reports from a distant air burst resulting in localization levels 1 or 2, printing out the individual alarms would result in excess burst reports. To accommodate this condition, each of the multiple target area complexes could be given an additional listing such as "Washington Area", or "Los Angeles Area". The Alarm Display control would select a "complex" listing when alarms are received from more than one target area within a "complex" in the absence of localization of the burst at any one of the areas.

3.4.3.e Report Storage and Evaluation. Each target area is provided with a unique location in the storage where there are stored the location addresses of other target areas in the same general area with space for input information from each of the Sensors associated with the area. This information includes:

(1) Time of arrival of the report at the DC, recorded to the nearest second.

(2) Status Character (Includes EM localization and HOB information).

(3) Yield Character.

(4) Yellow (unavailable Sensor) information derived from Availability Display control.

There may be a differential delay between alarm reports from Sensors of as much as six seconds. It is necessary, therefore, to delay evaluation after a report is received by this amount of time to insure that the reports with the highest localization level will be received. At the end of this period, the localization levels of all associated target areas will be checked and the report from the area with the highest availability level will be displayed, and reports with a lower level will be erased from the storage.

In the presence of a heavy attack, the high incidence of alarm traffic into the MCC may prevent the completion of the poll, initiated after the alarm message was sent from the MCC. Since new yellow status information cannot be transferred from the Availability Display control until after the completion of such a poll, more than six seconds may be required for evaluating an alarm on the basis of two unavailable Sensors. If, then, no further reports are received in the first six seconds to confirm single alarm reports for either the primary area or one of the associated areas, additional time may be required to determine whether an alarm should be displayed on the basis of unavailable Sensors. If no further yellow information is received within this additional time, the report is erased from storage and no alarm is displayed. It should be noted that any such single alarm report will show as a red light on the Availability Display so that investigative action can be taken.

It is entirely possible that in the two reports evaluated for the alarm, the yield information may differ in the case of a weapon with yield midway between the measurement levels. In this event, a worst-case solution would be to display the higher yield level. An alternative is to synthesize an intermediate yield display in the Alarm Display control circuits.

3.4.3.f <u>Alarm Display Interface</u>.

(1) Visual Display. This interface block provides the storage of the output of the Alarm Display control for successive alarms as they occur at a target area. The number of bursts can be increased over the five shown (Figure 3.6) by increase of the storage capacity in the interface equipment and in the size of the Display Panel.

(2) Printed Readout. The interface block includes the encoding circuits and equipment required to operate the readout printer. Since successive reports may be evaluated in intervals shorter than the cycle time of the printer, the interface unit will probably include buffer storage to average out the high peak rate of information input.

In areas of moderate target area concentration, an air burst may cause several areas to produce reports with localization levels 1 or 2 when the burst is beyond the range of the EM pulse detector. This condition may also prevail when a target area under heavy attack has no Sensors available. In these it is possible to deduce that the burst has occurred in an area common to the circles of detectivity of the Sensors producing the low localization level reports. To accomplish this, all the combinations would be determined and the addresses of the combinations stored to give an alarm display when a sufficient number of low localization level alarms have been received. This would result in rather imprecise locations and require extensive equipment to give even a crude location.

3.5 IMPLEMENTATION PROGRAM

Any augmentation of the Bomb Alarm System must be made with a minimum of interference with the present system, which is to be kept running until the augmented system is ready for operation.

Since the MCC and the DC in the augmented system are entirely different in operation from those in the present system, these two units could be built, installed and tested while the present system is in operation. When the augmented system is put into operation, the present MCC and DC equipment will become obsolete.

The location of additional Sensors at the SGS may require relocation of some of the stations to meet the distance requirements of the Sensors from the target areas.

Since the SGS in the augmented system are essentially the same as in the present system, it is contemplated that the present stations would be expanded with additional equipment and not replaced. An additional unit is required to communicate with the added Sensors and convert the information from them to a form suitable for transmission from the SGS. The station itself will require modification for the change to a two-character address and for the insertion of the several yield and status characters. A modification program must be established which will prepare the stations, with the circuits and wiring required for use in the augmented system, while leaving the stations capable of operating in the present system until all stations are ready for cut-over.

Approximately fifty of the SGS's in the Bomb Alarm System are of the design used in the prototype BAS, modified for current use, and are too small for further modification to the augmented system. It is necessary to manufacture enough new SGS's, prepared as discussed above, to replace the prototype stations. These new units would be installed in place of production design stations in the system, which would then be prepared and installed on a rotational basis until the last prepared stations are installed in place of the prototype designs.

When all SGS's are prepared and the new MCC and DC are ready, the system would be cut over, one MCC at a time, over a period of a few days. During this period, parts of both the present and augmented Bomb Alarm Systems would be operating, with at least two eastern and two western MCC's in operation at all times.

3.6 RESPONSE TO HYPOTHETICAL ATTACK

3.6.1 Repeat Capability of Augmented BAS

The augmented BAS has a significant increase in repeat capability. It is achieved by (1) eliminating the redundant alarm message and (2) increasing the reporting rate.

To transmit yield, HOB and localization information from the SGS's and, at the same time to retain the five-character alarm message, the first letter of the address, common to each MCC, is dropped. To decrease the polling time of the loops, the poll request message and the green response are each reduced to three characters from five.

The data rate on the SGS loops remains at 60 WPM. The repeat capability of the SGS's remains proportional to their position on the serial loop but is effectively doubled by elimination of the redundant alarm. The worst repeat capability, for the #7 SGS, would be for the improbable condition of simultaneous responses by all seven SGS's on the loop and is 5.8 seconds. The effect of polling on repeat capability is reduced because of the shortened message format. The longest loop (7 SGS) can now be polled in approximately 4 seconds. For the worst-case of the #7 SGS ready to report an event just after start of poll, it will be able to repeat in 3.5 seconds.

The reporting circuits from the MCC's to the DC's are speeded up sufficiently to handle the maximum 24 loop inputs on a time division multiplex basis. The MCC status storage register is eliminated and the yellow decision making function is performed by the DC. This function is prepared for with receipt of the start-of-poll control message and performed with receipt of the end-of-poll control message.

In order to handle 24 circuits operating at 45 bauds, the reporting circuits from the MCC's must operate at 1200 bauds. It is now possible to transmit all received traffic to the DC, including the yellow search reports regardless of whether an alarm is generated during the polling sequence or not. Therefore, the availability of the system will be updated much more rapidly than in the present BAS. Additional message delay, incurred at the MCC, will range from 33 ms minimum to 825 ms maximum with the latter figure occurring only for the improbable condition of simultaneous alarms on each of the 24 loops.

The DC will have an enhanced repeat capability achieved by sorting the increased information available. The true alarm will continue to be determined by two or more red reports or one red report and two yellow reports from a target area. This alarm will be timed locally from the first red report received. The first red report will be held to combine with a second red report arriving later, because of delay in the SGS loops, or with pre-existing yellows or yellows derived from a subsequent yellow search. The longest differential delay between two red reports would be approximately 6 seconds. A yellow search could be completed in a minimum time of 4 seconds but, depending upon the intensity of the attack, may not be immediately initiated by the MCC.

3.6.2 Repeat Capability of Augmented BAS with Respect to Hypothetical Attack

A series of timing diagrams (Figures 3.9, 3.10, 3.11) illustrate the flow of traffic from the SGS loops to the MCC's and from the MCC's to the DC's. The timing diagram (Figure 3.12) illustrates the sequence of "two-of-three" alarms received at the DC.

The analysis is useful for illustrating the reduced polling time and the increased data rate to the DC. Elimination of the redundant alarm reduces the ambiguity at the DC but a certain amount still exists in the absence of localizing information.

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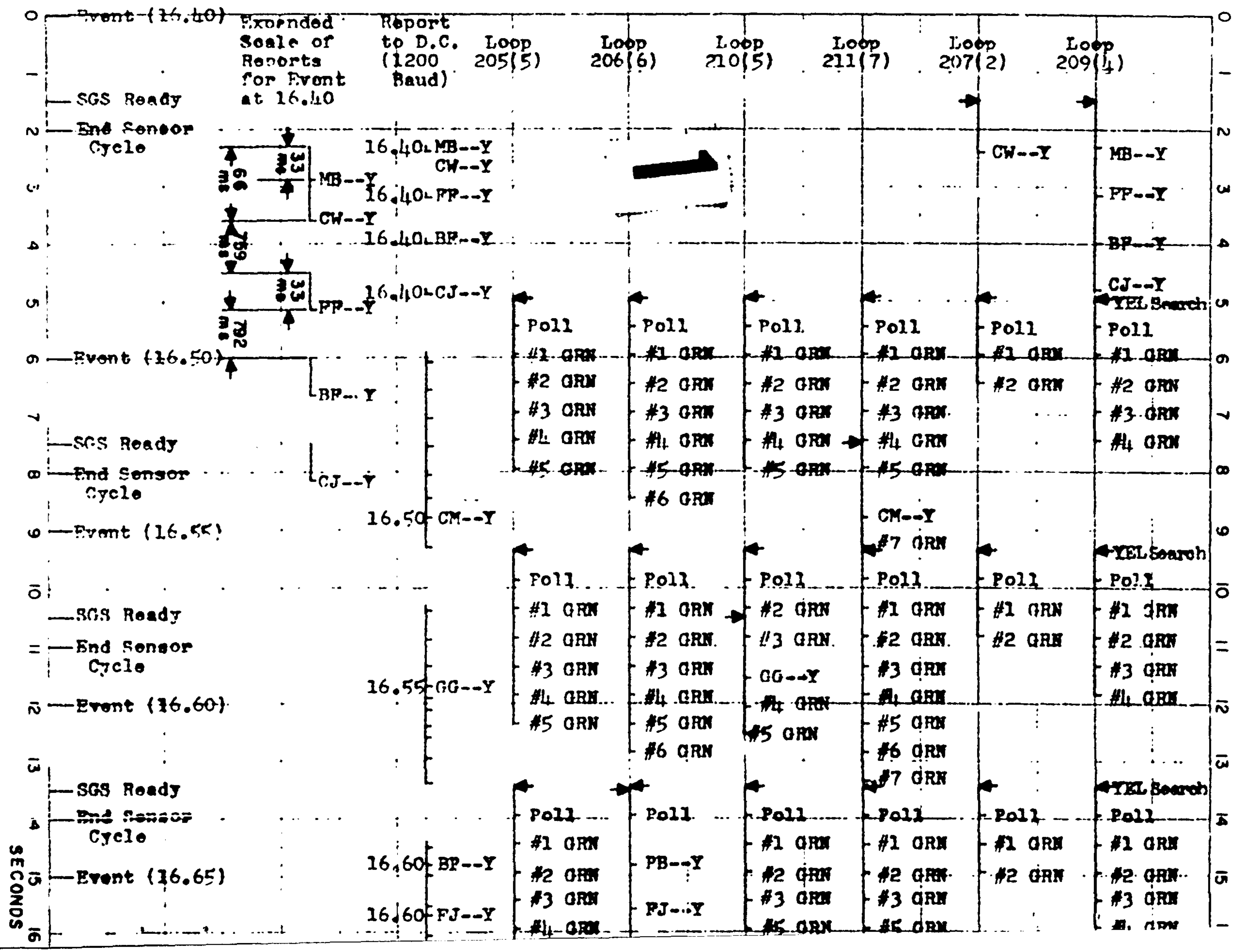

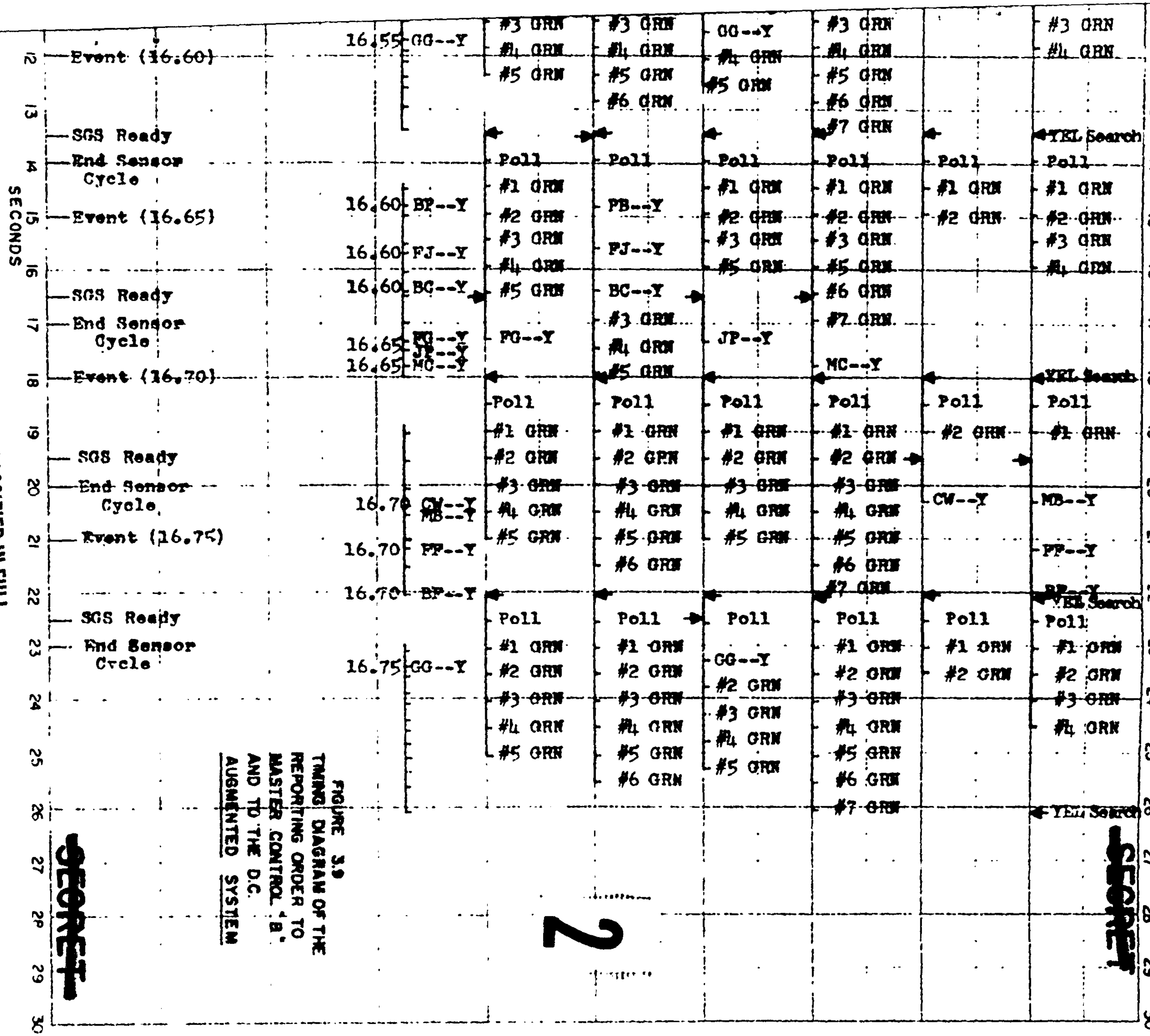

FIGURE 3.9
TIMING DIAGRAM OF THE REPORTING ORDER TO MASTER CONTROL 'B' AND TO THE D.C. AUGMENTED SYSTEM

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SECONDS	Events	Report to D.C.	Loop 105(6)	Loop 103(6)	Loop 109(7)	Loop 107(6)	Loop 106(6)
0	~~Event (16.40)~~						
1	SGS Ready						
2	~~End Sensor~~ Cycle	16.40 CJ--Y FP--Y				FP--Y	CJ--Y
3		16.40 BP--Y MB--Y				MB--Y	BP--Y
4		16.40 CW--Y				CW--Y	YEL Search
4–5			Poll	Poll	Poll	Poll	Poll
5			#1 GRN	#1 GRN	#1 GRN	#1 GRN	#1 GRN
			#2 GRN	#2 GRN	#2 GRN	#2 GRN	#2 GRN
6	Event (16.50)		#3 GRN	#3 GRN	#3 GRN	#3 GRN	#3 GRN
			#4 GRN	#4 GRN	#4 GRN	#4 GRN	#4 GRN
7			#5 GRN	#5 GRN	#5 GRN	#5 GRN	#5 GRN
	SGS Ready		#6 GRN	#6 GRN	#7 GRN	#6 GRN	#6 GRN
8	~~End Sensor~~ Cycle	16.50 CM--Y			CM--Y		YEL Search
9	Event (16.55)		Poll	Poll	Poll	Poll	Poll
			#1 GRN	#1 GRN	#1 GRN	#1 GRN	#1 GRN
10			#2 GRN	#2 GRN	#2 GRN	#2 GRN	#2 GRN
	SGS Ready		#3 GRN	#3 GRN	#3 GRN	#3 GRN	#3 GRN
11	End Sensor Cycle	16.55 GG--Y	#4 GRN	#4 GRN	#4 GRN	GG--Y	#4 GRN
			#5 GRN	#5 GRN	#5 GRN	#4 GRN	#5 GRN
12	~~Event (16.60)~~		#6 GRN	#6 GRN	#6 GRN	#5 GRN	#6 GRN
					#7 GRN		YEL Search
13			Poll	Poll	Poll	Poll	Poll
	SGS Ready		#1 GRN	#1 GRN	#1 GRN	#1 GRN	#1 GRN
14	~~End Sensor~~ Cycle				#2 GRN	#2 GRN	
		16.60 BC--Y, PJ--Y	PJ--Y	BP--Y	#3 GRN	#3 GRN	BC--Y
15	Event (16.65)		#2 GRN	#2 GRN	#4 GRN	#4 GRN	#2 GRN
			#3 GRN	#3 GRN	#5 GRN	#5 GRN	#3 GRN
16			#4 GRN	#4 GRN	#6 GRN		#4 GRN
	... Ready		#6 GRN	#5 GRN			#5 GRN

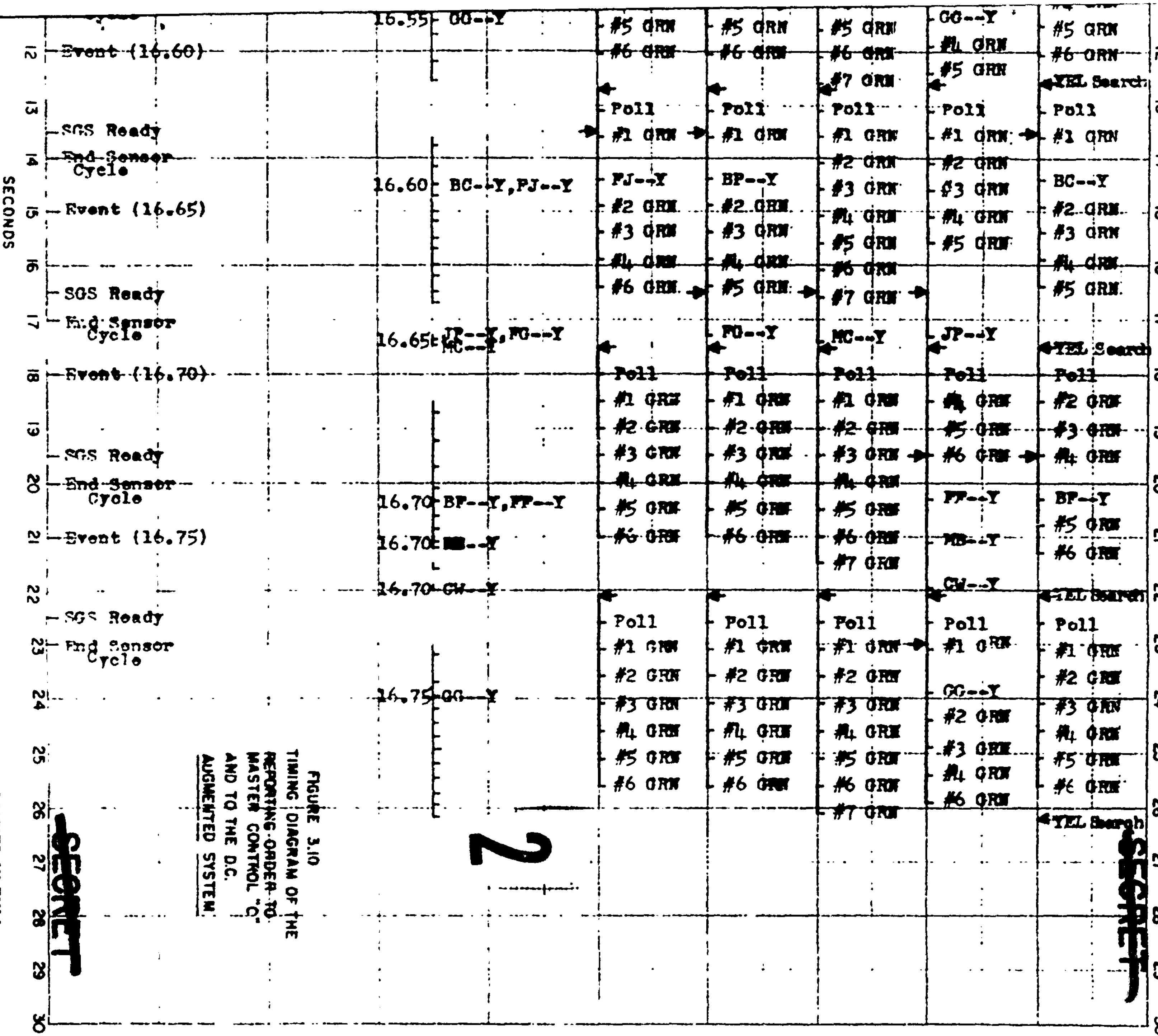
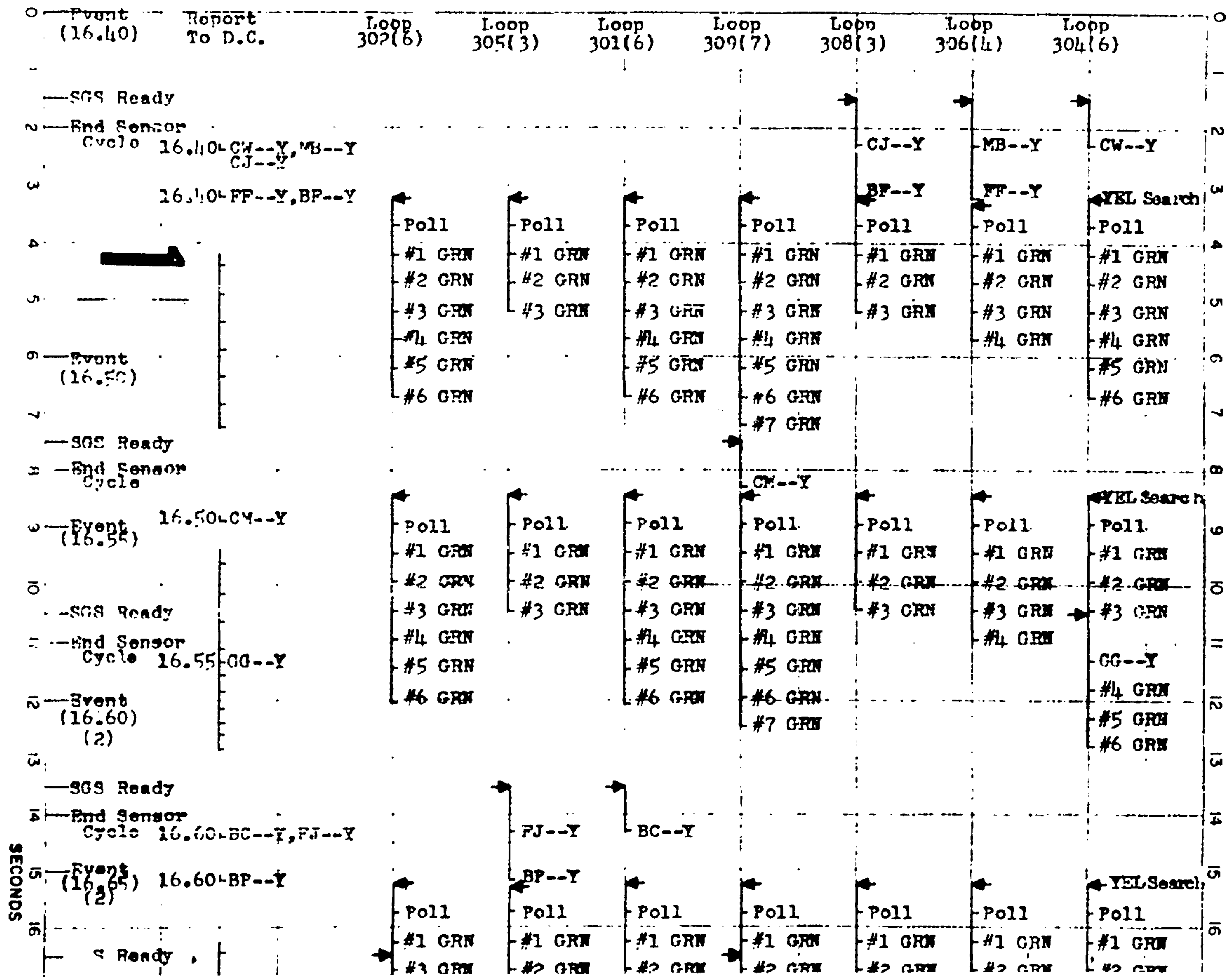


FIGURE 3.10
TIMING DIAGRAM OF THE REPORTING ORDER TO MASTER CONTROL "C" AND TO THE D.C. AUGMENTED SYSTEM


Event (16.40)
Report To D.C.
Loop 302(6)
Loop 305(3)
Loop 301(6)
Loop 309(7)
Loop 308(3)
Loop 306(4)
Loop 304(6)
SGS Ready
End Sensor Cycle
16.40-CW--Y, MB--Y CJ--Y
16.40-FF--Y, BF--Y
CJ--Y
MB--Y
CW--Y
BF--Y
FF--Y
YEL Search
Poll
#1 GRN
#2 GRN
#3 GRN
#4 GRN
#5 GRN
#6 GRN
#7 GRN
Event (16.50)
CW--Y
Event (16.55)
16.50-CW--Y
16.55-GG--Y
GG--Y
Event (16.60) (2)
16.60-BC--Y, FJ--Y
FJ--Y
BC--Y
BP--Y
Event (16.65) (2)
16.60-BP--Y
SECONDS

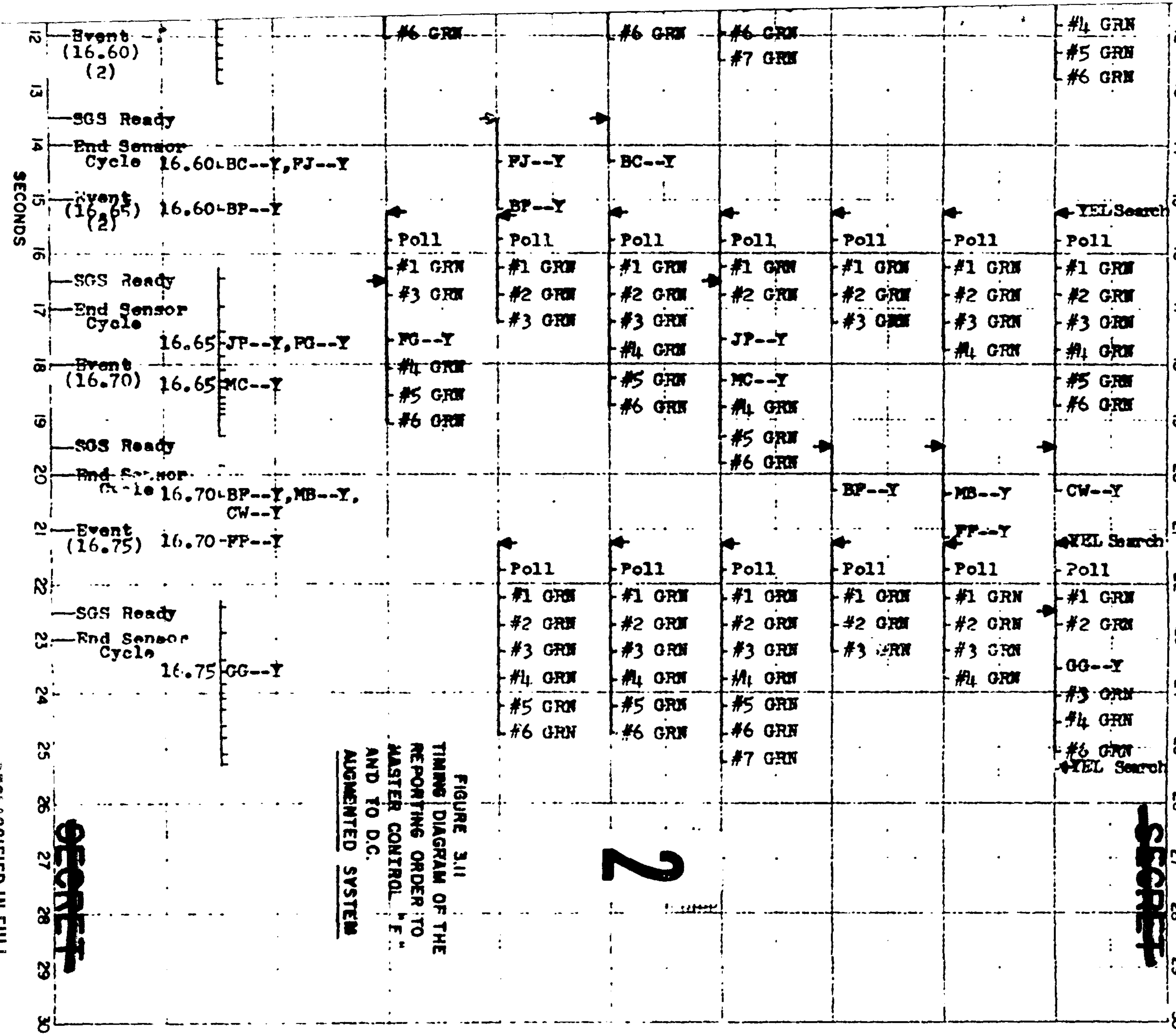


FIGURE 3.11
TIMING DIAGRAM OF THE REPORTING ORDER TO MASTER CONTROL "F" AND TO D.C. AUGMENTED SYSTEM

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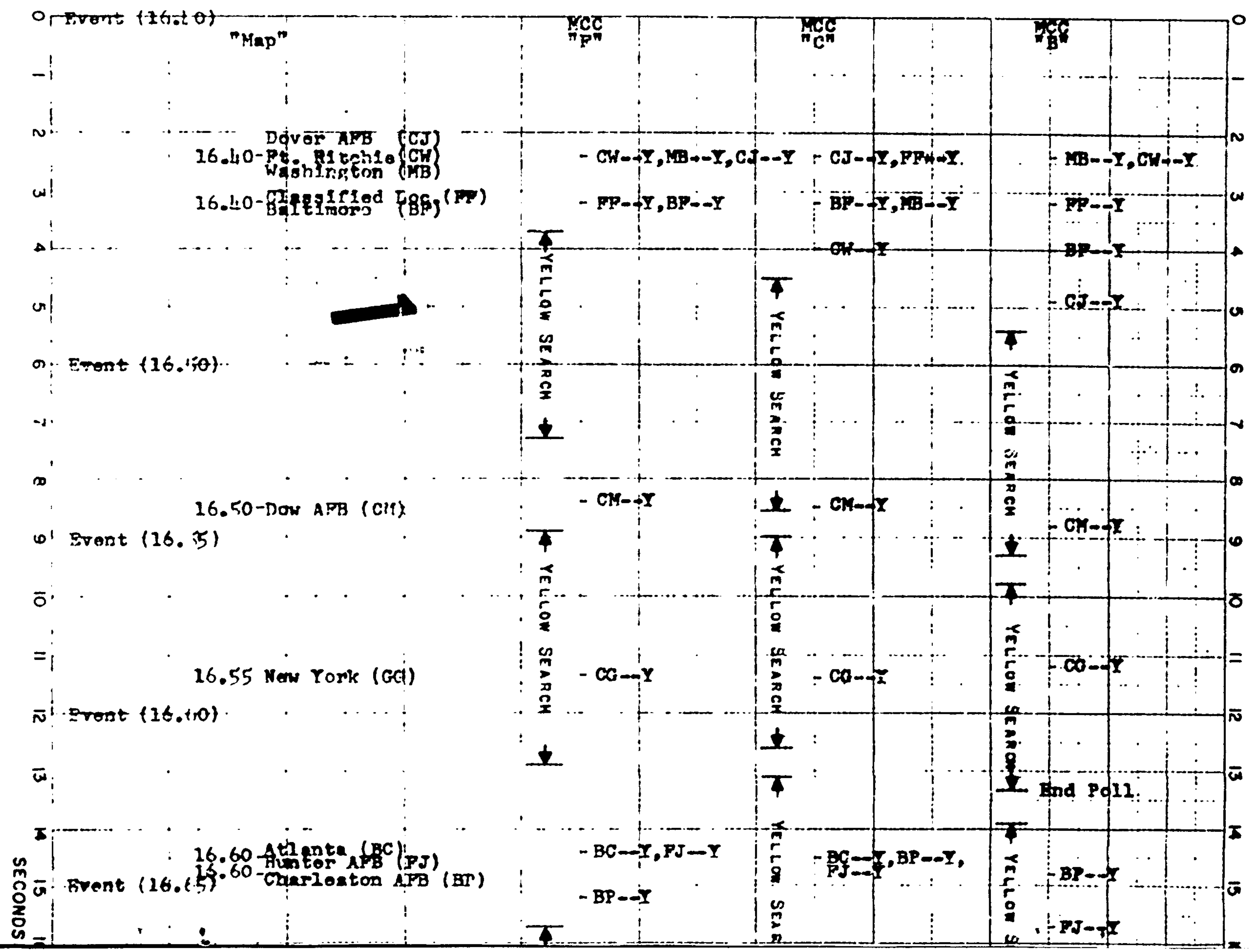

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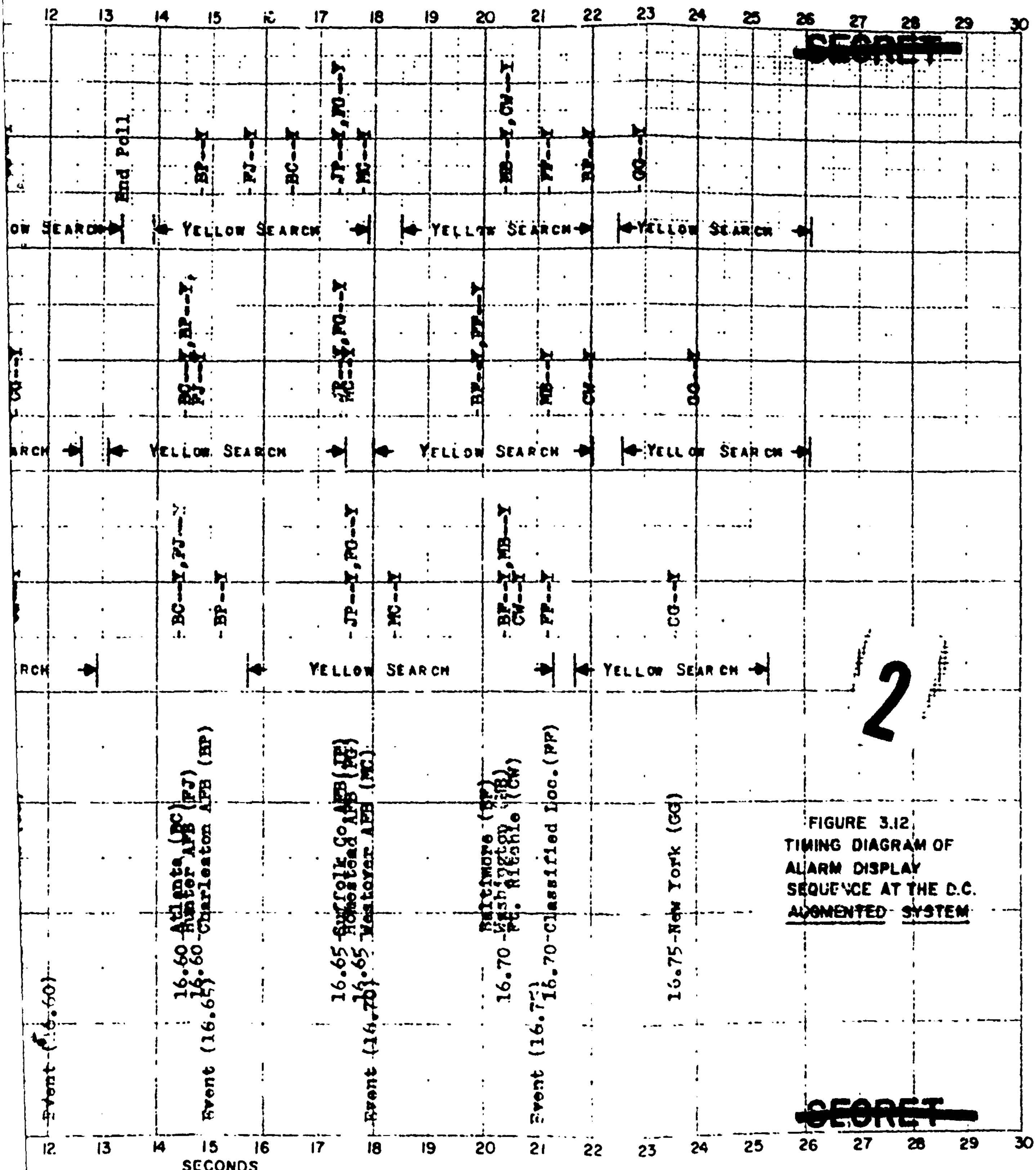

FIGURE 3.12
TIMING DIAGRAM OF ALARM DISPLAY SEQUENCE AT THE D.C. AUGMENTED SYSTEM

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The assumptions are again made that the system survives and that the SGS's will respond green to a poll unless in the red mode. This has the effect of creating the heaviest traffic on the loops during the attack interval, but eliminates the effect of possible yellow information in deriving alarms at the DC.

The poll request and green responses are three characters in length or 500 ms. The transmission times of five and three character messages, at the 1200 baud rate, are approximately 33 and 20 ms respectively. Transmission from the MCC to the DC during yellow searches is shown continuous because of the compressed time scale. Actually, it is not continuous because the loops have different numbers of reports but the length of the yellow search is determined by the longest loop. Also, simultaneous alarms at the MCC's, on parallel loops, are shown transmitted to the DC simultaneously whereas they are serial and of the order of 33 ms apart. These slight timing errors are insignificant when compared to the resolution time of the rest of the system.

Timing diagram (Figure 3.12) indicates the traffic to the DC and the sequence of displayed alarms. The start-of-poll control message is sent to the DC at the end of the start-of-poll message to the loops in order to compress the poll duration at the DC for the purpose of making yellow decisions in the absence of green reports. For the event at 16.40, which resulted in responses from five different target areas, four of the two-out-of-three alarms will receive the same local time and the fifth will be tagged one second later. If localizing information is available, the number of optical alarms, within this geographic area, is reduced to one and time-tagged from the earliest received report. If localizing information is absent, a general area name such as "Washington Area) will be displayed, also time-tagged from the earliest received report. The same sorting technique would apply to the reports received for the event at 16.70 in the same geographic area.

The simultaneous events at 16.60 are located at Atlanta and Savannah and involve two geographic areas of optical detectivity with one target area (Atlanta) responding from one and two target areas (Hunter AFB and Charleston AFB) responding from the other. Localizing information should result in displaying Atlanta and Hunter AFB (near Savannah) and eliminating Charleston AFB. Time tags would be the same or possibly one second apart.

The simultaneous events at 16.65 are located at Homestead, Florida and New London, Connecticut and involve two areas of optical detectivity with one target area (Homestead AFB) responding from one and two target areas (Suffolk County AFB and Westover AFB) responding from the other. Localizing information should be available for Homestead AFB. Localizing information may be present to resolve Suffolk County AFB and Westover AFB but, if it is not, a general area name would be printed out such as "New London Area". Time tags would be the same or possibly one second apart.

The assumption that all equipment survives during the attack interval is unrealistic, as borne out by the survivability study. Confirming red alarms will not be available for many of the target areas and a waiting interval may be required to update the yellow information. This is especially true at the beginning of an attack. For example, a yellow search is necessary after receipt of a single Sensor alarm for a target area having one inoperative Sensor prior to an event and that event destroying one of the operating Sensors before it can respond.

As the attack progresses, yellow information will be increasingly available for immediate combining with red reports. This is true since a yellow search at any period of the attack updates all yellow information such as disruption of communications facilities serving one target area by an event at another target area. This yellow information is permanently stored until green responses are received. Restated, yellow searches, of whatever frequency, provide an availability check of the entire system at a rate slightly slower than that of the attack itself.

For the density of the attack considered, i.e., randomly located events at 3 second intervals, it is seen that yellow searches are conducted at similar intervals. It would appear that, following the receipt of a single Sensor alarm, and in the absence of pre-existing yellows, a waiting period of the order of ten seconds might be necessary to confirm the report with yellow information subsequently extracted from the system. If the attack proceeds at a faster rate, yellow searches may be initiated less frequently or not at all since the MCC is busy handling red alarms. For an attack of this intensity, yellow information may be less significant anyway. If the attack proceeds at a slower rate, a yellow search will take place after each event. Also, the concept of all three MCC's within a geographic area conducting a yellow search on command from any one of them, after reporting an alarm, is most useful under these conditions.

The augmented system has a vastly improved repeat capability over that of the present system. The longest delays are still associated with the serial SGS loops, however. A further reduction of these delays can be accomplished by reducing the number of SGS's per loop to a maximum of four. This will further increase the repeat capability of the SGS's and improve their availability and survivability. The length of the yellow search would be nearly halved as would the maximum differential delay between two red reports from a target area. At the DC, the local time tag would be more accurate, the waiting period would be shortened and the sorting procedure would be simplified.

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3.7 COST ESTIMATES ← deleted by ESD(ESTI) TSgt Wassik 6 aug 64

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