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THE EFFECTS OF CASTLE DETONATIONS UPON THE WEATHER

#467

SPECIAL REPORT

OCTOBER 1954

HEADQUARTERS
JOINT TASK FORCE SEVEN
WASHINGTON 25, D. C.

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THE EFFECTS OF CASTLE DETONATIONS UPON THE WEATHER

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Special Report

October 1954

Headquarters
Joint Task Force SEVEN
Washington 25, D. C.

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INTRODUCTION

The detonation of the most powerful explosive device produced by man - a thermonuclear bomb - rightly concerns many as to the effects produced on the earth and its atmosphere. Detonation of atomic devices has led to conjecture that all manner of weather phenomena have resulted - droughts, floods, tornadoes and typhoons. Operation CASTLE offered an opportunity to observe qualitatively, at least, some of the effects, if any, of high yield explosions upon the weather.

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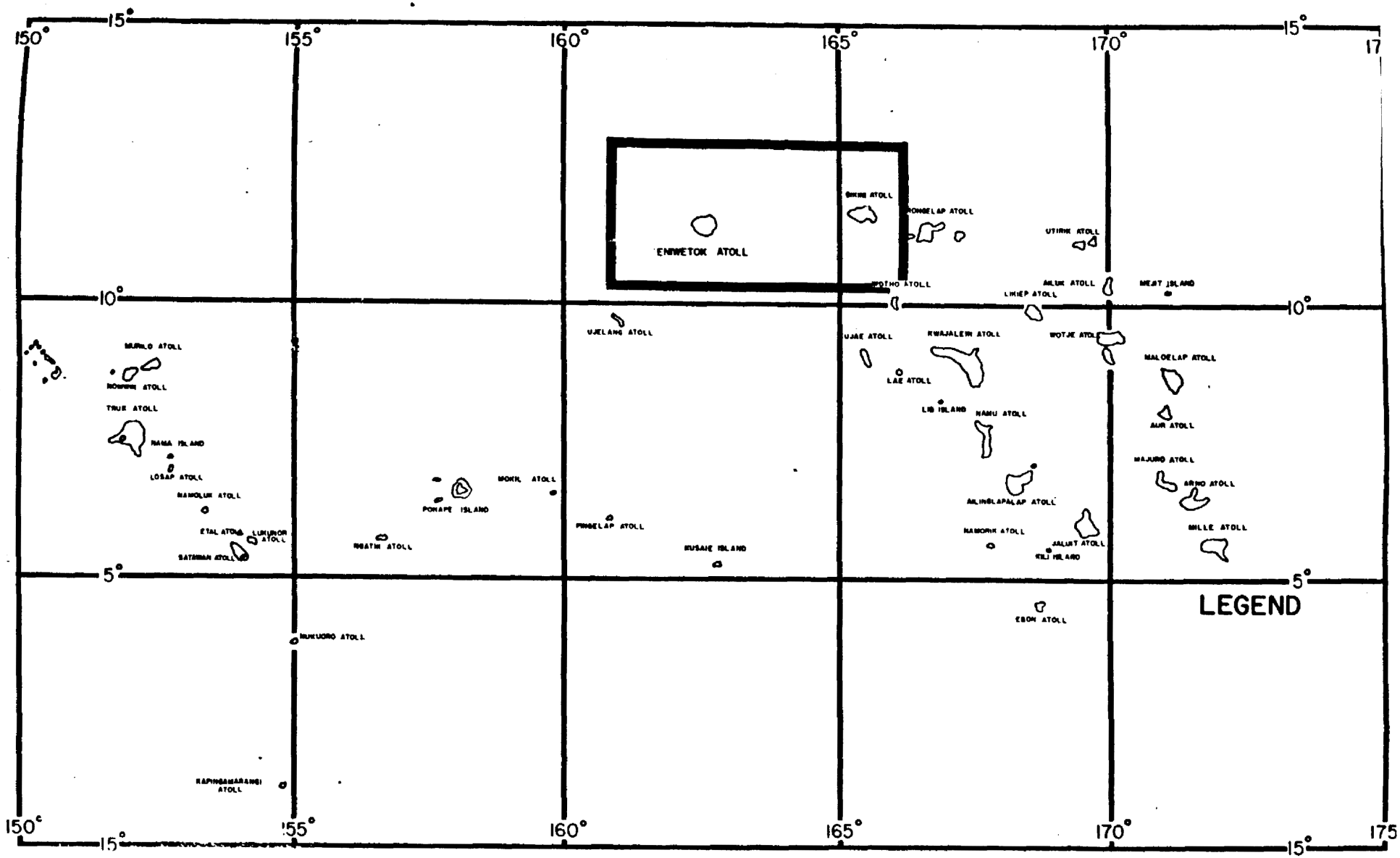

Figure 1

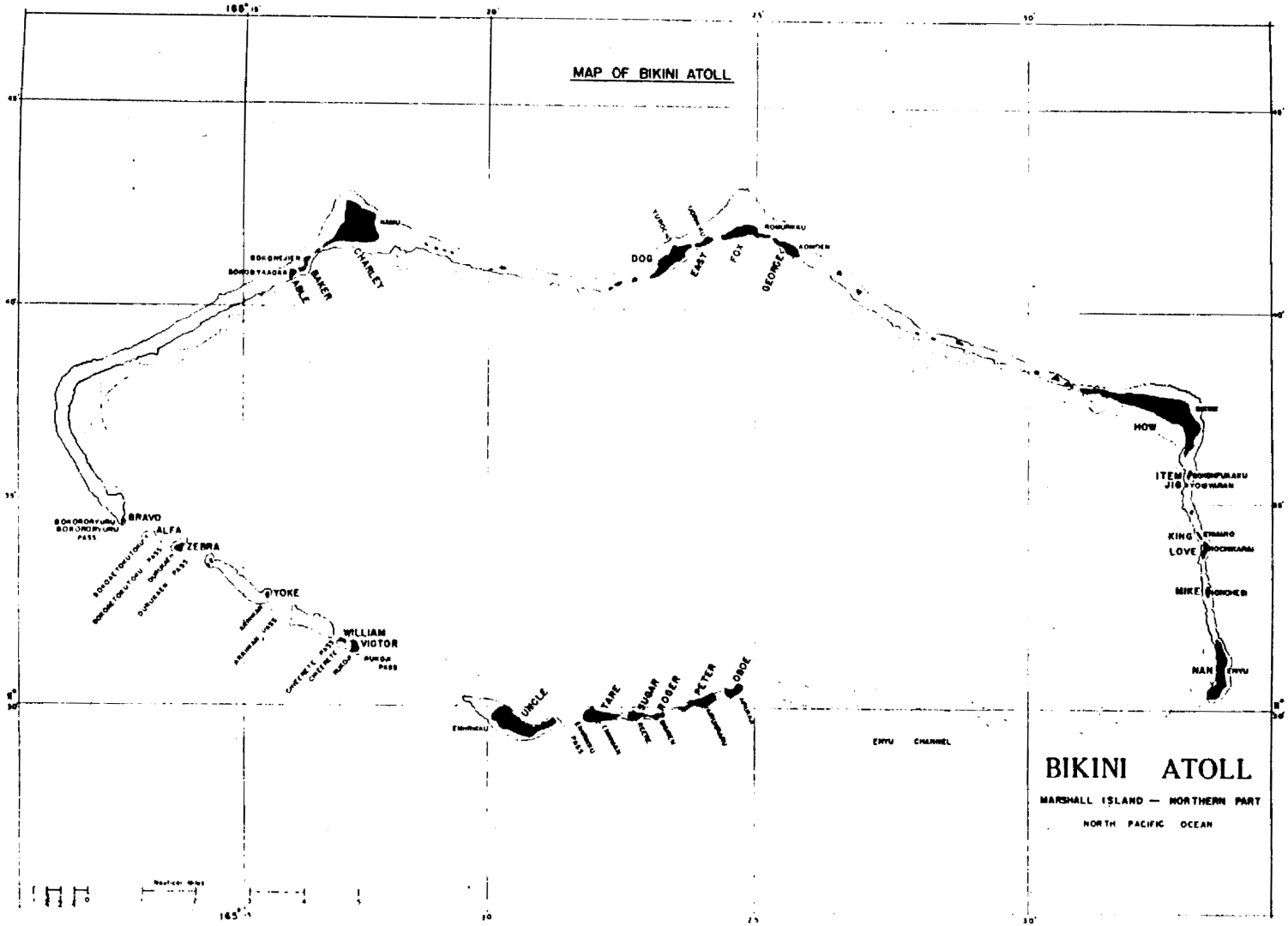

Figure 2

MAP OF ENIWETOK ATOLL

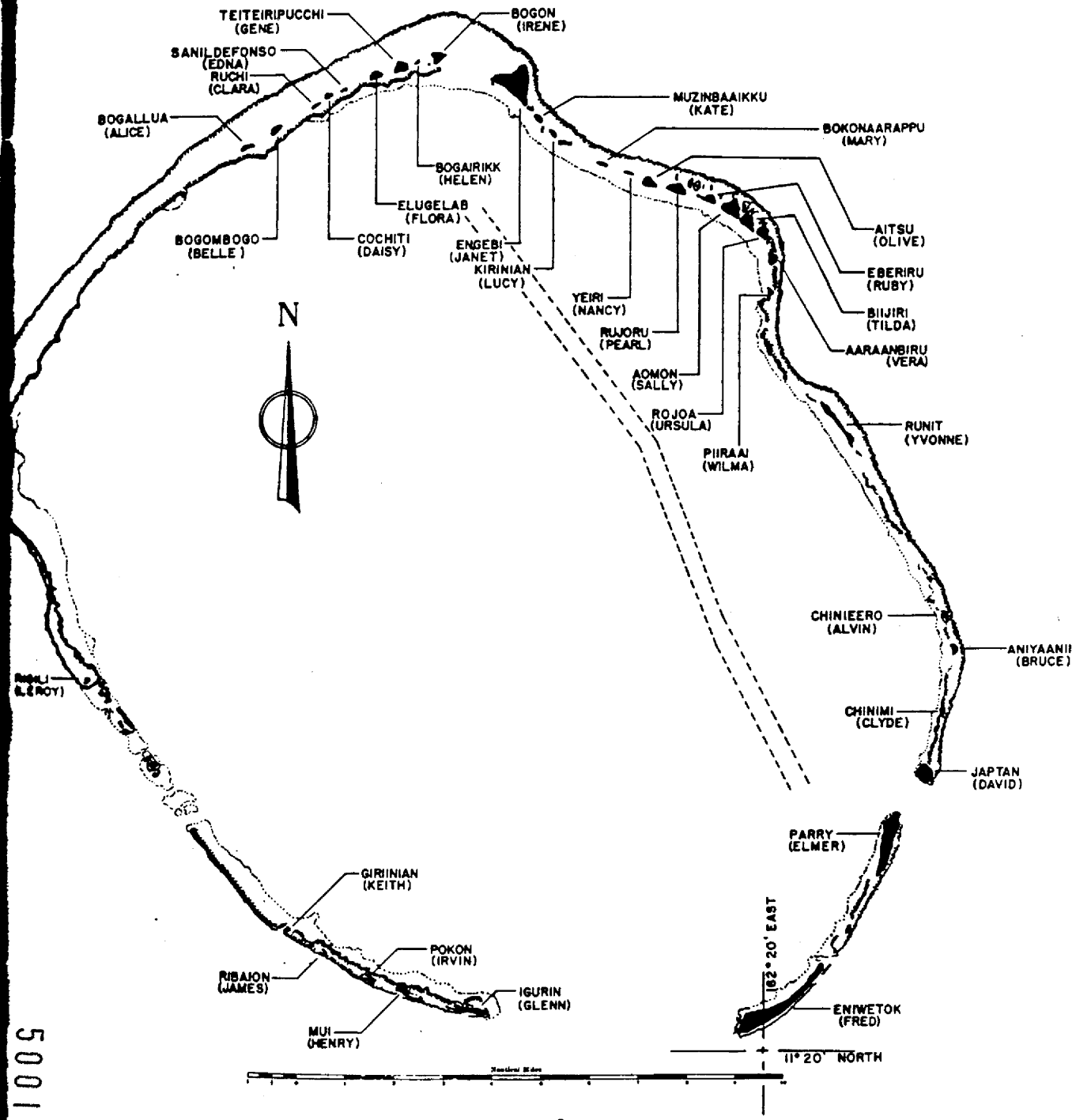

Figure 3

SOURCES OF DATA

There were five primary sources of information which may be used for a qualitative evaluation of weather changes attributable to detonation of high yield devices at the Pacific Proving Ground:

1. The network of surface and upper air observation stations. This network consisted of regularly reporting weather stations at Eniwetok, Kwajalein, Majuro, Ponape, Kusaie, Truk, Wake, Marcus and spasmodically reporting stations at Rongerik and Tarawa. These stations were within an area bounded by the equator and latitude 25° N., and longitudes 150° E. and 175° E. Eniwetok was approximately in the center of this trapezoid which has an area of about two-thirds that of the continental United States.

2. Aerial weather reconnaissance aircraft which maintained weather surveillance over approximately this area.

3. Limited radar coverage. Radar used was the SPS-6, installed on the command ship for the control of aircraft. It was not primarily used for weather surveillance, and sketches of shower distribution as shown on the SPS-6 scope were possible only when the scope was not being used to vector aircraft.

4. Visual sky and shower observation. Immediately prior to, and for a period of several hours following each shot, visual observations of sky and shower conditions were taken by personnel of the Task Force Weather Central. These observations were necessarily from a point upstream from the area where a major portion of the radioactive fallout

occurred. Since all tests were conducted at dawn, 30 minutes prior to sunrise, definitive pre-test visual weather observations were difficult to obtain. However, careful observations were made to ascertain cloud amounts through observations of stars and, when possible, optical phenomena such as lunar halos and coronas.

5. Photographs of the nuclear cloud. The weather and associated cloud cover can be better visualized by an inspection of the aerial photographs made at and subsequent to each of the detonations. Much useful information is available and certain conclusions can be made from an examination of these photographs. Consequently, a more realistic deduction can be made of the effects of high yield detonations upon the weather.

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BRAVO EVENT

The device was detonated at 0645 hours local (M), 1 March 1954 as a land surface shot on a small sand spit near NAMU Island (CHARLIE) at Bikini. Yield was approximately 15 megatons.

A trade wind type weather situation typified the Marshall Island weather on 1 March 1954. Winds with westerly components occurred as low as 7,000 feet. Ordinarily such winds are not present below 15,000 to 25,000 feet.

4/8 cumulus, bases 2,000 feet, tops 4,000 feet; few altostratus (1/8) at about 18,000 feet; and 6/8 very thin cirrostratus were observed at shot time. (See Figures 4 and 5.) No showers were discernible. As the fireball rose and the nuclear cloud developed, a series of pileus clouds developed and were penetrated by the rising stem. There was a brief increase in cumulus, both in amount and height of tops. (See Figure 6.) There was no definite evidence that showers occurred either before or immediately after the shot.

At Eniwetok, 180 miles to the west, small segregated patches of altocumulus and altostratus were seen to form near the explosion. Despite the marked westerly component of the winds at the levels where the altocumulus were observed, the clouds progressively increased to 3/8 to 4/8 coverage for a brief period at about H plus 3 hours. A great cirriform cloud formed from the mushroom and spread slowly. By H plus 5 hours the leading edge had reached Eniwetok. This cloud had the appearance of cirrocumulus intersticed with many long filaments which appeared from the

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ground to cross and form a pattern not unlike a cloth such as gaberdine. Figures 6 and 7 show the early development of this cirrus deck.

Aerial weather reconnaissance of the area about the Pacific Proving Grounds before the shot found the usual amount of trade shower activity. Following the shot reconnaissance to the northeast of ground zero reported no shower activity although a few cumulus tops rose to 9,000 feet in the period up to H plus 14 hours. By H plus 22 hours the most pronounced area of shower activity was found between 15° N. to 16° N. and 172° E. to 174° E. At H plus 36 hours an area of moderate rain, definitely falling from middle clouds, was observed on a line from 15° N. 170° E. to 17.5° N. 173.5° E.

Analysis of the synoptic weather charts subsequent to the shot showed no unusual developments.

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FIGURE 4

BRAVO EVENT - Taken 3½ seconds after shot time at a distance of 75 nautical miles east of ground zero, from an altitude of 12,500 feet.

[redacted]

[redacted]

22-[redacted]-1-7

[redacted]

[redacted]

Figure 5

BRAVO EVENT - Taken 1 minute after shot time at a distance of 50 nautical miles north of ground zero from an altitude of 10,000 feet.

22-AD-1-4

Figure 6

BRAVO EVENT - Taken 16 minutes after shot time at a distance of 50 nautical miles northwest of ground zero from an altitude of 10,000 feet.

22-AUG-11-37

Figure 7

BRAVO EVENT - Taken 30 minutes after shot time at a distance of 50 nautical miles west-~~south~~north west of ground zero from an altitude of 10,000 feet.

[redacted]

ROMEO EVENT

The device was detonated at 0630 hours local (M), 27 March 1954 as a water surface shot from a barge in the BRAVO crater in approximately 110 feet of water. Yield was approximately 11 megatons.

The day before ROMEO event, scattered patches of stratocumulus, a normal amount of cumulus (2/8 to 3/8), and broken to overcast cirrus (more than half-sky coverage) prevailed over the northern Marshalls. The cirrus had been extremely persistent for a period of 10 days. An aerial weather observer in an aircraft at 10,000 feet near ground zero reported 6/8 to 8/8 cirrus until H minus 2½ hours. Fifteen minutes later he reported 4/8 cirrus, and thereafter only 3/8 cirrus. Several showers occurred near Eniwetok during the evening before the shot.

The circulation at the time of ROMEO event was marked by an extensive clockwise outdraft. It existed at all levels from 10,000 feet to the tropopause and was centered approximately 550 miles east-northeast of Bikini. This system produced a deep layer of winds with pronounced southerly components over the northern Marshalls. Moderate strength northeast trades prevailed near the surface.

At shot time a consensus of the observations taken at Bikini from the command ship by sixteen trained weather observers and forecasters was 2/8 cumulus, bases 1,800 feet, tops 4,000 to 5,000 feet and 3/8 cirrus at approximately 40,000 feet, as shown in Figures 8, 9 and 10. No showers were observed. Identical conditions were reported at Eniwetok.

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As the nuclear cloud rose, a pileus of altostratus formed over it at about 18,000 feet. This was quickly penetrated by the nuclear cloud. Another similar deck of cloud formed at about 33,000 feet. (See Figure 8.) Neither of these altostratus decks persisted. There was no significant increase in cumulus. No showers were observed except one which was 60 miles west of Bikini at H plus 5 hours and one which was 16 miles southeast of Eniwetok at H plus 4 hours. However, a thick persistent deck of cirrostratus cloud formed (see Figures 11, 12 and 13), and by H plus 4 hours spread over the whole northern Marshalls. The cirrostratus varied in density and had the ribbed appearance seen in connection with BRAVO. It persisted throughout shot day and well into the following day.

A large fluctuation occurred in the 40,000-foot wind speed just prior to the shot. At H minus 3 hours the wind velocity measured by the USS CURTISS was 190° at 19 knots. Just prior to H Hour it was 200° at 36 knots. This observation was confirmed by an aircraft flying at 39,300 feet. Three hours later the wind was 190° at 13 knots. This fluctuation cannot be attributed to the explosion. It does indicate, however, the magnitude of variations that occur naturally over short intervals in the free atmosphere.

FIGURE 8

ROMEO EVENT - Taken 18½ seconds after shot time at a distance of 75 nautical miles northwest of ground zero, from an altitude of 10,500 feet.

Figure 9

ROMEO EVENT - Taken 2½ minutes after shot time at a distance of 50 nautical miles west-northwest of ground zero from an altitude of 37,000 feet.

Figure 10

ROMEO EVENT - Taken 7 minutes after shot time at a distance of 50 nautical miles west of ground zero from an altitude of 37,000 feet.

Figure 11

ROMEO EVENT - Taken 21 minutes after shot time at a distance of 50 nautical miles south of ground zero from an altitude of 37,000 feet.

Figure 12

ROMEO EVENT - Taken 30 minutes after shot time at a distance of 50 nautical miles southeast of ground zero from an altitude of 37,000 feet.

Figure 13

ROMEO EVENT - Taken 1 hour and 3 minutes after shot time at a distance of 50 nautical miles south-southeast of ground zero from an altitude of 37,000 feet.

[redacted]

KOON EVENT

The [redacted] device was a land surface shot detonated at 0620 hours local (M), 7 April 1954 on the western tip of ENINMAN Island (TARE) at Bikini. The yield was approximately 110 kilotons.

A low level wave in the easterlies moved across the Marshalls on 6 and 7 April 1954. A convergence line to the east of this wave had a great amount of weather, i.e., heavy cumulus and shower activity, associated with it.

The attached series of "Sketch of Cloud Return on SPS-6 Radar" were constructed from the three hours prior to, until five minutes after, shot time, and show the distribution of the major shower clouds near ground zero (See Figures 14 through 22.) The radar scope from which these tracings were made was primarily assigned for monitoring the three B-50 test aircraft. Outlines of cloud return near or approaching ground zero were constructed only at such times when the monitor could make the scope available for tracing clouds. The tracings were made rapidly and as accurately as possible with particular attention directed to those water-bearing clouds from which precipitation could be expected to be induced after the shot.

An observer aboard a weather reconnaissance aircraft flying at 10,000 feet in the vicinity of Eniwetok and Bikini during the period five hours before shot time observed 5/8 to 8/8 cumulus with the tops generally 7,000 feet, and some higher clouds reported as altocumulus with bases estimated from 15,000 to 22,000 feet. At approximately the same time another air-

[redacted]

[redacted]

craft encountered scattered tops of clouds at 40,000 feet. One hour before detonation the aircraft, still at 40,000 feet, entered the edge of a cumulus over ground zero (Figure 19) and encountered moderate turbulence within 15 miles of ground zero. Light to moderate showers occurred from H minus 9 hours to H minus 6 hours at Eniwetok on 6 April 1954.

The sky at shot time was chaotic. A consensus of visual observations near ground zero indicated about 2/8 cumulus, 4/8 to 6/8 stratocumulus at 4,000 to 6,000 feet and multiple decks of altostratus and altocumulus above. (See Figure 30.) The vertical and horizontal distribution of cloud and showers is further illustrated by Figures 23 through 29. No cirrus clouds were reported by the ground observers, apparently because of the obscuring lower clouds. However, observers at Eniwetok reported 2/8 cirrus. The total sky coverage in the vicinity of the shot site averaged 8/8 with small breaks. (See Figure 30.) Showers were visible in all directions. One was located between ground zero and the command ship at shot time. Twenty six minutes before H-Hour it was 12 miles wide.

Based on the radar scope observations (Figures 14 through 22), a large shower was almost certainly over or immediately adjacent to ground zero when the device was detonated. An observer aboard the control aircraft at 37,000 feet stated that the nuclear cloud emerged from the top of a cirrus deck at 37,000 feet. Figures 31 and 32 show a cumulus top merging with the cirrus. The top of the natural cloud, as he described it, appeared to rise about 1,000 feet after the device exploded.

[redacted]

Throughout the day there was no appreciable change in the weather. Showers were observed at all times over the Eniwetok-Bikini area throughout the day. The sky continued to retain the chaotic appearance it had when the device was detonated.

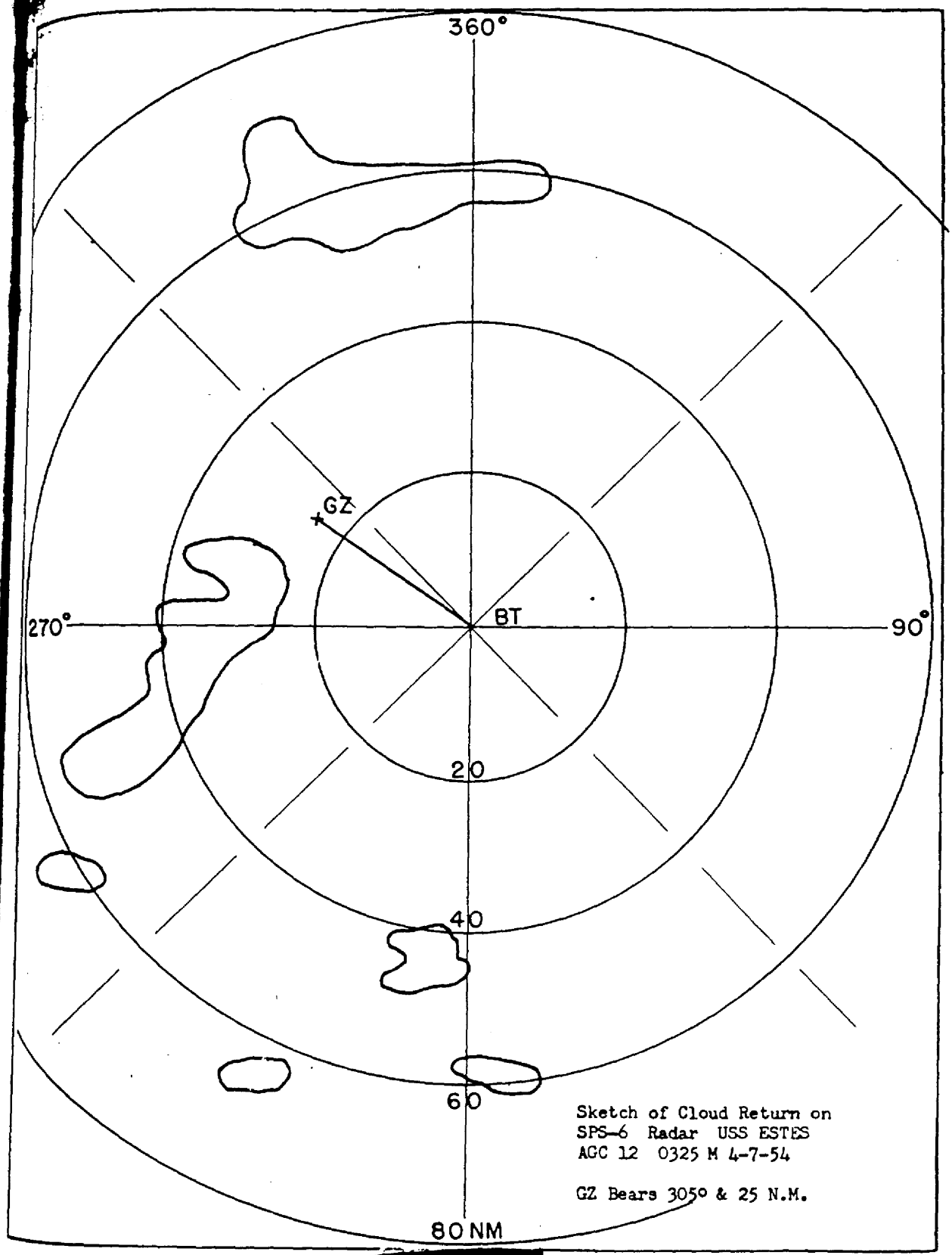
[redacted]

FIGURES 14 through 22

Sketches of cloud return taken from SPS-6 Radar during KOON Event.

Abbreviations: GZ - Ground Zero

BT - Boundary Tare, code name for USS ESTES (AGC-12), Task Force Command Ship.



Sketch of Cloud Return on
SPS-6 Radar USS ESTES
AGC 12 0325 M 4-7-54

GZ Bears 305° & 25 N.M.

Figure 14

KOON EVENT

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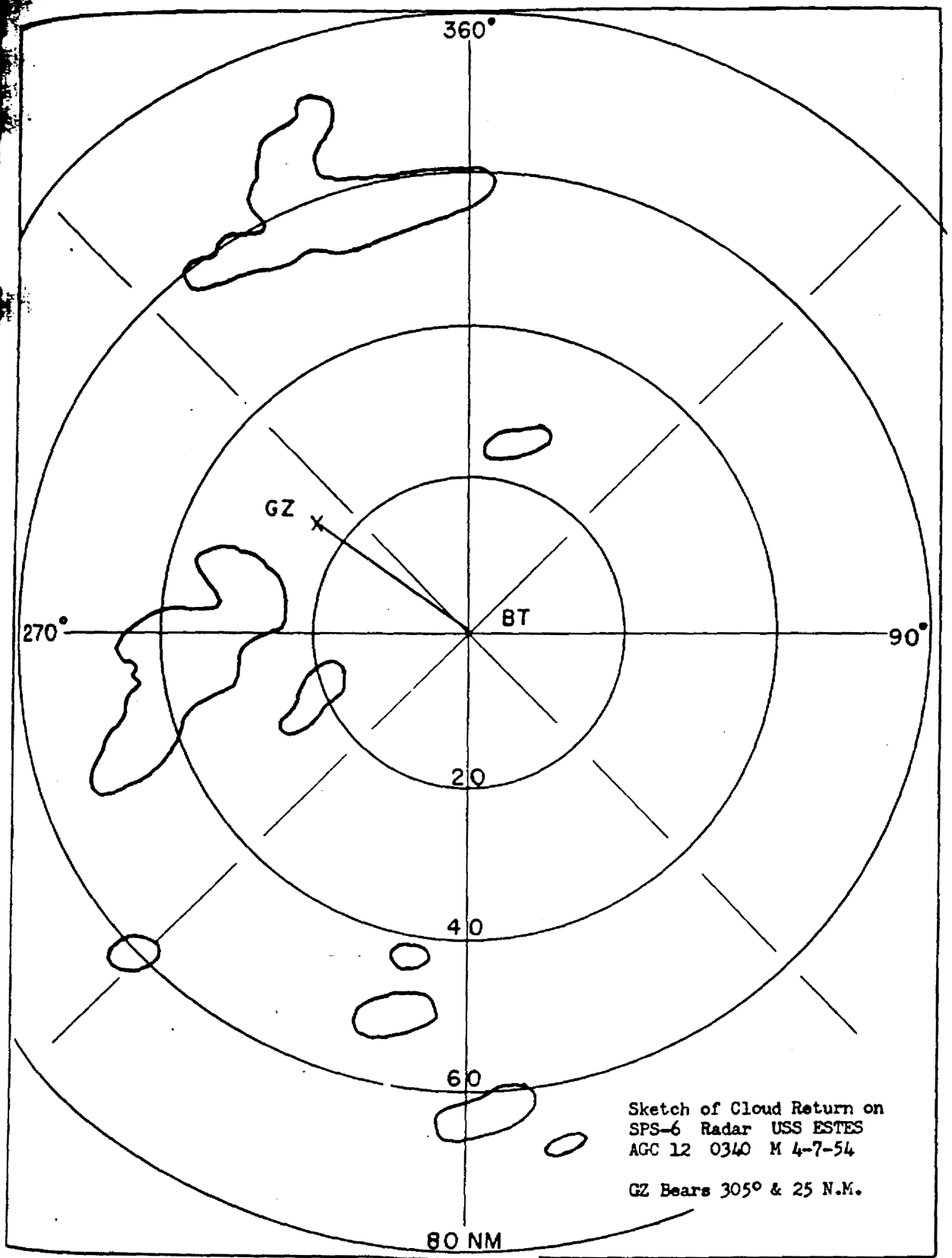

Figure 15

5001662

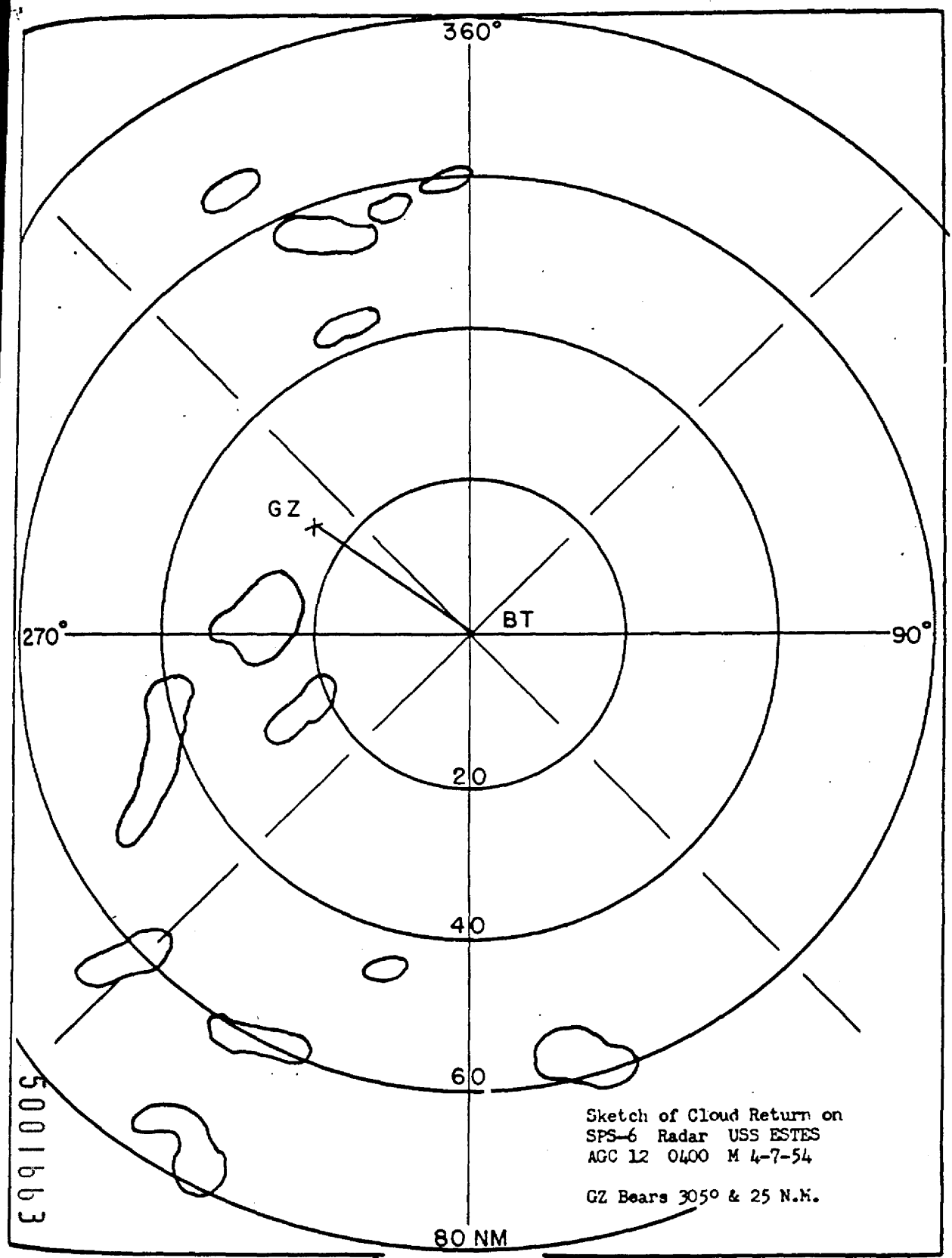
360°
GZ
270°
BT
90°
20
40
60
80 NM
Sketch of Cloud Return on
SPS-6 Radar USS ESTES
AGC 12 0400 M 4-7-54
GZ Bears 305° & 25 N.M.
5001613

Figure 16

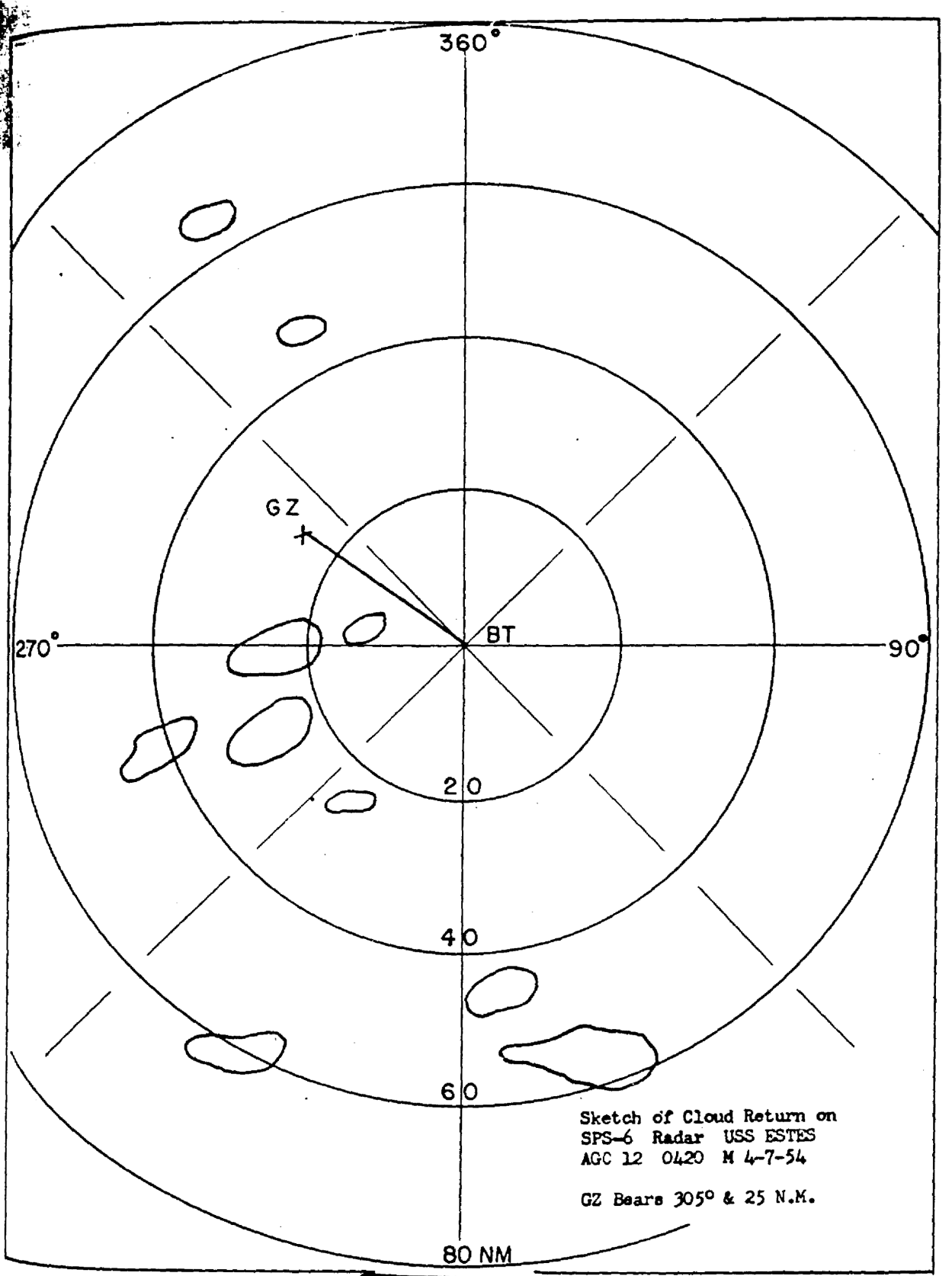

Figure 17 KOON EVENT

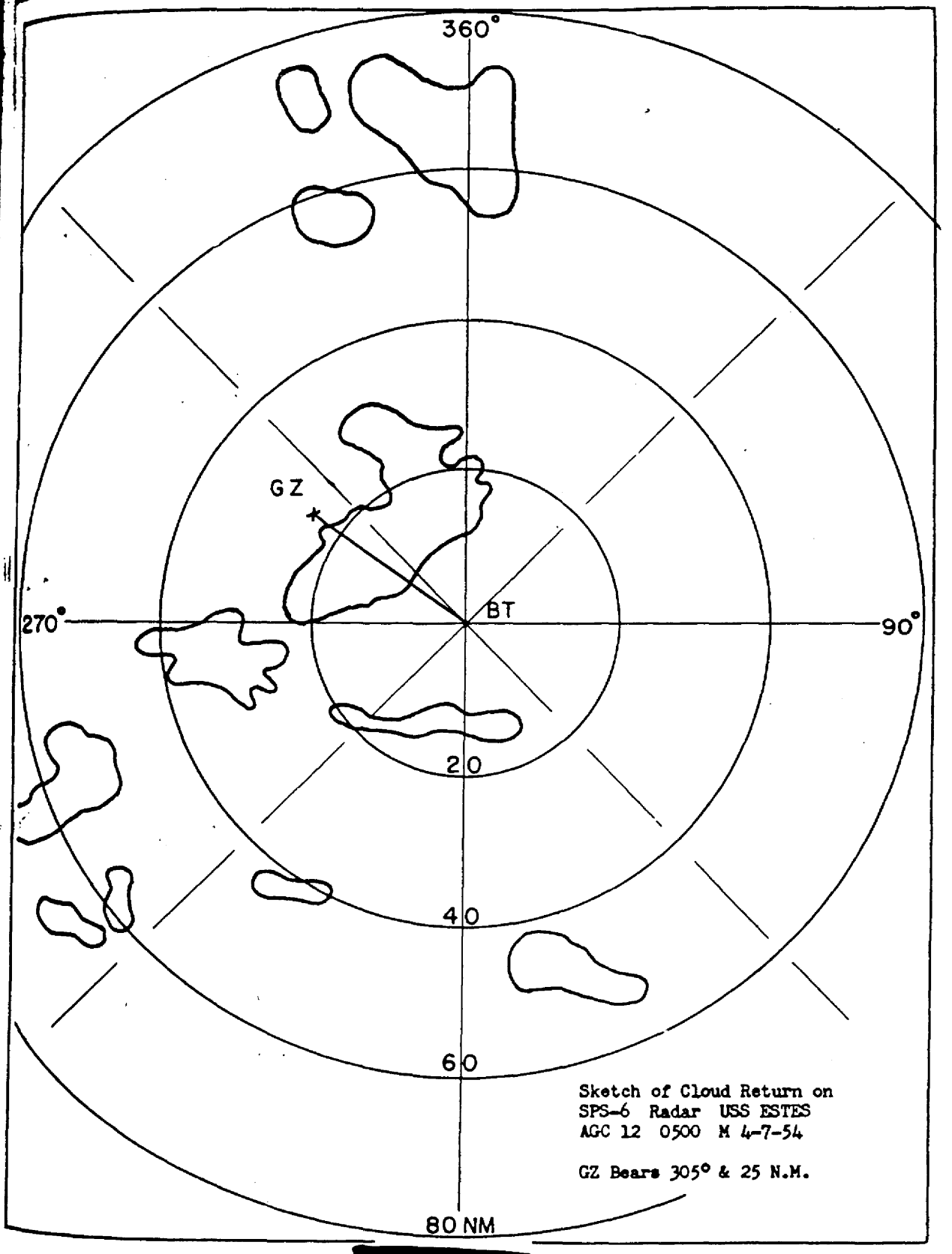

Figure 18

KOON EVENT

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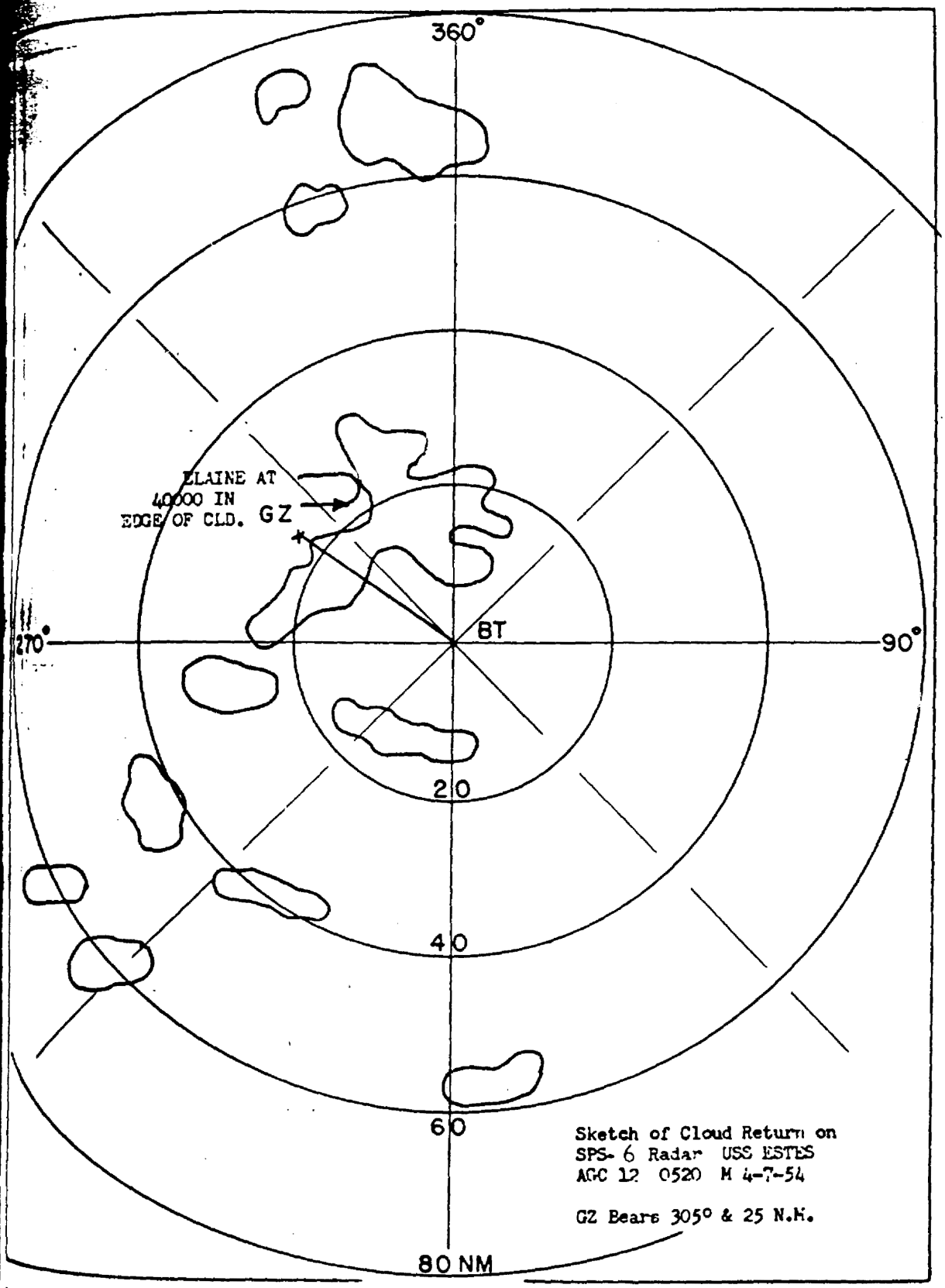


Sketch of Cloud Return on
SPS-6 Radar USS ESTES
AGC 12 0520 M 4-7-54

GZ Bears 305° & 25 N.M.

Figure 19

KOON EVENT

5001666

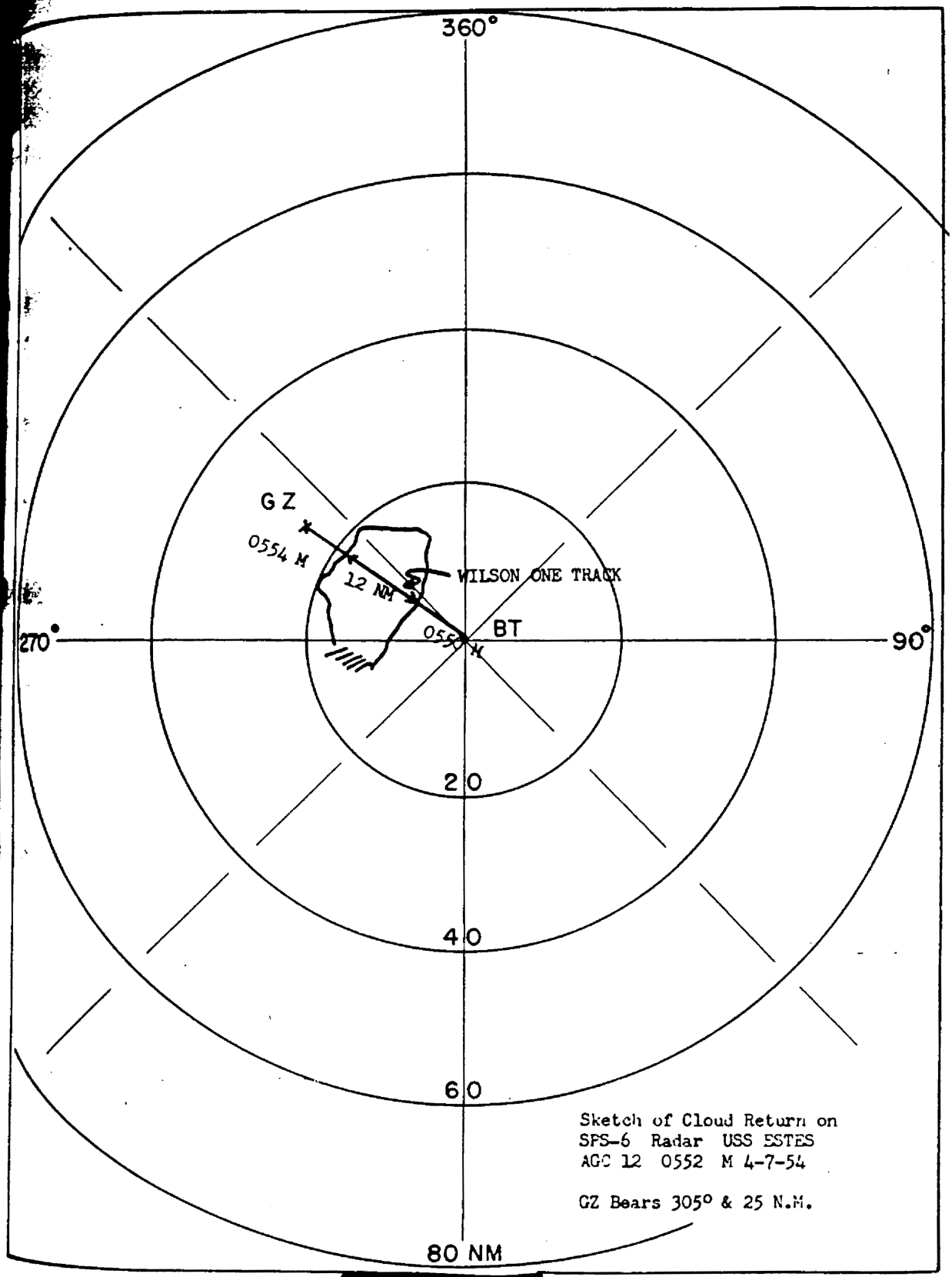
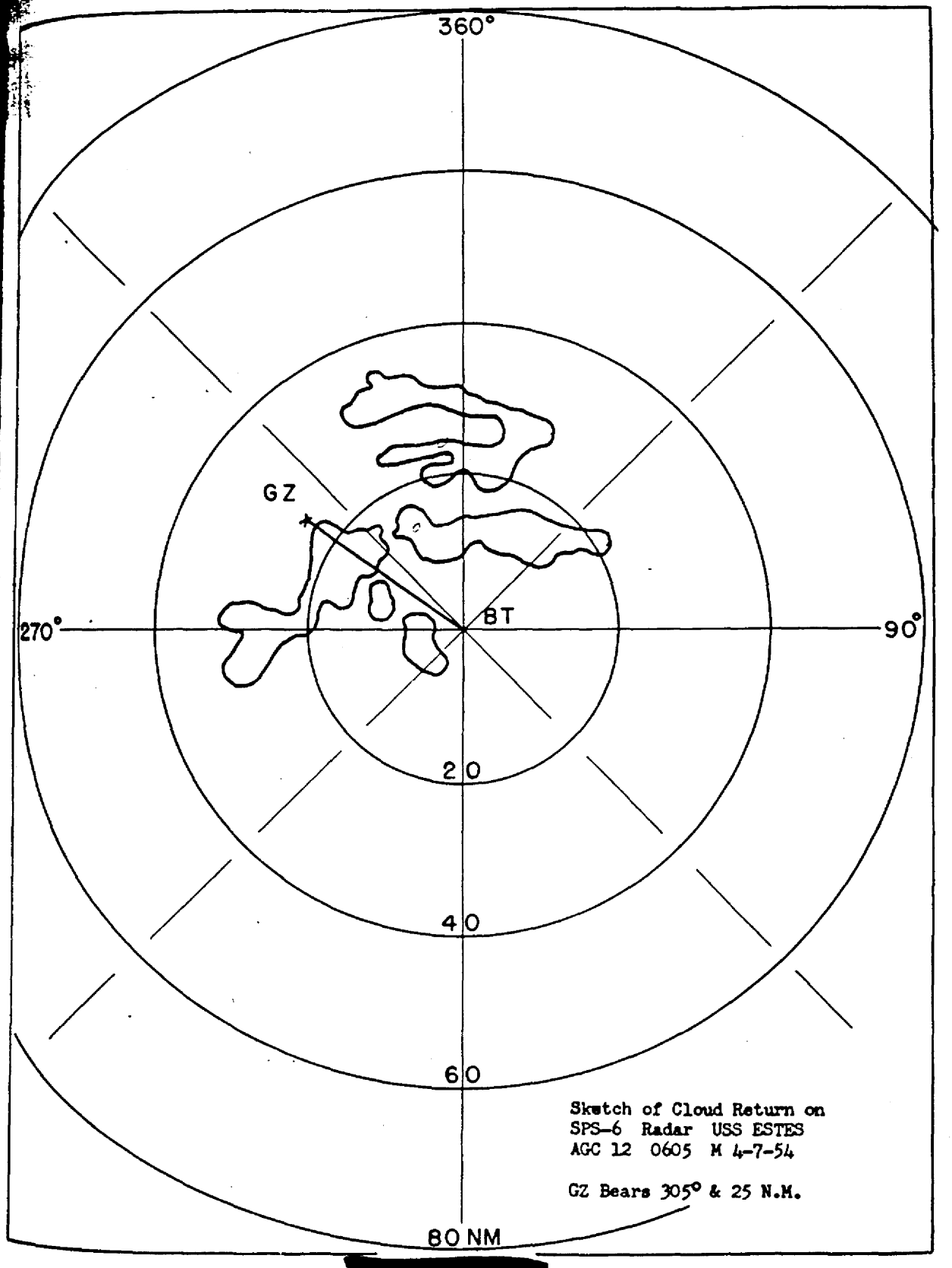


Figure 20

KOON EVENT

5001667



Sketch of Cloud Return on
SPS-6 Radar USS ESTES
AGC 12 0605 M 4-7-54

GZ Bears 305° & 25 N.M.

Figur

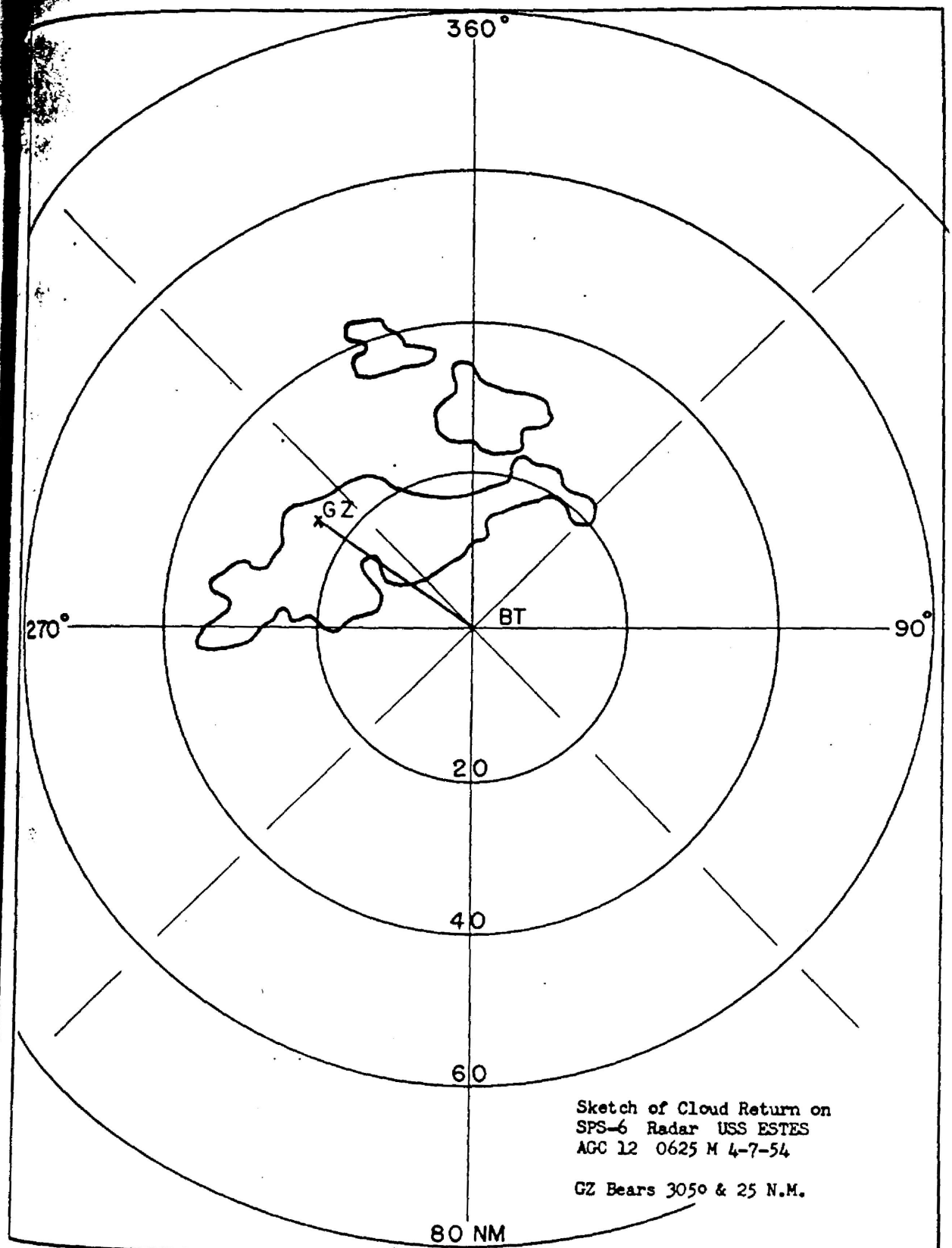


Figure 22

KCON EVENT

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Figure 23

KOON EVENT - Radar scope photograph showing cloud coverage over ground zero at shot time.

Figure 24

KOON EVENT - Radar scope photograph shows cloud coverage over ground zero dissipating at 12 seconds after shot time.

Figure 25

KOON EVENT - Radar scope photograph taken at 2 minutes after shot time showing rain clouds south of ground zero.

Figure 26

KOON EVENT - Radar scope photograph showing decreased gain to permit initial shot return to be seen. Rain clouds less clearly defined with low gains.

Figure 27

KOON EVENT - Taken 30 minutes after shot time from an altitude of 37,000 feet southeast of ground zero.

Figure 28

KOON EVENT - Taken 1 hour and 25 minutes after shot time from an altitude of 37,000 feet south-southwest of ground zero.

Figure 29

KOON EVENT - Taken 1 hour and 20 minutes after shot time south-southeast of ground zero at an altitude of 37,000 feet. Top of cirrus in vicinity of main cloud at 38,000 feet.

FIGURE 30

KOON EVENT - Taken at shot time at a distance of 60 nautical miles northwest of ground zero, from an altitude of 14,000 feet.

Figure 31

KOON EVENT - Taken at shot time at a distance of 75 nautical miles northeast of ground zero at an altitude of 14,000 feet.

Figure 32

KOON EVENT - Taken 5 minutes after shot time at a distance of 75 nautical miles northeast of ground zero from an altitude of 14,000 feet.

[redacted]

UNION EVENT

The [redacted] device was detonated at 0610 hours local (M), 26 April 1954 as a water surface shot from a barge in approximately 120 feet of water near YUROCHI Island (DOG) at Bikini. Yield was approximately 7 megatons.

An upper level trough which persisted for many days over the northern Marshalls had not produced acceptable wind conditions for detonating UNION device. On the night of 24 April an indraft began to break off in the trough at 10,000 feet slightly north of Eniwetok. This perturbation expanded and gave winds with southerly components at Bikini. This indraft was very short-lived. Within 24 hours winds with northerly components prevailed up to 25,000 feet.

A great deal of weather (clouds and precipitation) had persisted over the southern Marshalls and eastern Carolines on the two days prior to the shot, associated with a weak low level vortex between Tarawa and Kusaie. No more than scattered patches of middle clouds and the usual trade cumulus prevailed over the northern Marshalls.

Aerial weather surveillance over the shot area during the four hours prior to H-hour reported generally 3/8 to 5/8 cumulus, tops averaging 3,500 feet with scattered tops to 7,000 to 9,000 feet. 1/8 to 3/8 altocumulus at 22,000 feet prevailed over the area. At H minus 2 hours aircraft reported a large cumulus 150 miles east-southeast of Bikini and observed lightning in that area. This was the only report of lightning or thunderstorms received in the northern Marshalls during the entire

[redacted]

operation. Figures 33 through 36 illustrate the area of cloud cover to the southeast of the command ship.

At shot time the weather over ground zero was 2/8 cumulus, bases 2,500 feet, tops 3,500 feet; 1/8 altocumulus estimated 12,000 feet; and a few very thin cirrus (Figure 37). No showers were observed except some 60 miles to the south and southeast where a line of cumulus existed (Figures 35 and 36).

After the detonation there was no increase in low or middle cloudiness in the shot area (Figure 38). The now usual formation of a large area of cirrus occurred. (See Figure 39.) However, at H plus 6 hours aircraft encountered rain from an altostratus based at 18,000 to 25,000 feet (estimated) about 200 miles east of Bikini. At H plus 12 hours, similar conditions were observed about 500 miles east of Bikini. The deck of overcast altostratus covered a triangle defined by 10° N - 169° E, 13° N - 167° E, and 10° N - 175° E. No aircraft reports were available south of 10° N and, consequently, the southern edge of the altostratus was poorly delineated.

FIGURES 33 through 36

Sketches of cloud return taken from SPS-6 Radar during UNION Event.

Abbreviations: GZ - Ground Zero

BT - Boundary Tare, code name for USS ESTES (AGC-12), Task Force Command Ship.

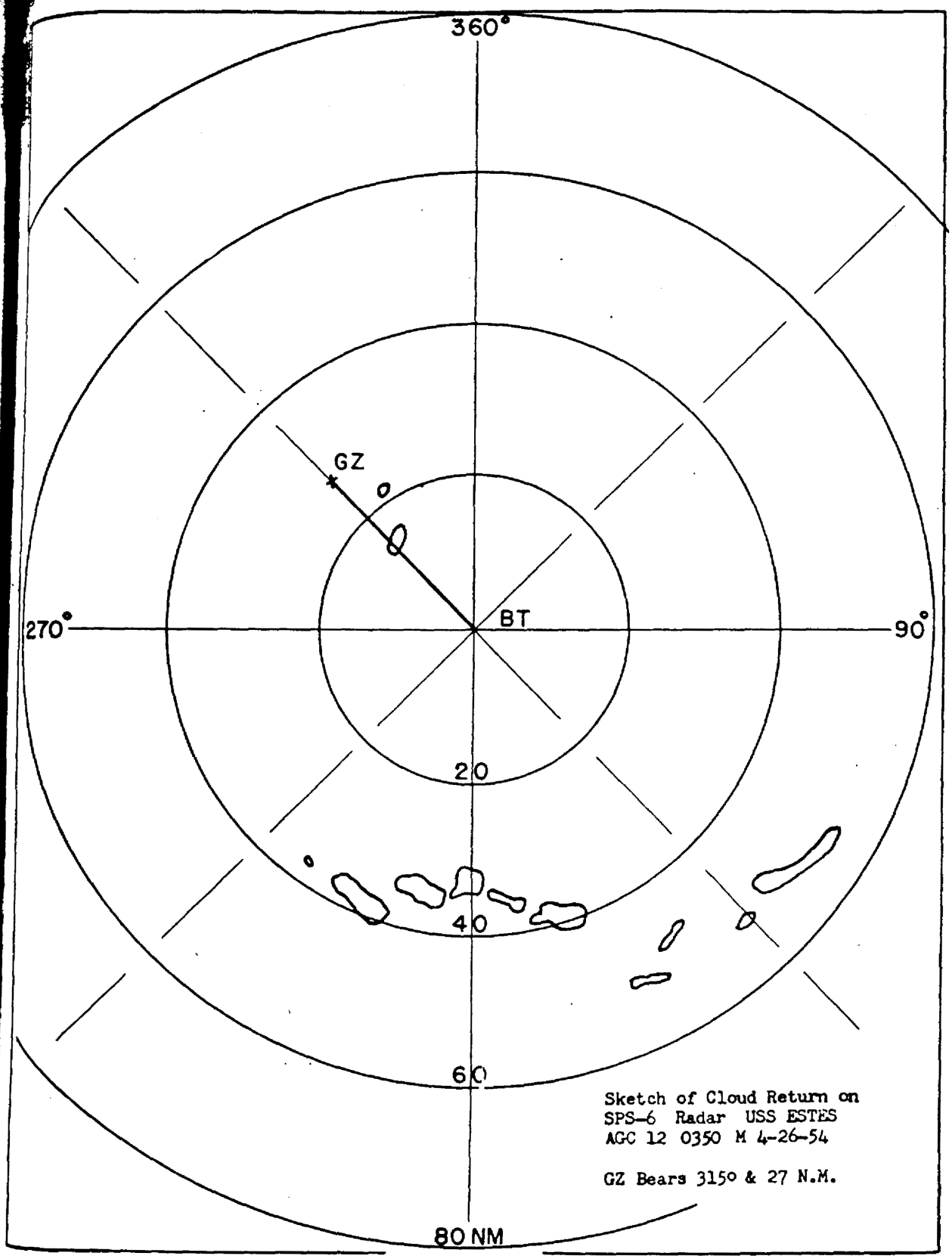
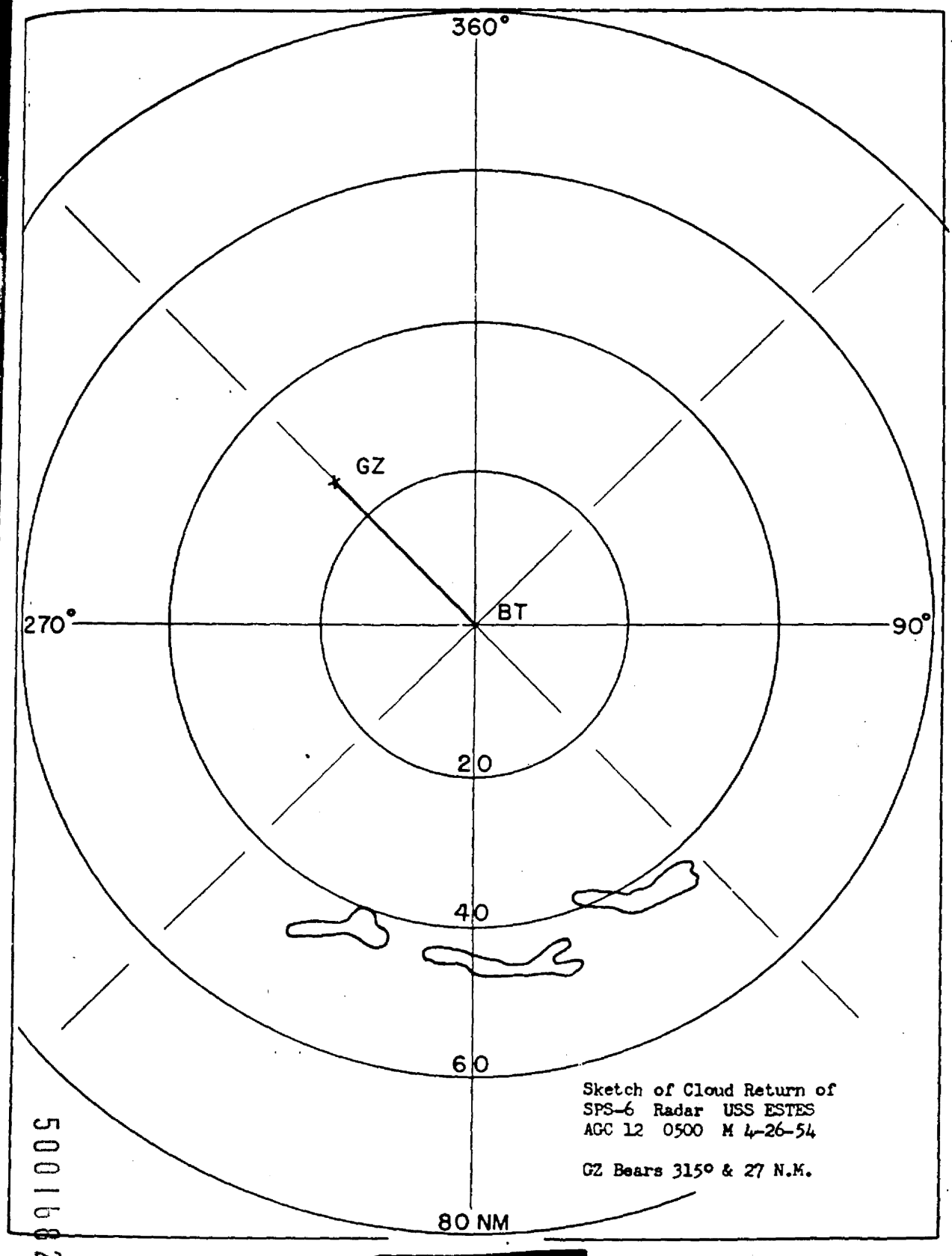


Figure 33

UNION EVENT



500168

Figure 34

UNION EVENT

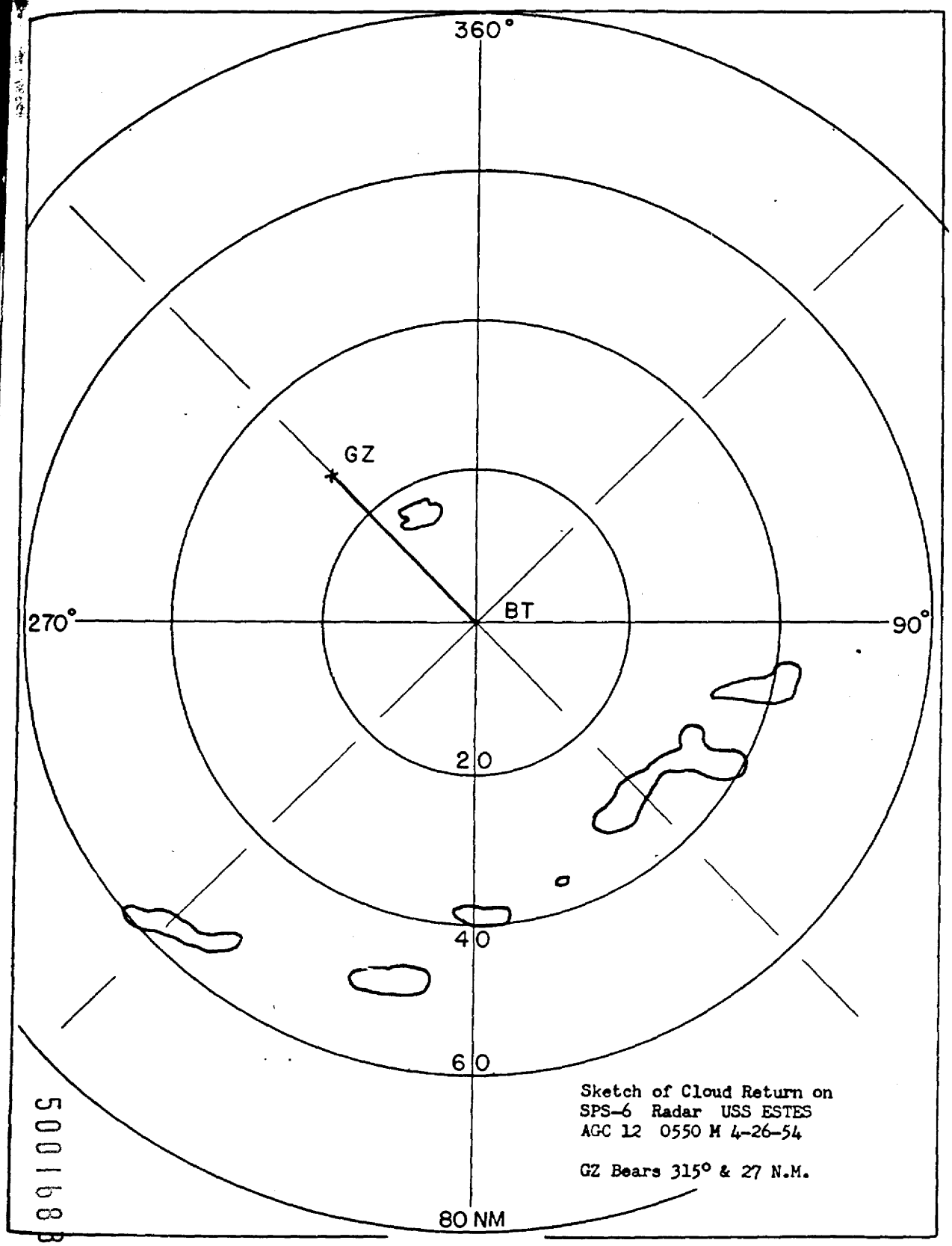


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Figure 35

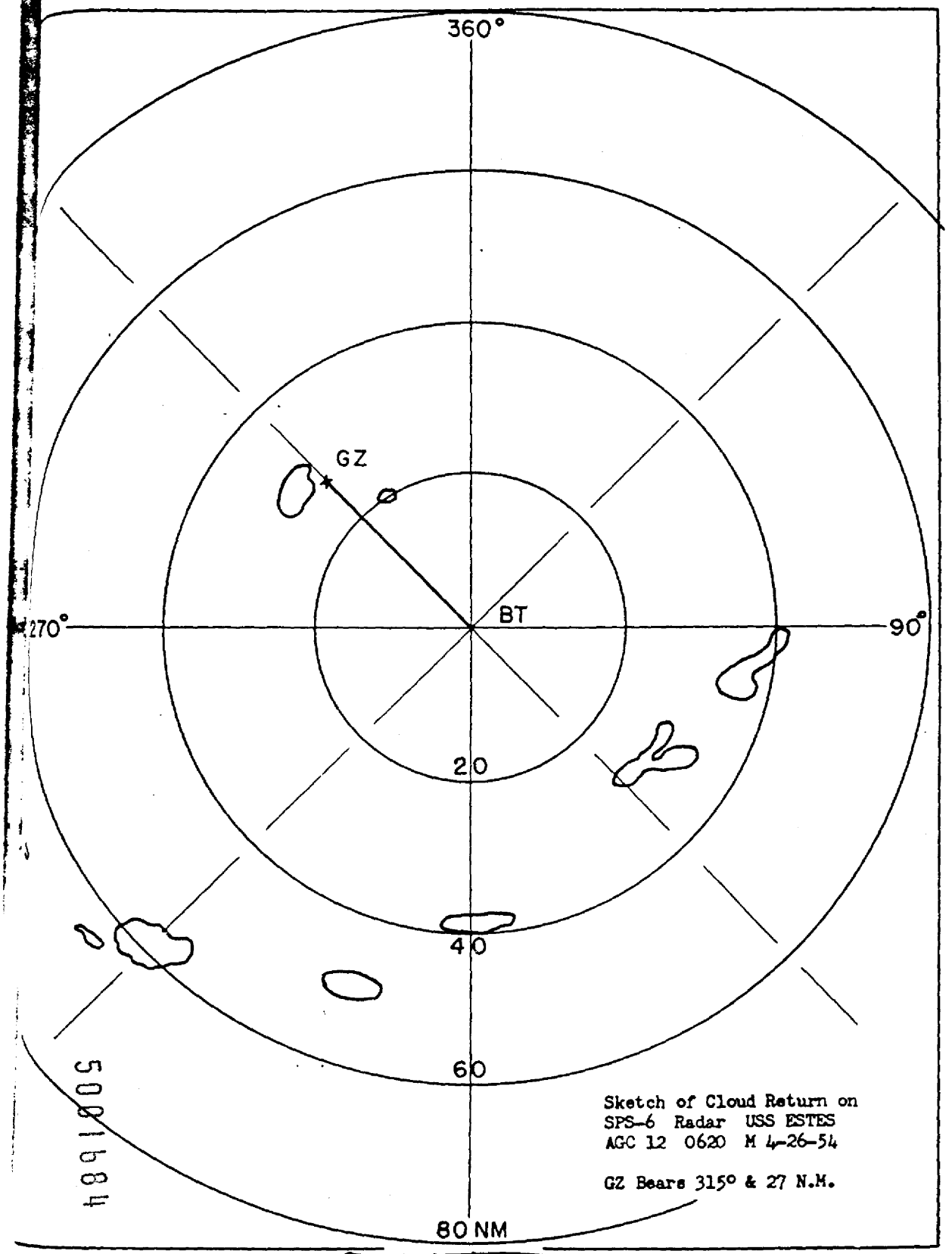

Figure 36

UNION EVENT

FIGURE 37

UNION EVENT - Taken 8½ seconds after shot time at a distance of 75 nautical miles northwest of ground zero, from an altitude of 12,500 feet.

Figure 38

UNION EVENT - Taken 9 minutes after shot time at a distance of 50 nautical miles east of ground zero from an altitude of 40,000 feet.

22-40-23-4

Figure 39

UNION EVENT - Taken 15 minutes after shot time at a distance of 50 nautical miles northeast of ground zero from an altitude of 40,000 feet.

[redacted]

YANKEE EVENT

The device was detonated at 0610 hours local (M), 5 May 1954 as a water surface shot from a barge in the lagoon in approximately 120 feet of water near YUROCHI Island (DOG) at Bikini. Yield was approximately 13.5 megatons.

Trade wind flow prevailed in the lower levels over the northern Marshalls prior to and during YANKEE event. A weak low level wave east of Majuro was oriented north-south along the meridian 174° E. The amplitude of this wave was such that the wave could be detected in the 1,500-foot streamlines as far north as latitude 15° N.

3/8 to 6/8 cumulus were reported over the proving ground area just immediately prior to the test. Tops were generally 6,000 to 7,000 feet but occasionally extended to 10,000 feet or slightly above. 3/8 to 5/8 altocumulus and altostratus in patches persisted. The bases were variously reported from 12,000 to 21,000 feet. The best estimate was probably 21,000 feet as the altocumuli were reported at the latter height after the aircraft climbed from 10,000 to 20,000 feet.

Twelve hours prior to the shot, patches of altocumulus and altostratus from which rain fell were observed 600 miles due east of Bikini and several patches were reported from that point westward to Bikini.

Although showers were not reported specifically by aircraft flying at 10,000 and 20,000 feet in the four hours prior to the detonation, weak radar echoes were reported. Fifteen individual showers were observed on the SPS-6 radar scope within 30 miles of the command ship which was

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[redacted]

located 28 miles southeast of ground zero. All echoes were small; the largest was not over two miles wide by four miles long (See Figures 40 through 50).

At shot time 4/8 cumulus at 2,000 feet, 1/8 altocumulus at 20,000 feet and some cirrus were observed. (See Figures 51 and 52.) Showers were visible in the vicinity.

Immediately after the detonation there was no appreciable change in the number of showers observed on the SPS-6 radar aboard the command ship. The majority of them occurred to the south of the ship where they were before the detonation. The now usual canopy of cirrostratus formed. (See Figure 53.) At H plus 15 minutes altocumulus castellatus of a puffy form, like bursts of anti-aircraft shells, began to appear just to the east of the atomic cloud at 20,000 feet. This continued to form and thicken until, at H plus 25 minutes, the whole area to the east was [illegible]ered. This altocumulus then dissipated considerably, and by H plus 1 hour, what was left merged with the atomic cloud (See Figure 54). Rain was observed 300 miles east-southeast of Bikini at H plus 12 hours. From H plus 30 hours to H plus 36 hours an overcast of altocumulus estimated at 20,000 feet was observed from 600 miles east of Bikini to Eniwetok, 180 miles west of Bikini. This deck of the altocumuli may have been even more extensive.

FIGURES 40 through 50

Sketches of cloud return taken from SPS-6 Radar during YANKEE Event.

Abbreviations: GZ - Ground Zero

BT - Boundary Tare, code name for USS ESTES (AGC-12), Task Force Command Ship.

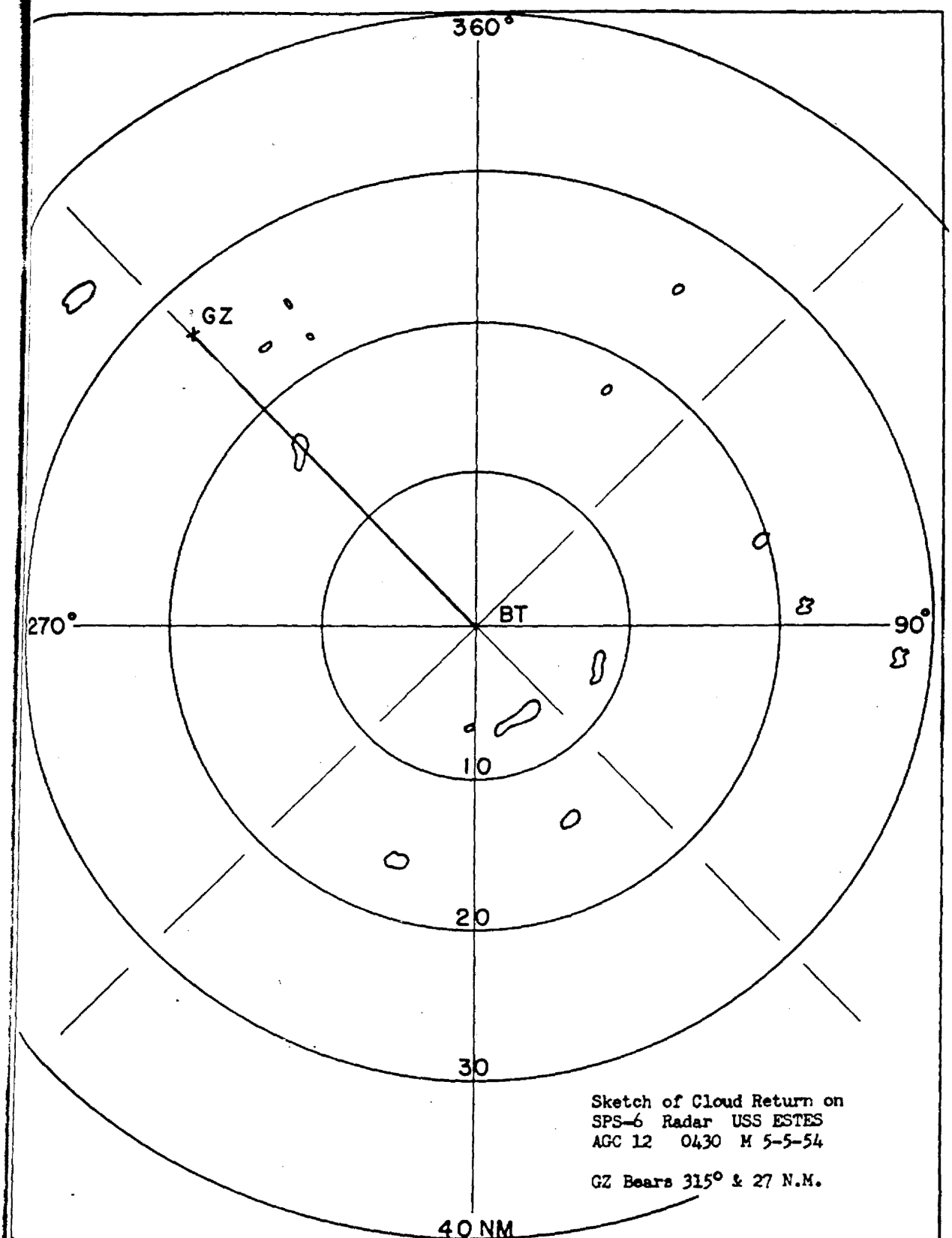


Figure 40

YANKEE EVENT

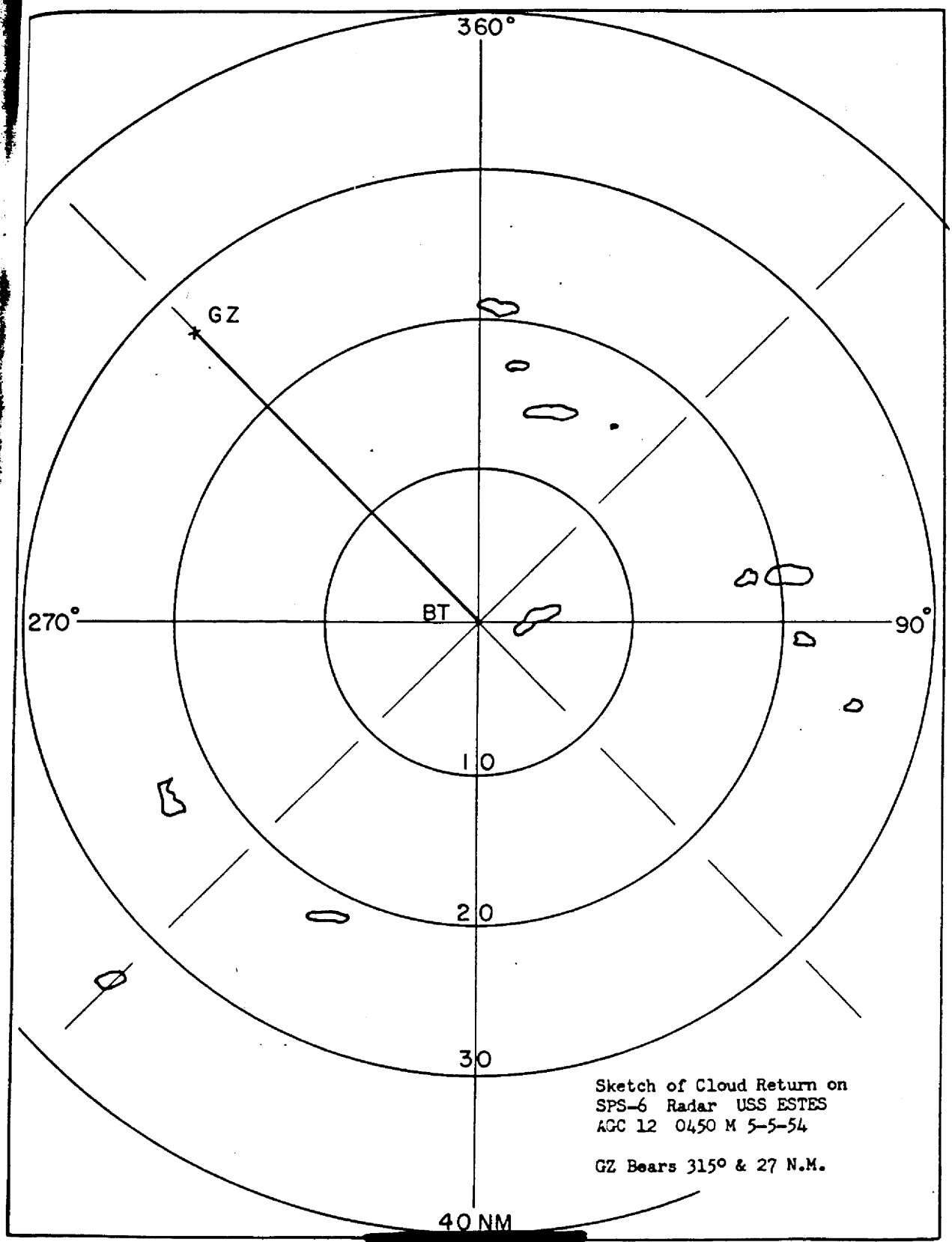


Figure 41

YANKEE EVENT

5001693

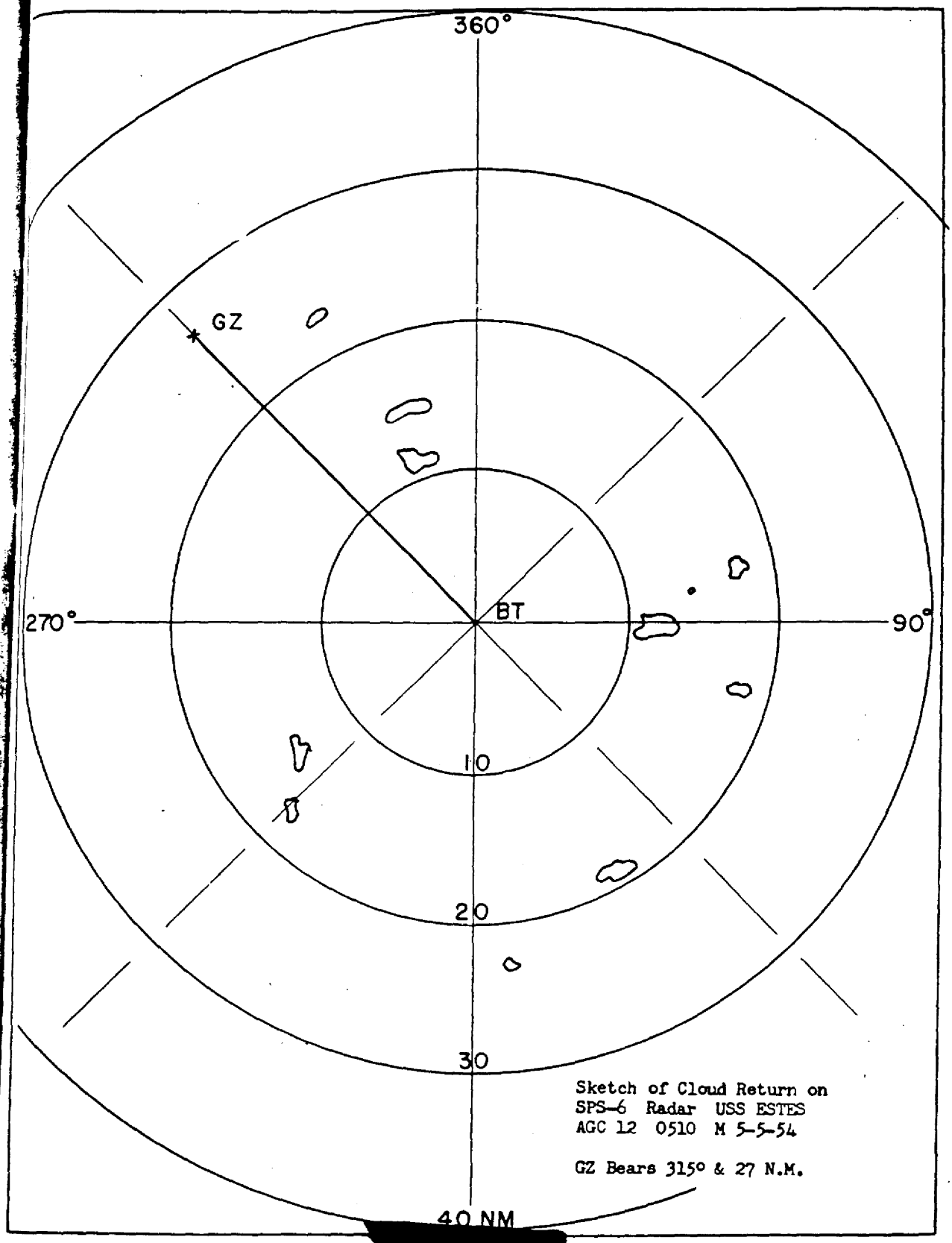


Figure 42 YANKEE EVENT

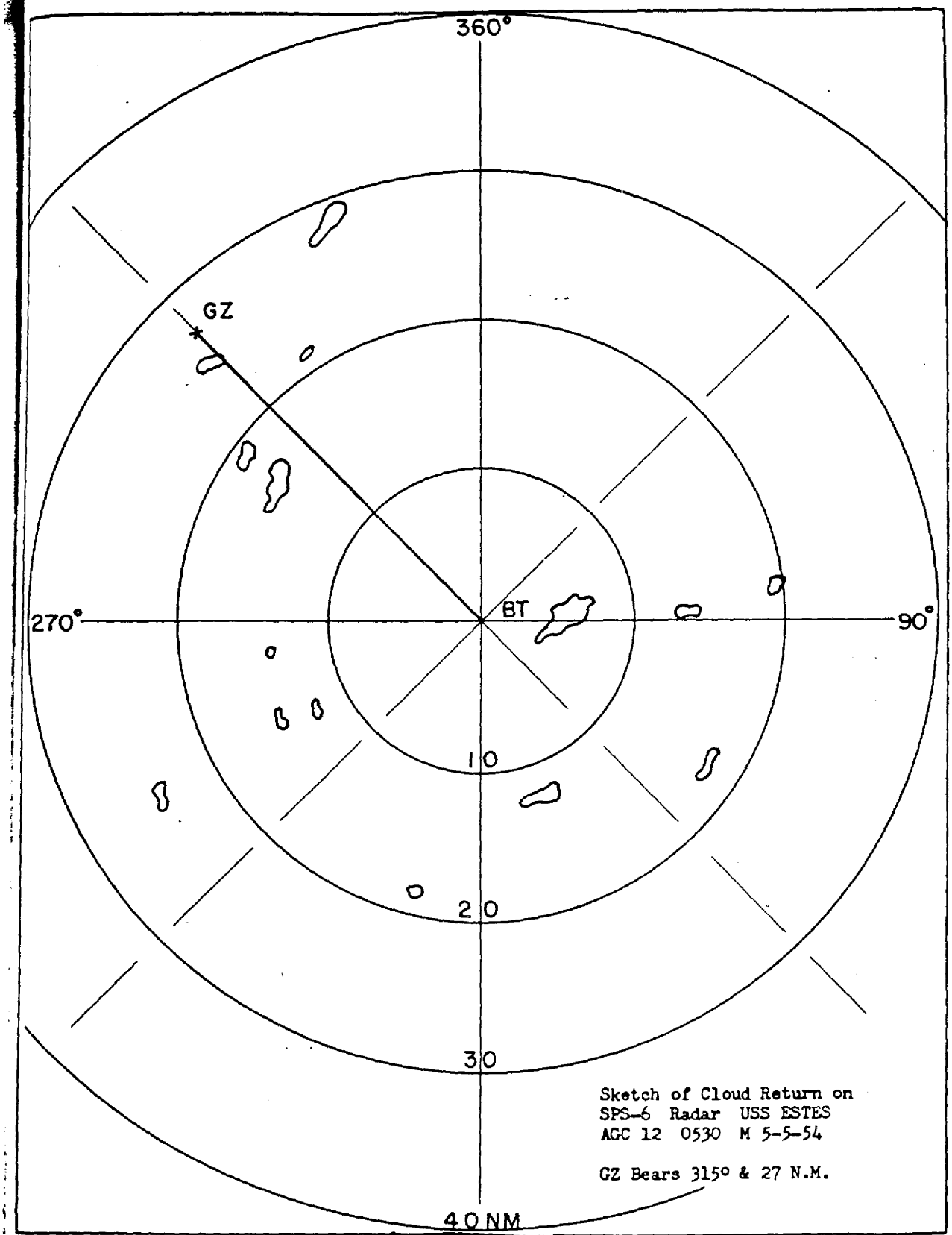
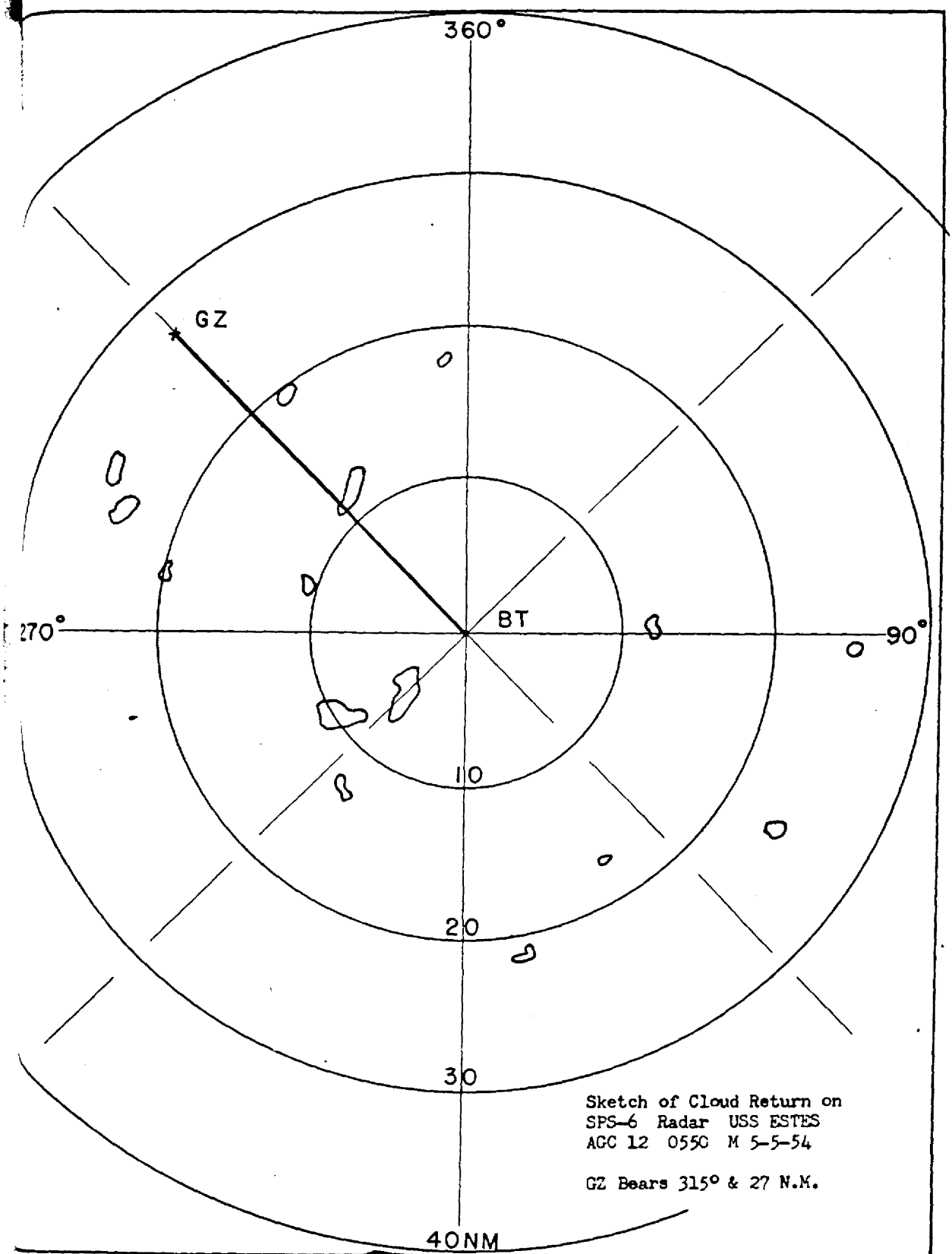


Figure 43



igure 44

5001696

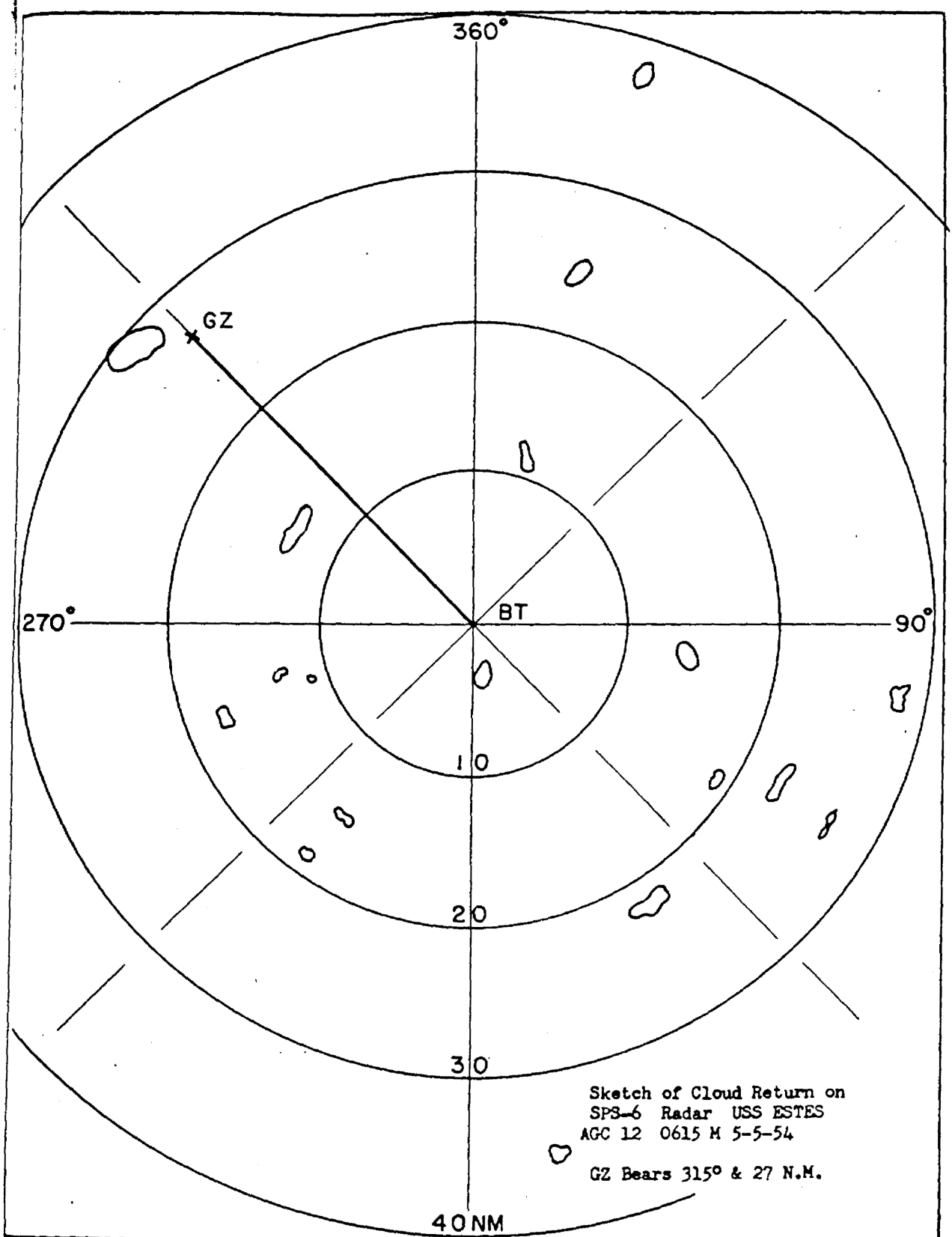


Figure 45

5001697

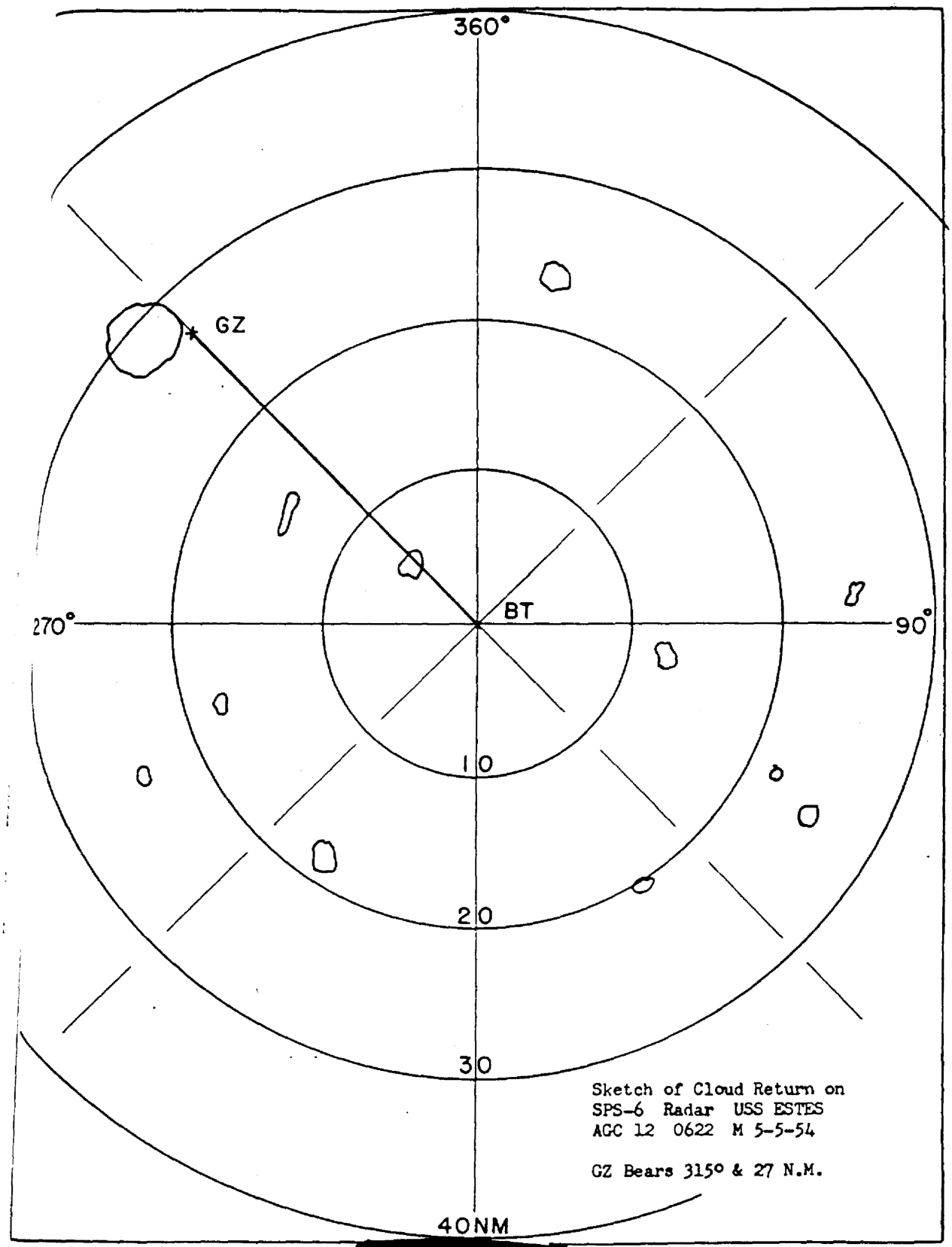
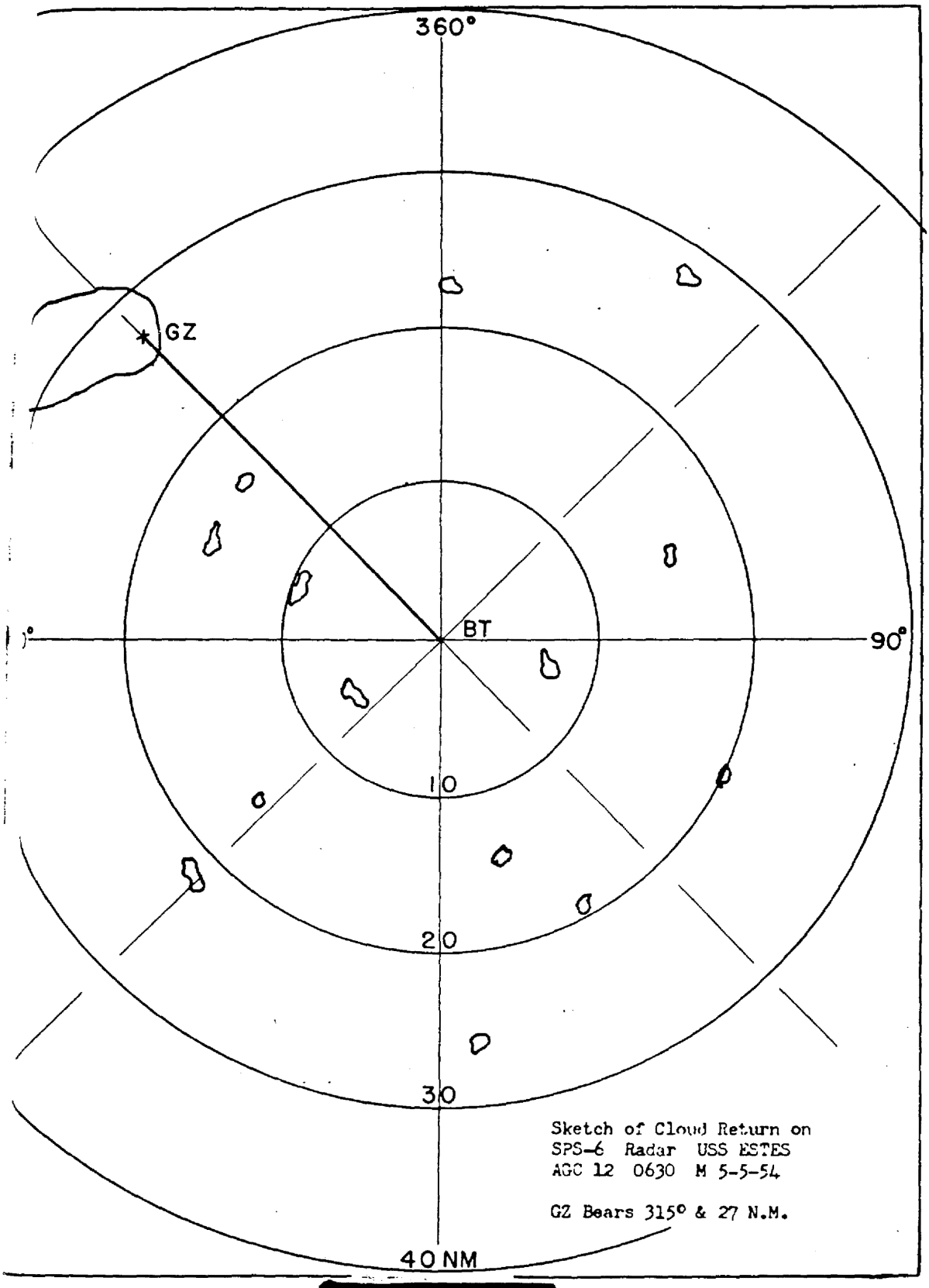


Figure 46

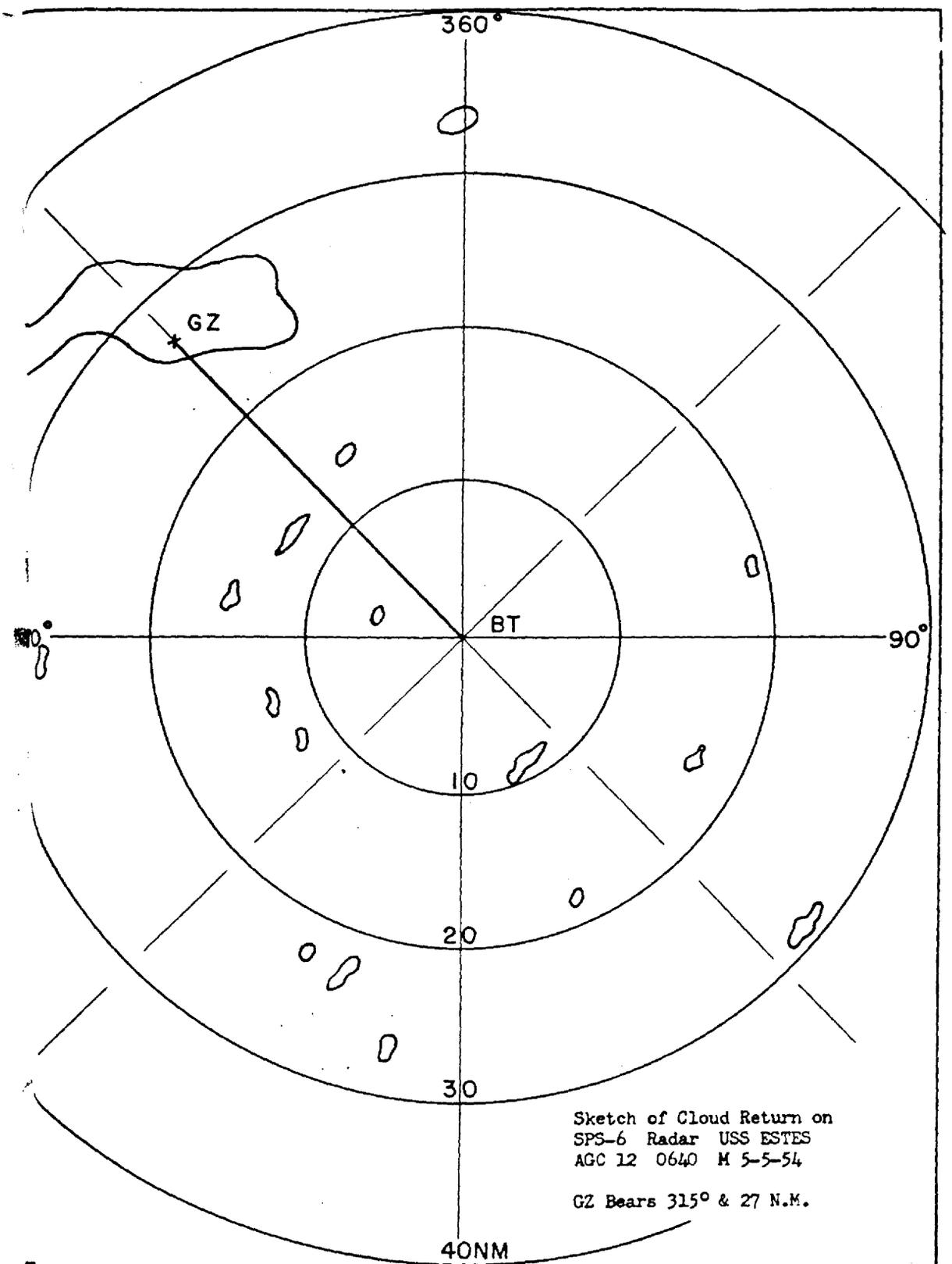


Sketch of Cloud Return on
SPS-6 Radar USS ESTES
AGC 12 0630 M 5-5-54

GZ Bears 315° & 27 N.M.

re 47

5001699

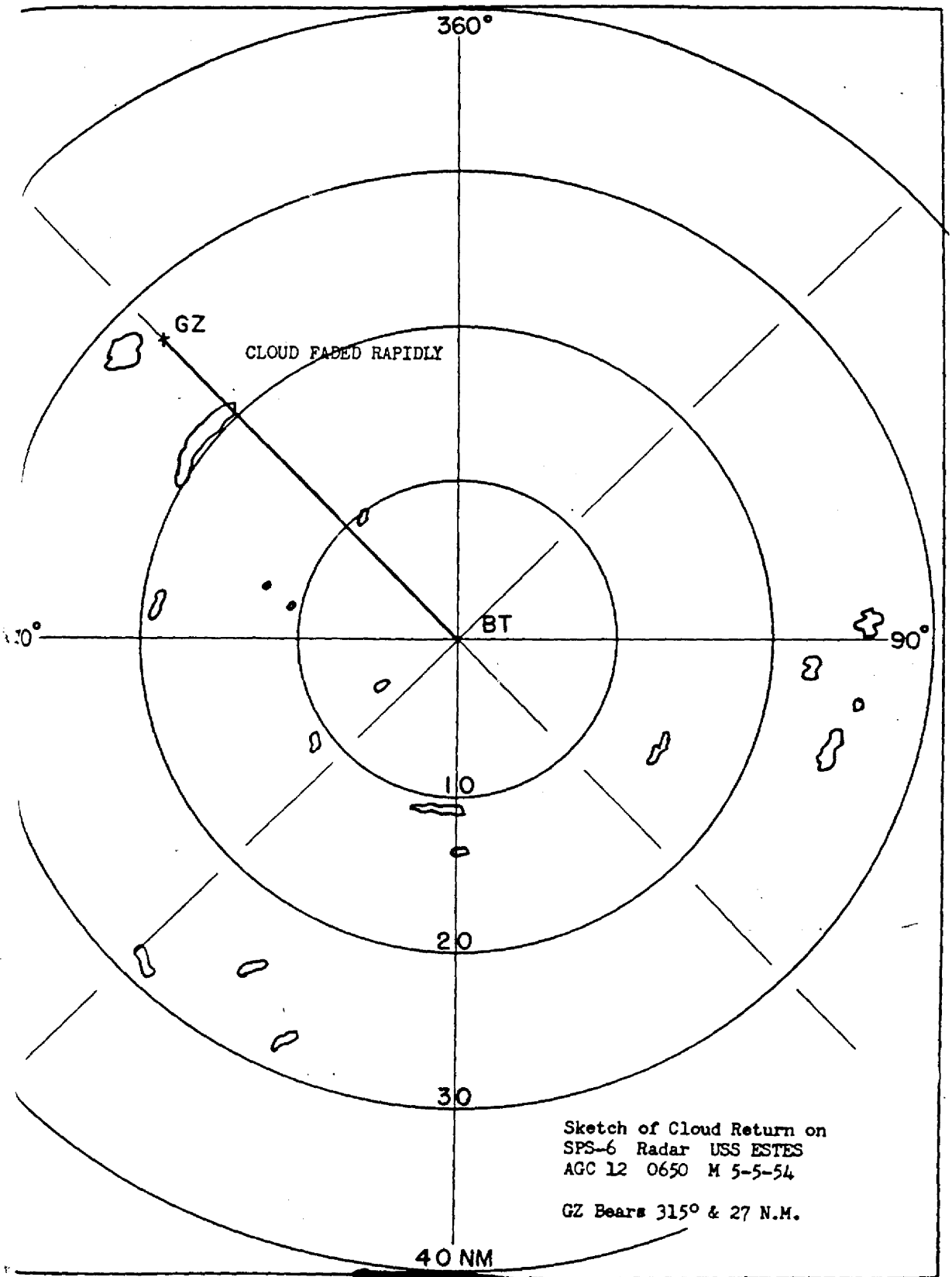


Sketch of Cloud Return on
SPS-6 Radar USS ESTES
AGC 12 0640 M 5-5-54

GZ Bears 315° & 27 N.M.

re 48 YANKEE EVENT

500 100

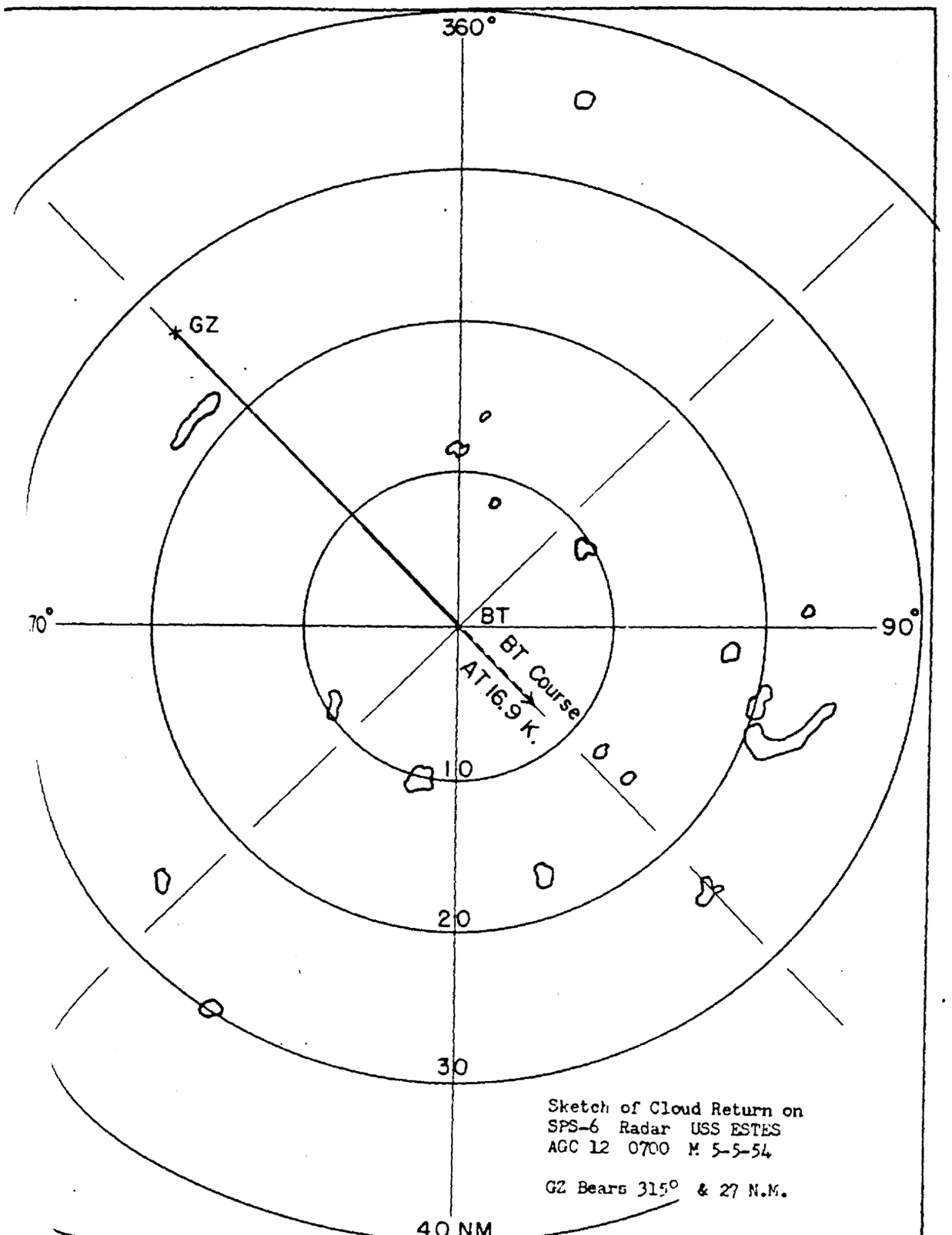


Sketch of Cloud Return on
SPS-6 Radar USS ESTES
AGC 12 0650 M 5-5-54

GZ Bears 315° & 27 N.M.

ure 49

5001701



Sketch of Cloud Return on
SPS-6 Radar USS ESTES
AGC 12 0700 M 5-5-54

GZ Bears 315° & 27 N.M.

FIGURE 51

YANKEE EVENT - Taken 14 seconds after shot time at a distance of 75 nautical miles northwest of ground zero, from an altitude of 12,500 feet.

Figure 52

YANKEE EVENT - Taken 30 seconds after shot time at a distance of 50 nautical miles west-southwest of ground zero from an altitude of 10,500 feet.

Figure 53

YANKEE EVENT - Taken 27 minutes after shot time at a distance of 50 nautical miles southwest of ground zero from an altitude of 10,500 feet.

[redacted]

Figure 54

YANKEE EVENT - Taken 44 minutes after shot time at a distance of 50 nautical miles southwest of ground zero from an altitude of 10,500 feet.

[redacted]

[redacted]

NECTAR EVENT

The [redacted] device was detonated at 0620 hours local (M), 14 May 1954 as a water surface shot from a barge in the IVY MIKE crater in approximately 100 feet of water off TEITERIPUCHI Island (GENE) at Eniwetok. Yield was approximately 1.7 megatons.

The circulation over the Marshalls was in a transitional state at shot time. Basically, two features dominated:

1. A low level vortex had moved westward through the southern Marshalls and was located southwest of Ponape at about 5° N - 156° E at shot time.

2. At high levels (from 20,000 feet to the tropopause) an east-northeast to west-southwest trough lay to the north of the Marshalls between parallels 15° N and 20° N. The westerly flow south of the upper level trough was dominated by two anticyclonic outdrafts (best identified at 30,000 feet) located near Guam at 8° N - 165° W. Between these major high level cells and over the Marshalls the pattern was broken into several minor cells which gave winds with pronounced southerly components above 15,000 feet.

Overcast conditions existed for over twenty-four hours prior to the test. The overcast consisted of a solid deck of cirrostratus estimated at 35,000 feet, variable 1/8 to 7/8 cumulus and stratocumulus, and scattered patches of altocumulus. The trade cumulus assumed a definite

[redacted]

stratocumulus appearance at times. The average of low cloudiness increased from 2/8 in the period 12 to 24 hours prior to the test, to 4/8 in the 12-hour period immediately preceding the shot.

Weather reconnaissance aircraft had reported widespread shower activity over the Marshalls south of 8° N and over the western Carolines 60 hours prior to shot time. An area of rain about 400 miles in diameter was centered at 6.5° N- 165.5° E at H minus 60 hours. The northwest periphery of the area was located about 300 miles southeast of Eniwetok. By H minus 13 hours the area of rain had moved eastward and assumed an elliptical shape with the major axis along 6.5° N. Its northern border was located about 150 miles south-southeast of Eniwetok and its southern border was near Kusaie. The eastern and western extremities were not definitely ascertained, but were at least as far east as 165° E and as far west as 158° E. Light showers began at Eniwetok at H minus 11 hours.

The WB-29 weather reconnaissance aircraft monitoring the weather north of Eniwetok Atoll, beginning about H minus 4 hours, reported overcast cirrus, 4/8 to 6/8 cumulus, tops averaging 4,000 feet, and one cumulus with a top at 12,000 feet was reported at H minus 2½ hours. At H minus 40 minutes tops to 22,000 feet were reported. The weather observer wrote the following summary of the weather as he observed it from the aircraft:

"At 0135 local (M) on the morning of 14 May 1954, I departed Eniwetok on a Wilson One weather reconnaissance mission. Weather phenomena were investigated in an area approximately 60 miles to the north of Eniwetok. Initially the area to the northwest had the least

cloudiness, which was comprised of a lower scattered (3/8) stratocumulus layer having tops at 4,000 feet, with a very thin overcast of cirrus at about 40,000 feet. The moon was clearly visible through the overcast and nearly all the stars directly overhead were visible. The area to the northeast had considerably more cloudiness. There was a lower broken (6/8) layer of stratocumulus having tops at 4,000 feet, and high cirrus overcast through which the stars were not always clearly visible, and were even at times completely obscured. After 0300M the vertical development of cumulus clouds began to increase to the northeast of ground zero. The tops of the cumulus reached 22,000 feet by 0600M. Rain showers were occasionally encountered in these clouds at altitudes of ten and twenty thousand feet. With the vertical development of the cumulus clouds the coverage decreased slightly. Following 0400M the cirrus overcast was noted to gradually decrease. By 0600M this layer was very thin and scattered. No visible veil was evident over the stars and the lower magnitude stars could be seen. It should also be pointed out that between the hours of 0400 and 0500M the island of Eniwetok was noted to be clearly visible from the northeast. This description of cloudiness is based upon continuous and careful observation wherein no difficulty was encountered which would compromise an accurate observation."

"Following zero hour no accurate record of observations was maintained. Our position was in the proximity of a 40-mile radius of ground zero, and our altitude was above twenty thousand feet. During the subsequent four hours the lower cumulus-type clouds were noted to be 7/8 coverage, and there was a nondescriptive dispersion of altostratus

and altocumulus patches within the fifteen to thirty thousand foot levels. At flight altitude we had no difficulty in avoiding these patches of middle clouds."

A consensus of the observations taken from the ground at Eniwetok, 20 miles south-southeast of ground zero at shot time, indicated 6/8 stratocumulus and cumulus, 3/8 altocumulus and 8/8 cirrostratus. (See Figure 55.) A large shower was over the lagoon between ground zero and the observation point on Eniwetok. The cloud decks merged considerably to the north (toward ground zero) and to the east. (See Figure 56.) To the south such merging did not occur, but there still was no clear view of the higher clouds from the ground.

No appreciable change in the Eniwetok weather occurred until about H plus 4½ hours. At that time a shower occurred of such intensity that the visibility lowered to ½ mile for four minutes. Rather steady rain then developed. At H plus 6 hours and 28 minutes the ceiling and visibility lowered to 500 feet and ½ mile in heavy rain. This condition prevailed for 39 minutes - an unusually long period for such conditions to persist in the northern Marshalls. Rain and showers were continuous for 3 hours and 34 minutes. The precipitation became intermittent until H plus 17 hours when light to moderate rain began once again and continued for 6½ hours. A total of 1.66 inches of rain fell in the 36 hours following the test; 0.92 inches of this total occurred between H plus 5 hours and 40 minutes and H plus 8 hours and 20 minutes.

A weather reconnaissance aircraft flew due east 300 miles and reported precipitation on each observation. At 10,000 feet instrument condi-

tions were reported about 50 percent of the time on this flight which occurred between H plus 4 and H plus 8 hours. Another aircraft, flying at 5,500 feet to the west of, and within 250 miles of Eniwetok, reported rain or showers on all but two of the 24 reports made between H plus 4 and H plus 13½ hours. On these two occasions showers were reported as past weather.

An observer aboard the control aircraft which took off at approximately H minus 2 hours and landed approximately H plus 8 hours, reported that the altocumulus deck was topped on the climb at 25,000 feet, and that cirrus was "prevalent" at 38,000 feet. At H plus 15 minutes he saw the nuclear cloud briefly as it emerged from the top of the cirrus, but consolidation of the lower clouds and cirrus soon occurred, and the nuclear cloud was not identified as a separate entity thereafter.

Another test aircraft reported the tops of the clouds as about 52,000 feet. At H plus 7 hours heavy rain was encountered at 16,000 feet 140 miles due north of Eniwetok.

The weather was very poor for this test, and it definitely deteriorated even more following the shot. However, reconnaissance the day before the test located a large area of rain within 180 miles of Eniwetok. Furthermore, information obtained after the shot indicates rather conclusively that the shower activity had already begun to increase prior to the detonation.

FIGURE 55

NECTAR EVENT - Taken 3 seconds after shot time at a distance of 50 nautical miles west of ground zero, from an altitude of 10,500 feet.

Figure 56

NECTAR EVENT - Taken 9 minutes after shot time at a distance of 50 nautical miles west of ground zero from an altitude of 10,500 feet.

CONCLUSIONS

1. High yield devices detonated on the surface of water or on land at the Pacific Proving Ground during Operation CASTLE produced considerable amounts of high cloud at cirrus levels.

2. Limited amounts of middle cloud (altostratus or altocumulus) were produced by the rising fireball and nuclear cloud.

3. The detonations caused a very small, if any, increase of low cloud (cumulus).

4. There was no significant change in the shower activity following the first five detonations, and there is no evidence that in the period just subsequent to the last shot the increased shower activity was caused by the detonation.

5. Operation CASTLE experience indicates that self-perpetuating circulations which might effect weather changes at points distant from the test site, are not induced by high yield detonations.