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**Nimbus Dynamics Analysis
For Ejection Mechanism**

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SUMMARY

Ejection of the SNAP 19 generator from the NIMBUS-B satellite has been studied theoretically using a modified 3 degree-of-freedom (pitch plane) trajectory computer program. Effects of initial altitude and satellite attitude have been included. Nearly every case investigated showed that interference would exist between the generator and NIMBUS stabilization and control sub system immediately following ejection. Interference was reduced by approximately 50% when the following stabilization and control sub system protuberances were removed from the ejection path of the generator:

sun shield horizon scanner

baffle - coarse yaw sensor

albedo shield coarse yaw sensor

In the cases where there was no interference between the generator and NIMBUS, the generator was ejected well beyond the satellite.

I. INTRODUCTION

If the NIMBUS-B re-enters the atmosphere because of an ascent abort or orbital decay, the release of the nuclear fuel from the SNAP 19 generator would have to occur at a high enough altitude in order to insure complete fuel "burn-up" and dispersion. The mechanical ejection of the generator from the NIMBUS during the early portion of the re-entry would insure complete exposure of the generator to atmospheric aerodynamic heating. The probability of fuel release, burn-up and dispersion would then be much greater. Without ejection, it is possible that the generator could be shielded from the freestream heating by the NIMBUS-B.

The object of this study is to determine the relative trajectory between the generator and NIMBUS after ejection and to investigate the possibility of interference between them. A 3 degree-of-freedom trajectory computer program has been modified in order to accomplish this. Initial satellite altitudes with and without a pitch rate are considered in order to determine their effect on the relative trajectory. Altitude effects were included by assuming generator ejection at 400,000 ft, 350,000 ft. and 310,000 ft. The effect of flight path angle has also been included by investigating trajectory variations, with this angle set at -0.2 and -85° . Initial flight velocity at time of ejection was 25,650 ft/sec for all cases. The angle of the generator relative to the NIMBUS at ejection was fixed at 16° for all cases considered.

II. SYSTEM DESCRIPTION

A brief description of the NIMBUS-B, the SNAP 19 generator and the ejection mechanism is given below. Detailed satellite and generator data are given in Reference 1.

NIMBUS-B

The basic components of this satellite as shown in Figure 1 are:

- sensory sub system container
- stabilization and control sub system
- solar paddles
- trusses
- command antenna - upper section
- " " - lower section

The lower section of the command antenna has been modified in order to allow sufficient clearance for the SNAP 19.

Generator

SNAP 19 generator details are shown in Figure 2. The generator consists of two cylindrical bodies joined at their ends, twelve fins and an attachment plate (to ejection mechanism). It has been assumed that the center of gravity of the generator lies at the parting plane between the two cylindrical bodies and on the axis of symmetry.

Ejection Mechanism

The support structure which contains the ejection mechanism is also shown in Figure 2. A compressed spring contained within the housing ejects the generator after receiving the eject signal. The spring has a constant of 720 lbs/ft and when compressed exerts a force of 338 lbs. If the NIMBUS-B is in orbit, the eject signal would be sent via a ground command. During an ascent abort or following an orbital decay, a heat sensing device would release the compressed spring. Details of the development history of the generator ejection mechanism are contained in the Appendix.

III. RELATIVE TRAJECTORY DETERMINATION

A knowledge of the relative trajectory between the generator and the NIMBUS-B satellite is required before an interference study between the two bodies can be performed. Since the re-entry attitude of the NIMBUS is arbitrary, a large number of re-entry orientations (and relative trajectories) are possible. In order to decrease computation time a computer program was used to determine the relative trajectories. Initial NIMBUS attitudes chosen covered various pitched orientations with and without tumbling. A description of the computer program and the method used to determine the aerodynamic coefficients are discussed below. Computer program results are given in the next section.

A. Computer Program Description

The 3 degree-of-freedom trajectory program which was used for the trajectory studies of the NIMBUS (Reference 1) was modified for use in the present study. The modification allowed for separate input of the aerodynamic characteristics of the NIMBUS and generator so that in addition to the NIMBUS trajectory parameters, the motions of the generator relative to the NIMBUS were computed. The starting point of the program is at the instant when the retaining nut is removed from the ejection mechanism. When the generator reaches a location which insures that it has cleared the NIMBUS (regardless of interference), the program is stopped.

Program input includes:

1. Aerodynamic coefficients (C_N , C_A , C_M versus α) of NIMBUS without paddles.
2. Aerodynamic coefficients of the solar paddles.
3. " " " " generator
4. Starting point of trajectory which includes an initial:
 - a. altitude, h
 - b. velocity, V
 - c. flight path angle, γ
5. NIMBUS orientation at ejection which is determined by:
 - a. angle of attack, α
 - b. pitch rate
6. Masses and moments of inertia (in pitch) of NIMBUS and generator.
7. Solar paddle data including the following:
 - a. area
 - b. incidence (constant 0°)
 - c. pitch rate (constant at zero)
 - d. friction torque and breaking force
 - e. moment of inertia (in pitch) and length of moment arm
8. Generator data as follows:
 - a. cross-sectional area
 - b. incidence angle with respect to NIMBUS axis of symmetry
 - c. location of c.g. with respect to c.g. of NIMBUS at time of ejection
9. Deflected and undeflected spring lengths and spring constant

B. Aerodynamic Characteristics

Aerodynamic coefficient determination for the NIMBUS, paddles and generator were determined using Modified Newtonian Theory. Initially, the coefficients of the NIMBUS without paddles and generator were determined. Calculations similar to those given in Reference 1 were performed except the contributions of the generator to C_N , C_A and C_M were omitted. Results as a function of angle of attack are given in Figures 5, 6 and 7.

Solar paddle and generator aerodynamic coefficients used in the computer program were the same as those given in Reference 1. Figures 8 through 13 show the variation of these coefficients with angle of attack.

Mutual interference effects on the aerodynamic characteristics of the NIMBUS and the generator have been ignored. This assumption was made when the NIMBUS and generator aerodynamic coefficients were calculated in order to reduce the number of calculations.

IV. RESULTS AND DISCUSSION

A. Trajectories Generated

The velocity and flight path angle of the NIMBUS at the time of generator ejection were assumed constant at 25,650 ft/sec and -0.2° respectively. All runs were initiated with the generator at an angle of incidence of 16° with respect to the NIMBUS axis of symmetry. Table 1 summarizes all the cases investigated. Examples of initial NIMBUS orientations are shown in Figure 3. Figure 4 depicts the initial orientation of the generator with respect to the NIMBUS c.g.

The flight paths followed by the generator relative to the NIMBUS-B are shown in Figures 14 through 33. In some cases it was obvious that the generator collides with the stabilization and control sub system (e.g., Figure 20) while in other cases, it was not evident.* Part B of this section discusses a study performed to determine when interference occurred among the cases investigated.

In addition to investigating generator ejection from the NIMBUS when the initial NIMBUS flight path angle was set at -0.2° , the effect of varying this angle was analyzed. An angle of -85° was used in this study. Two cases were investigated (cases 8 and 23 in Table 1) at two altitudes. The NIMBUS angle of attack and pitch rate were assumed to equal zero. Table 2 summarizes the results of this study. The one second increment studied allows the generator enough time to completely clear the NIMBUS if interference is

*Relative trajectory plots were not made for the cases where the initial pitch rate of the NIMBUS exceeded 0.2 rad/sec. It was clearly obvious in these cases that interference resulted.

nonexistent. It is indicated in Table 2 that the effect of varying the flight path angle is negligible, therefore, only one value of γ (-0.2°) was used for the remainder of the study.

B. Interference Study

An interference study was conducted in which it was assumed that:

1. The NIMBUS stabilization and control sub system contained protruding instrumentation (protuberances) which was positioned in the plane of the ejection path of the generator (see Figure 1).
2. The stabilization and control sub system did not contain these protuberances.

Figure 34 is an enlarged view of the stabilization and control sub system with the protuberances attached.

In order to determine whether interference occurred, the results of the computer program were analyzed in detail graphically. The plot of the trajectory of each case investigated was drawn to a much larger scale than those shown in Figures 14 through 33. Examples of these enlarged plots are given in Figures 35 and 36.

Since the generator does not rotate about its axis of symmetry after ejection and is confined to travel in the pitch plane only, it is possible for the protuberances to extend between the generator fins without interference occurring. The amount of clearance between the fins and protuberances was defined as ΔZ_1 as shown in Figure 34. Without the protuberances on the stabilization and control sub system, the amount of clearance available was defined as ΔZ_2 as shown in

Figure 37. In each of these figures, the generator is shown inclined at a 10° angle from the NIMBUS axis of symmetry. This is the angle of inclination of the generator as it passes the stabilization and control sub system; it was found to be a constant for the cases investigated. The foremost contact points of the protuberances and stabilization and control sub system were also inclined at 10° (see Figures 34 and 37). This permitted interference measurements to be made from a plan view of the generator along a line of sight parallel to the longitudinal axis of the generator.

The allowable distances of penetration between the protuberances and the generator fins are shown in Figure 34. A distance of 0.17' measured from the outer edge of the fins can be penetrated before interference occurs. This distance is increased to 0.30 ft without protuberances as shown in Figure 37.

For each case investigated, plots similar to Figures 35 and 36 were drawn. The interference criterion given in Figures 34 and 37 was then applied. Table 3 contains the results of this study. The amount of clearance was given for the cases where it occurred. The magnitude of the interference found in the remaining cases was not given since it has no bearing on the conclusions drawn from this study.

When generator ejection occurs, the composite pitching motion of the NIMBUS is a combination of 1.) the reaction from the generator ejection spring which imparts a positive pitching moment to the NIMBUS 2.) the aerodynamic pitching moment of the NIMBUS itself and 3.) the initial pitching rate of NIMBUS, $\dot{\alpha}_0$ (if one is assumed).

The moment resulting from the spring reaction is applied only for a short duration while the aerodynamic pitching moment is effective throughout the duration of generator ejection. This latter moment is also more effective at lower altitudes because of increased air density.

The combination of the above pitching moments in conjunction with the pitching motion of the generator allowed generator clearance in some cases and in others, interference resulted. For the cases investigated, Table 3 indicates that:

1. With protuberances added, the only case that did not show interference was Case #17 ($h_0=310,000$ ft, $\alpha_0 = +90^\circ$ with $\dot{\alpha}_0=0$).
2. Without protuberances added, interference occurred when it was assumed that the initial pitch rate of NIMBUS was 0.2 rad/sec or greater and when $\alpha_0=-90^\circ$ with $\dot{\alpha}_0=0$. Interference resulted under these conditions at the three altitudes investigated.

V. CONCLUSIONS

A theoretical study has been performed to determine the motion of a SNAP 19 generator after it is ejected from a NIMBUS-B satellite. From this study it has been concluded that:

1. Given the satellite configuration shown in Figure 1, the generator will almost always interfere with the stabilization and control sub system following ejection.
2. If the additional protuberances on the stabilization and control sub system (which lie in the path of the generator) are removed, interference between the satellite and generator will be reduced 50%.
3. The generator will follow a trajectory which takes it rapidly away from the NIMBUS-B if interference does not exist between the two bodies.

VI. REFERENCES

1. MND-3169-41, " Safety Evaluation of the SNAP 19 Thermoelectric Generator On Board the NIMBUS B Satellite" (Preliminary Draft), Martin Marietta Corporation, Nuclear Division, January, 1965 (Confidential).

VII. TABLES AND FIGURES

TABLE 1.-INITIAL ORIENTATIONS AND ALTITUDES

	Case							
	1	2	3	4	5	6	7	8
Altitude, Ft	400,000	→						
Velocity, Ft/sec	25,650	→						
Angle γ , Deg	-0.2	→ -85						
Angle α , Deg	0	90	179	0	0	0	0	0
Pitch Rate, Rad/sec	0	0	0	0.2	0.5	0.75	1.0	0

	Case						
	9	10	11	12	13	14	15
Altitude, Ft	350,000	→					
Velocity, Ft/sec	25,650	→					
Angle γ , Deg	-0.2	→					
Angle α , Deg	0	90	179	0	0	0	0
Pitch Rate, Rad/sec	0	0	0	0.2	0.5	0.75	1.0

TABLE 1. - Continued.

	Case							
	16	17	18	19	20	21	22	23
Altitude, Ft	310,000 →							
Velocity, Ft/sec	25,650 →							
Angle γ , Deg	-0.2 →							-85
Angle α , Deg	0	90	179	0	0	0	0	0
Pitch Rate, Rad/sec	0	0	0	0.2	0.5	0.75	1.0	0

	Case						
	24	25	26	27	28	29	30
Altitude, Ft	400,000	400,000	350,000	350,000	310,000	310,000	400,000
Velocity, Ft/sec	25,650 →						
Angle γ , Deg	-0.2 →						
Angle α , Deg	-90	-179	-90	-179	-90	-179	0
Pitch Rate, Rad/sec	0	0	0	0	0	0	-0.2

TABLE 2. - VARIATION OF RELATIVE TRAJECTORIES
DUE TO CHANGE IN FLIGHT PATH ANGLE

Alt. = 400,000 Ft
V = 25,650 Ft/sec

Time After Ejection	X Coordinate of Gen. c.g. ($\gamma = -0.2^\circ$)	X Coordinate of Gen. c.g. ($\gamma = -85^\circ$)	Z Coordinate of Gen. c.g. ($\gamma = -0.2^\circ$)	Z Coordinate of Gen c.g. ($\gamma = -85^\circ$)
0 sec	-0.5978 ft	-0.5978 ft	1.519 ft	1.519 ft
0.1	-1.412	-1.412	1.730	1.730
0.2	-2.194	-2.194	1.915	1.915
0.3	-3.129	-3.129	2.113	2.113
0.4	-4.070	-4.070	2.287	2.287
0.5	-5.016	-5.015	2.436	2.436
0.6	-5.965	-5.965	2.562	2.562
0.7	-6.919	-6.918	2.663	2.663
0.8	-7.876	-7.875	2.739	2.739
0.9	-8.836	-9.074	2.791	2.801
1.0	-9.798	-9.796	2.819	2.819

Alt. = 310,000 Ft
V = 25,650 Ft/sec

Time After Ejection	X Coordinate of Gen. c.g. ($\gamma = -0.2^\circ$)	X Coordinate of Gen. c.g. ($\gamma = -85^\circ$)	Z Coordinate of Gen. c.g. ($\gamma = -0.2^\circ$)	Z Coordinate of Gen. c.g. ($\gamma = -85^\circ$)
0 sec	-0.5978 ft	-0.5978 ft	1.519 ft	1.519 ft
0.1	-1.419	-1.419	1.732	1.732
0.2	-2.194	-2.193	1.916	1.915
0.3	-3.116	-3.110	2.111	2.110
0.4	-4.035	-4.022	2.281	2.279
0.5	-4.952	-4.926	2.427	2.424
0.6	-5.866	-5.821	2.549	2.544
0.7	-6.777	-6.704	2.648	2.642
0.8	-7.684	-7.574	2.724	2.718
0.9	-8.587	-8.425	2.778	2.773
1.0	-9.484	-9.256	2.810	2.811

TABLE 3.- RESULTS OF INTERFERENCE STUDY

17

RUN NO.	ALTITUDE (FT.)	ANGLE OF ATTACK (DEG.)	PITCH RATE AT EJECTION (RAD./SEC.)	CLEARANCE *		
				ΔZ_1 (FT.)	ΔZ_2 (FT.)	
1	400,000	0	0	INTERFERENCE	0.30	
2	↓	+ 90	↓	↓	0.30	
24		- 90			0.30	
3		+179			0.30	
25		179			0.30	
4		0	+ 0.2		INTERFERENCE	
5	↓	↓	+ 0.5	↓	↓	
6			+ 0.75			
7			+ 1.0			
9			0		0.30	
10		+ 90	↓		0.40	
26	↓	- 90	INTERFERENCE	↓		
11		+179	0.30			
27		- 179	0.30			
12		0	+ 0.2		INTERFERENCE	
13	↓	↓	+ 0.5		↓	
14			+ 0.75			
15			+ 1.0			
16			0	↓	0.30	
17	↓	+ 90	↓	0.2	0.76	
28		- 90		INTERFERENCE	INTERFERENCE	
18		+179		↓	0.30	
29		- 179			0.30	
19		0	+ 0.2		INTERFERENCE	
20	↓	↓	+ 0.5		↓	
21			+ 0.75			
22			+ 1.0			
30	400,000	↓	- 0.2	↓	0.40	

* ΔZ_1 = AMOUNT OF CLEARANCE FOR NIMBUS WITH PROTUBERANCES
 ΔZ_2 = AMOUNT OF CLEARANCE FOR NIMBUS WITHOUT PROTUBERANCES

FIGURE 1. - NIMBUS-B/SNAP 19 GENERATOR CONFIGURATION.

VIEW A-A

FIGURE 1. - Continued.

REVISIONS	DATE	GENERAL ELECTRIC
1	10/1/61	FILE
2	11/1/61	NIMBUS B - RTG/CONTROL
3	12/1/61	BOX CLEARANCE DEFINITION
CONTRACT NO.		15227 R SK 56152-152
WORK ORDER NO.	15227 R	SK 56152-152
DATE	10/1/61	BY

FIGURE 1.- Continued.

FIGURE 2.- SNAP 19 ASSEMBLY MOUNTED ON EJECTION MECHANISM.

FIGURE 3. - EXAMPLES OF SOME INITIAL NIMBUS-B ATTITUDES.

FIGURE 4.-
NIMBUS-B/GENERATOR GEOMETRY AT TIME OF EJECTION.

FIGURE 5 .- NIMBUS PROGRAM
GENERATOR EJECTION STUDY

NORMAL FORCE COEFFICIENT
VERSUS ANGLE OF ATTACK
OF NIMBUS SATELLITE

PLATFORMS AND
GENERATOR NOT INCLUDED

FIGURE 6 .-

NIMBUS PROGRAM
GENERATOR EJECTION STUDYAXIAL FORCE COEFFICIENT
VERSUS ANGLE OF ATTACK
OF NIMBUS SATELLITEPLATFORMS AND
GENERATOR NOT INCLUDED

FIGURE 7.- NIMBUS PROGRAM
GENERATOR EJECTION STUDY

PITCHING MOMENT COEFFI-
CIENT VERSUS ANGLE OF ATTACK
OF NIMBUS SATELLITE

PLATFORMS AND
GENERATOR NOT INCLUDED

K-2
AERODYNAMIC
DATA
3520

K&E
ENGINEERING
CORPORATION

FIGURE 13-

SNAP 19

AERODYNAMIC PITCHING MOMENT
2 STACKED 30 WATT GENERATORSREFERENCE AREA 51.5 SQ. IN.
REFERENCE LENGTH 3.093 IN.

FIGURE 14.-
NIMBUS GENERATOR
EJECTION STUDY

RUN NO. 1

$h = 400,000 \text{ FT.}$

$V = 25,650 \text{ FT./SEC.}$

$\gamma = -0.2^\circ$

$\alpha_0 = 0^\circ$

$\dot{\alpha}_0 = 0 \text{ RAD/SEC.}$

FIGURE 15. -
NIMBUS GENERATOR
EJECTION STUDY

RUN NO. 2

$h = 400,000$ FT.

$V = 25,650$ FT./SEC.

$\gamma = -0.2^\circ$

$\alpha_0 = +90^\circ$

$\dot{\alpha}_0 = 0$ RAD/SEC.

FIGURE 16.-
NIMBUS GENERATOR
EJECTION STUDY

RUN NO. 24

$h = 400,000$ FT.

$V = 25,650$ FT./SEC.

$\gamma = -0.2^\circ$

$\alpha_0 = -90^\circ$

$\dot{\alpha}_0 = 0$ RAD./SEC.

FIGURE 17.-
NIMBUS GENERATOR
EJECTION STUDY

RUN NO. 3

$h = 400,000$ FT

$V = 25,650$ FT./SEC.

$\gamma = -0.2^\circ$

$\alpha_0 = +179^\circ$

$\dot{\alpha}_0 = 0$ RAD/SEC.

**FIGURE 18 -
NIMBUS GENERATOR
EJECTION STUDY**

RUN NO. 25

$h = 400,000$ FT.

$V = 25,650$ FT./SEC.

$\gamma = -0.2^\circ$

$\alpha_0 = -179^\circ$

$\dot{\alpha}_0 = 0$ RAD./SEC.

FIGURE 19.-
NIMBUS GENERATOR
EJECTION STUDY

RUN NO. 4

$h = 400,000$ FT.

$V = 25,650$ FT./SEC.

$\gamma = -0.2^\circ$

$\alpha_0 = 0^\circ$

$\dot{\alpha}_0 = +0.2$ RAD./SEC.

FIGURE 20.-
NIMBUS GENERATOR
EJECTION STUDY

RUN NO. 7

$h = 400,000$ FT.

$V = 25650$ FT./SEC.

$\gamma = -0.2^\circ$

$\alpha_0 = 0^\circ$

$\dot{\alpha}_0 = +1.0$ RAD./SEC.

FIGURE 21.-
NIMBUS GENERATOR
EJECTION STUDY

RUN NO. 9

$h = 350,000$ FT.

$V = 25.650$ FT./SEC.

$\gamma = -0.2^\circ$

$\alpha_0 = 0^\circ$

$\dot{\alpha}_0 = 0$ RAD./SEC.

FIGURE 22.-
NIMBUS GENERATOR
EJECTION STUDY

RUN NO. 10

$h = 350,000$ FT.

$V = 25,650$ FT./SEC

$\gamma = -0.2^\circ$

$\alpha_0 = +90^\circ$

$\dot{\alpha}_0 = 0$ RAD/SEC.

**FIGURE 23. -
NIMBUS GENERATOR
EJECTION STUDY**

RUN NO. 26

$h = 350,000$ FT.

$V = 25650$ FT./SEC.

$\gamma = -0.2^\circ$

$\alpha_0 = 90^\circ$

$\dot{\alpha}_0 = 0$ RAD./SEC.

FIGURE 24.-
NIMBUS GENERATOR
EJECTION STUDY

RUN NO. 11

$h = 350,000$ FT.

$V = 25,650$ FT./SEC.

$\gamma = -0.2^\circ$

$\alpha_0 = +179^\circ$

$\dot{\alpha}_0 = 0$ RAD./SEC.

**FIGURE 25. -
NIMBUS GENERATOR
EJECTION STUDY**

RUN NO. 27

$h = 350,000$ FT.

$V = 25,650$ FT./SEC.

$\gamma = -0.2^\circ$

$\alpha_0 = -179^\circ$

$\dot{\alpha}_0 = 0$ RAD./SEC.

FIGURE 26.-
NIMBUS GENERATOR
EJECTION STUDY

RUN NO. 12

$h = 350,000$ FT.

$V = 25,650$ FT./SEC.

$\delta = -0.2^\circ$

$\alpha_0 = 0^\circ$

$\dot{\alpha}_0 = +0.2$ RAD/SEC.

FIGURE 27.-
NIMBUS GENERATOR
EJECTION STUDY

RUN NO. 16

$h = 310,000 \text{ FT.}$

$V = 25,650 \text{ FT./SEC.}$

$\gamma = -0.2^\circ$

$\alpha_0 = 0^\circ$

$\dot{\alpha}_0 = 0 \text{ RAD./SEC.}$

FIGURE 28.-
NIMBUS GENERATOR
EJECTION STUDY

RUN NO. 17

$h = 310,000 \text{ FT.}$

$V = 25,650 \text{ FT./SEC.}$

$\gamma = -0.2^\circ$

$\alpha_0 = +90^\circ$

$\dot{\alpha}_0 = 0 \text{ RAD./SEC.}$

**FIGURE 29 -
NIMBUS GENERATOR
EJECTION STUDY**

RUN NO. 28

$h = 310,000$ FT.

$V = 25650$ FT./SEC.

$\gamma = -0.2^\circ$

$\alpha_0 = -90^\circ$

$\dot{\alpha}_0 = 0$ RAD./SEC.

FIGURE 30.-
NIMBUS GENERATOR
EJECTION STUDY

RUN NO. 18

$h = 310,000 \text{ FT}$

$V = 25,650 \text{ FT./SEC.}$

$\gamma = -0.2^\circ$

$\alpha_0 = +179^\circ$

$\dot{\alpha}_0 = 0 \text{ RAD./SEC.}$

**FIGURE 31. -
NIMBUS GENERATOR
EJECTION STUDY**

RUN NO. 29

$h = 310,000$ FT.

$V = 25650$ FT./SEC

$\gamma = -0.2^\circ$

$\alpha_0 = -179^\circ$

$\dot{\alpha}_0 = 0$ RAD./SEC.

FIGURE 32.-
NIMBUS GENERATOR
EJECTION STUDY

RUN NO. 19

$h = 310,000$ FT.

$V = 25,650$ FT./SEC.

$\gamma = -0.2^\circ$

$\alpha_0 = 0^\circ$

$\dot{\alpha}_0 = +0.2$ RAD/SEC.

FIGURE 33 -
NIMBUS GENERATOR
EJECTION STUDY

RUN NO. 30

$h = 400,000 \text{ FT}$
 $V = 25,650 \text{ FT/SEC}$
 $\gamma = -0.2^\circ$
 $\alpha_0 = 0^\circ$
 $\dot{\alpha}_0 = -0.2 \text{ RAD/SEC.}$

FIGURE 3A.- INTERFERENCE CRITERION - PROTUBERANCES INCLUDED.

FIGURE 35.- EXAMPLE OF TYPE OF PLOT USED TO DETERMINE INTERFERENCE WHEN PROTUBERANCES ARE INCLUDED.

FIGURE 36.- EXAMPLE OF TYPE OF PLOT USED TO DETERMINE INTERFERENCE WHEN PROTUBERANCES ARE EXCLUDED.

FIGURE 37.-INTERFERENCE CRITERION- PROTUBERANCES EXCLUDED.

APPENDIX A

HISTORY OF EJECT MECHANISM DEVELOPMENT

Preliminary analyses which were conducted prior to the start of the SNAP 19 Program indicated that separation of the generators from spacecraft would be necessary to insure a safe re-entry from orbit.

Early in the program, therefore, various methods of separation were considered. These included both mechanical and explosive modes of separation. Means of activating separation were studied--ground command and initiation by devices sensitive to spacecraft re-entry. Various design concepts were reviewed with the cognizant agencies and a concept selection was made. This concept encompassed (1) initiation by ground command to a spacecraft in orbit (2) squib release of separation mechanism and (3) ejection of generators by spring energy. This concept was detail designed and became part of the generator support structure. The configuration and ejection clearances were determined for compatibility with the then existent spacecraft drawings--those of Nimbus A.

Later in the program it was decided to incorporate a capability of initiating ejection during re-entry from orbit by a device sensitive to aerodynamic heating. Thermal batteries and thermal switches were considered and a thermal switch system was selected. Since during re-entry the spacecraft would be subject to various motions and forces not present at orbital ejection this led to the need for the dynamic analysis discussed in this report.

The eject mechanism is currently undergoing developmental testing to demonstrate functional capability. The results of this development will be reported in a subsequent topical report.