



OFFICE OF INDUSTRIAL RESEARCH

STUDY COVERING THE ELECTRICAL AND MECHANICAL
CHARACTERISTICS OF A TRANSMITTING ANTENNA

FINAL REPORT

CONTRACT NO. OSU76-00117
DSS FILE NO. 01SU.36001-6-7134

Dr. L. Shafai

March 1977



The University of Manitoba, Winnipeg, Manitoba, Canada R3T 2N2

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RESEARCH PERSONNEL

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CONTRIBUTIONS

ABOUL-ATTA, O.

Blockage formulation, study, and calculation.
Aperture field distribution for front-fed systems.
Total relative gain for both symmetric systems
(front-fed/cassegrain).
The main program of Appendix A.
The side program of Appendix B.

CHUGH, R. K.

The aperture field distribution to both classical and shaped
cassegrain systems.
The polynomial fitting to the distribution is achieved by the program
listed in Appendix C.

SHAFAI, L.

Project coordination.
Front-fed design and measurements which are used with the above
program for testing.

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SUMMARY:

Theoretical treatment is presented of the energy lost by blocking and means are indicated to minimize this blocked energy for front-fed paraboloid antennas. Although cassegrain antenna appears to have a better location for the primary feed for service purposes and low circuit noise, the start of the report deals with various aspects of blockage effects for front-fed paraboloid only. Calculation for the blocking influence of the special primary feed (Experimental feed, DSS OISU-36100-5-0313) and its one strut supporting structure on the general directive gain pattern is computerised. The computer program deals with detailed analysis of the blockage efficiency with respect to several parameters, such as the aperture illumination, dimension of the flanged feed and its strut, F/D ratio, and the shaping of the support. The purpose of this work is to explain and calculate these various effects with regard to antenna efficiency and to outline the design principles for the support of this experimental primary feed. The analysis and computation of the blockage has been extended for two cases of dual reflector systems (classical/shaped subreflector). The complete computer programs are made to handle the three different cases mentioned above with minimum effort. Test cases are listed toward the end of the report to help the designer operate the program and seek the desired output information.

INTRODUCTION:

It is common knowledge that in front-fed paraboloid the primary feed is considered a free space point source (reflector reactor is neglected) situated at the focus of the paraboloid. That is, within the cone of illumination falling on the reflector the incident wave fronts differ negligibly from spheres about the focus (spherical wave front). On reaching the main dish, these spherical waves are reflected in accordance with ray optics, and because of the antenna geometry employed, the rays emerge parallel, with a plane wave front forming a collimated beam. As a first order approximation, the problem of the blockage by the feed itself and its supporting structure can be tackled if the interaction between the obstacles and the source (multiple scattering processes) is assumed to be of secondary importance (Silver, 1949; p. 130) and that the shadow of the obstacles on the aperture or the reflector surface does not radiate. Usually, ray optics is used to define a spherical wave shadow (centre of the focus) when the obstacle is inside the main cone of illumination and a plane wave shadow for the outside obstacle e.g. the feed itself is a plane wave shadow while any of the supporting strut would in general have two parts depending on the way it bends toward the reflector (Dijk et al, 1968). The literatures point out that radio frequency shadow wider than optical one which can only be used as an approximation (Ruze, 1968). But the limitation on the use of optical shadows, thickness of the supporting legs $2W$ and the diameter of the circular symmetric central blocking $D_S = 2R_2$, (Trentini, 1965; Kay, 1965; Mei and Van Bladel, 1963) are all in agreement with the case to be studied in this section of the report as long as we concentrate on the neighbourhood of the bore-sight radiation pattern of the antenna, $\theta_{\max} = 2\sqrt{\frac{2F}{\lambda}}$ (Width Main Beam) , (Afifi, 1967; p.20). Whether the dish's current distribution

or the aperture field method (Silver, 1949; p.144) is used to determine the secondary pattern of the unblocked reflector, a surface current cancellation on the shadowed part of the reflector or the "zero field concept" on the blocked part of the aperture indicate how the obstacles perturb the secondary pattern of the antenna. Mathematically, they are regarded as producing a field equal in amplitude but 180° out of the phase with the original unblocked distribution over the area that the shadow covers. In this way zero illumination is obtained over the blocked parts and the perturbation can be calculated and studied for the different design of supporting the feed. For the experimental feed (Shafai et al, 1976) the optimization of the unblocked antenna supplies us here with the following information:

- the radiation pattern of the primary feed, $G_f(\theta')$;
- the diameter of the experimental primary feed D_S ;
- the ratio F/D or the aperture subtended angle ψ .
- the program of calculating the 10° near the main axis of the unblocked secondary radiation pattern.

The purpose of the proceeding section is to study, for the above data, the effect and the influence on the directive gain pattern, especially the boresight gain, by different subshadows. The resulting effects:

- decrease of the antenna gain factor, generally expressed by the relative blocking coefficient η_B/η_o where η_o is the efficiency of the unblocked aperture;
- increase of the side lobes of the antenna pattern, by studying the different contribution of the subshadows;
- the cross polarization for different locations of the struts design, especially the unsymmetric ones.

are programmed to yield a flexible search for a simple support with least

reduction in the antenna efficiency.

The previously described analysis (approximate) of the strut, blocking has been based on the null-field hypothesis (currents/fields on the shadowed portion of the surface/aperture are non-radiative), fails to take into account the depth, cross-section, tilt of the struts and does not provide any differences for frequency or polarization effects. The "induced field ratio, IFR" (Rusch, 1974), defined as a measure of the scattered field by an infinitely long cylindrical scatterer when it is immersed in an incident plane wave, is considered a useful first step in "coming to grip" with the problem of strut blocking and it is incorporated in the computer program developed here. That is; the tilt, polarization, and frequency of all straight cylindrical portions of the struts that lie outside the main illuminating cone (spherical wave shadows) can be treated according to the IFR hypothesis and compared with straight results using the null-field hypothesis.

PARABOLOID BLOCKAGE FORMULATION:

For a prime-focus paraboloid with circular aperture, (the focal plane) taken to be the XY plane as shown in figure 1, the co-ordinates are adjusted to have the boresight of the secondary radiation in the positive Z axis and that the principal polarization of the aperture field is in the positive X direction. This can be visualised by assuming a primary feed illuminating the dish as a point source with a principal polarization along the negative X direction. That is, the incident wave fronts on the dish differ negligibly from spherical waves (the focal point acts as the phase centre) and the incident field be recognized by:

$$\bar{E}_{\text{inc}} = \frac{e^{-jk\rho'}}{\rho'} [-EP(\theta') \cos\phi' \hat{\theta}' + HP(\theta') \sin\phi' \hat{\phi}'] \quad (1)$$

where EP (θ') and HP (θ') are the E- and H- plane patterns of the primary feed respectively, while $(r', 2\pi - \phi', \theta')$ are the standard co-ordinates spherical of the dish surface relative to the focus as shown in figure 1.

For a perfectly conducting reflector and the properties of the paraboloidal surface leads to the reflected field (Silver, 1949)

$$\bar{E}_{\text{ref}} = \frac{e^{-jk\rho'}}{\rho'} [EP(\theta') \cos\phi' \hat{r}' - HP(\theta') \sin\phi' \hat{\phi}'] \quad (2)$$

which obeys the pencil-beam (a beam of parallel rays) technique to give the following aperture field distribution

$$\begin{aligned} \bar{E}_{\text{Aperture}} = & \frac{e^{-jk2f}}{\rho'} [\hat{X} \left(\frac{\hat{EP}(\theta') + \hat{HP}(\theta')}{2} - \frac{\hat{HP}(\theta') - \hat{EP}(\theta')}{2} \cos 2\phi' \right) - \\ & - \hat{Y} \left(\frac{\hat{HP}(\theta') - \hat{EP}(\theta')}{2} \sin 2\phi' \right)] \end{aligned} \quad (3)$$

where ρ' and ϕ' can be written in terms of the circular (r', ϕ') co-ordinates of the aperture points and the parameters of the reflector $(f/D, \psi)$

$$\tan \frac{\psi}{2} = \frac{D}{4f}, \quad \tan \frac{\theta'}{2} = \frac{2r'}{4f} = \frac{2r'}{D} \tan \frac{\psi}{2}$$

$$\rho' = \sec^2 \frac{\theta'}{2} = f(1 + (\frac{2r'}{D})^2 \tan^2 \frac{\psi}{2})$$

$$\theta' = 2 \tan^{-1} [\frac{2r'}{D} \tan \frac{\psi}{2}]$$

$$\bar{E}(P) = \frac{jke^{-jkk}}{4\pi R} \int_A [(\hat{R} + \hat{Z}) \times \bar{E}_A] \times R e^{jk\bar{r}' \cdot \hat{R}} dA$$

If the general formulation of the radiated field is derived from the aperture field distribution (Silver, 1949) the approximation becomes sufficiently accurate near the boresight especially when the radius of the aperture is appreciably larger than a wave length (Rusch, 1974). The steps leading to the following final results are deleted as they are similar to the literature (Shafai, 1976, Rusch, 1974).

$$\bar{E}(P) = \frac{jk}{4\pi R} e^{-jk(R+2f)} (1 + \cos\theta) [(A \cos\phi - B) \hat{\theta} - (A \sin\phi + C) \hat{\phi}] \quad (4)$$

where,

$$A = \int_A \left(\frac{HP(\theta') + EP(\theta')}{2\rho'} \right) e^{jk\bar{r}' \cdot \hat{R}} dA = K \int_A F(r', \phi') e^{jk\bar{r}' \cdot \hat{R}} dA = K g(\theta, \phi)$$

$$[C] = \int_A \left(\frac{HP(\theta') - EP(\theta')}{2\rho'} \right) e^{jk\bar{r}' \cdot \hat{R}} [\cos(2\phi' - \phi) \quad \sin(2\phi' - \phi)] dA$$

$$K = \text{Max} \left(\frac{HP(\theta') + EP(\theta')}{2\rho'} \right) \text{ inside the aperture}$$

for example, if circular symmetric aperture distribution is considered

$$\bar{E}(P) = \frac{jk}{R} e^{-jk(R+2f)} \cos^2 \frac{\theta}{2} [(\alpha + \beta) \cos\phi \hat{\theta}] \quad (5)$$

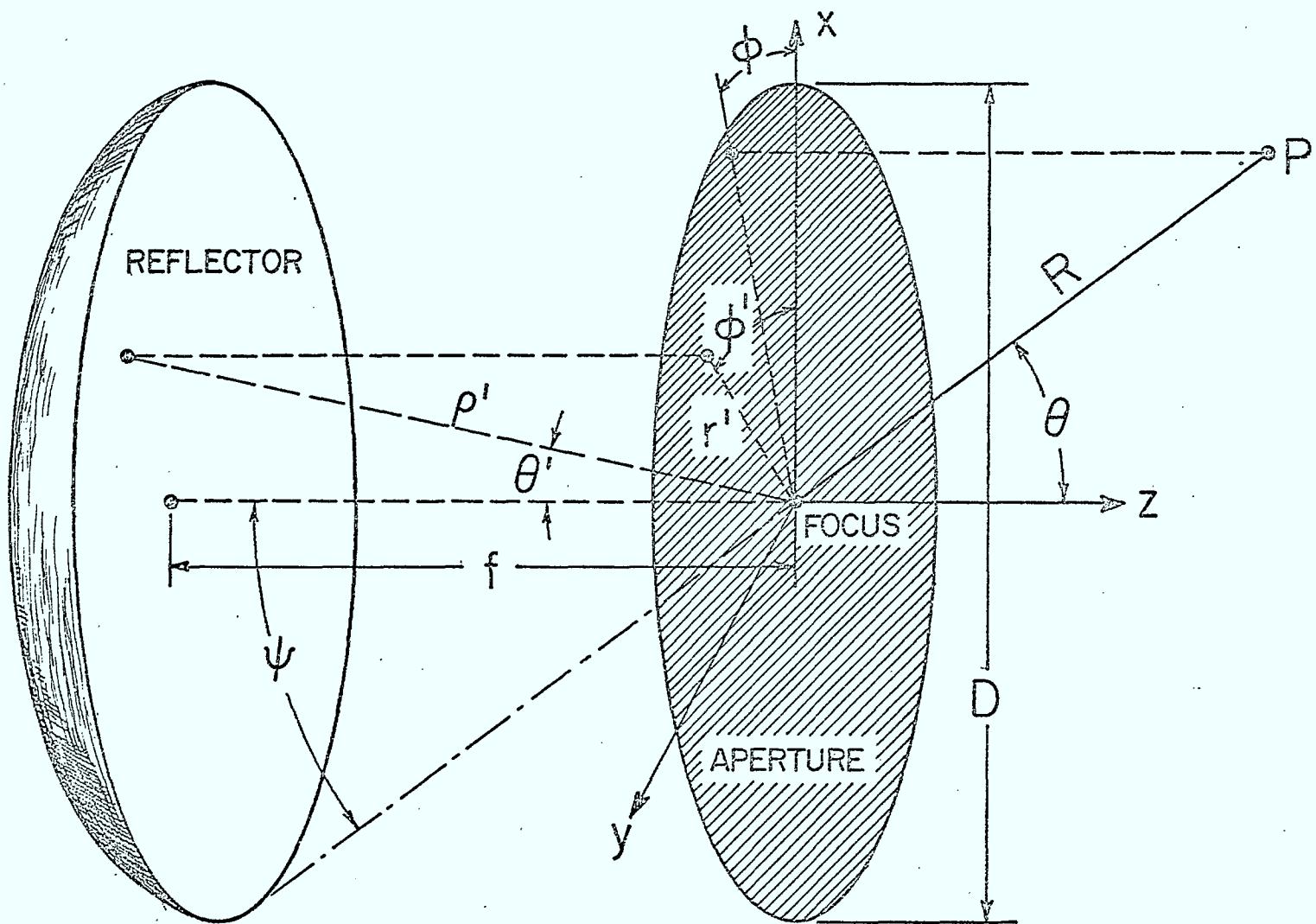


FIGURE 1: GEOMETRIC PARAMETERS AND THE CO-ORDINATES INVOLVED FOR PRIME-FOCUS PARABOLIC REFLECTOR

where,

$$\alpha = \int_0^{1/2D} \left(\frac{HP(\theta') + EP(\theta')}{2\rho} \right) J_0(kr' \sin\theta') r' dr' =$$

$$= 1/2D \tan \frac{\psi}{2} \int_0^1 \left(\frac{HP(\theta') + EP(\theta')}{1 + t'^2 \tan^2 \frac{\psi}{2}} \right) J_0(t'u) t' dt'$$

$$\beta = \int_0^{1/2D} \left(\frac{HR(\theta') - EP(\theta')}{2} \right) J_2(kr' \sin\theta') r' dr' =$$

$$= 1/2D \tan \frac{\psi}{2} \int_0^1 \left(\frac{HP(\theta') - EP(\theta')}{1 + t'^2 \tan^2 \frac{\psi}{2}} \right) J_2(t'u) t' dt'$$

$$k = \frac{2\pi}{\lambda}, \quad u = \pi \frac{D}{\lambda} \sin\theta, \quad t' = \frac{2r'}{D}, \quad kr' \sin\theta = ut$$

then the accepted practice is to justify the small error involved by neglecting the β part of the solution ($HP \approx EP$, $J_2(ut) \rightarrow 0$ as $\theta \rightarrow 0$) near the boresight. Accordingly, the frontal portion of the secondary radiation pattern varies closely to the following relation (Silver, 1965, p.173).

$$\bar{E}(P) \approx \frac{jk}{4\pi R} e^{-jk(R+2f)} (1 + \cos\theta) A \hat{e}, U_p = \frac{je^{jkR}}{2\lambda R} (1 + \cos\theta) A$$

$$\hat{e} = (\cos\phi) \hat{\theta} - (\sin\phi) \hat{\phi}, \bar{E}(P) = U_p \hat{e}$$

Therefore, within the above justification, the blockage effect can be observed by studying their effect on A or simply the factor $g(\theta, \phi)$ which is to be called during the rest of the report "the relative far field directive pattern" and is represented by the scalar equation (Silver, 1965, p.173).

$$g(\theta, \phi) = \iint_A F(X, Y) \exp[jk \sin\theta(X \cos\phi + Y \sin\phi)] dxdy \quad (\text{Rectangular Aperture}) \quad (7)$$

$$g(\theta, \phi) = \iint F(r', \phi') \exp[jkr' \sin\theta \cos(\phi - \phi')] r' dr' d\phi' \quad (\text{Circular Aperture}) \quad (8)$$

Where $F(X, Y)$ and $F(r', \phi')$ represent the field distribution over the aperture (A) and is normalized to have a maximum value of unity. The orientation of the aperture is assumed to be in the XY-plane or equivalent (r', ϕ') while the principle polarization of the aperture is taken to be in the positive X-direction. The aperture field distribution is proportional to the primary feed effective gain function $G_{eff}(\theta', \phi')$ as follows:

$$F(r', \phi') = N [G_{eff}(\theta')]^{1/2} / \rho', G_{eff}(\theta') = \frac{1}{4} [G_f'(\theta') + G_f''(\theta') + 2\sqrt{G_f'(\theta') G_f''(\theta')}]$$

Where $G_f'(\theta')$ and $G_f''(\theta')$ are relative power pattern in the E- and H- planes, (normalized to the same value at $\theta'=0$) of the experimental feed to be used in this study. Typical performance of this feed is shown in Figure 2 (Shafai and

Aboul-Atta, 1976) where the selection of feed (a) and feed (b), (Shafai, 1976) will be used as the test cases for the proceeding analysis.

Review of the available literature (e.g. Rusch, 1974 and Dijk et al., 1971) shows that the influence of the blockage on the directive pattern can be summed up in the following relation:

$$g_t(B, \phi) = g_o(\theta, \phi) - A_{CB} g_{CB}(\theta, \phi) - A_{PS} g_{PS}(\theta, \phi) - A_{SS} g_{SS}(\theta, \phi) \quad (9)$$

where

$g_t(\theta, \phi)$ is the total directive pattern after including the blockage effect,
 $g_o(\theta, \phi)$ is the directive pattern of the unblocked aperture,
 $g_{CB}(\theta, \phi)$ is the contribution of the central blockage (feed's shadow),
 $g_{PS}(\theta, \phi)$ is the contribution of the support's plane wave shadow,
 $g_{SS}(\theta, \phi)$ is the contribution of the support's spherical wave shadow,
and (A_{CB}, A_{PS}, A_{SS}) are the weighing coefficients (taken as unity in the first order approximation) that correct for the different factors involved like the tilt between the plane wave front and the support, the radio frequency shadow being slightly larger than the optical one, and the diffraction due to edge effect of the central blockage and so on.

THE APERTURE FIELD

Most of the literature available deals with the blockage effect for a special family of curves representing possible aperture field distributions. None of the existing cases covers the field distribution due to the experimental feed to be used in this report, (Shafai et al, 1976). Accordingly, the actual field (from available experimental data) has been interpolated in a general polynomial. A program is adjusted to yield this interpolation in the form:

$$F(t) = \sum_{r=1}^N COEFF(r) t^{2(r-1)}, \quad t = \frac{2r}{D}, \quad N \leq 15 \quad (10)$$

The appropriate fitting to the data of feed A and feed B types (DSS OISU-36100-5-0313) can be seen in the following table and Figure . (N=11) was found sufficient for the purpose at hand. The fitting is done to the average E-plane and H-plane measurements, according to the previous analytic justification, and the comparison is shown. Also a copy of the program that accomplished this task is documented at the back. A by-product of the same programme is a quick and a simple search for the optimum illumination angle and an estimation of the maximum gain which runs around the 80% for the class of feed mentioned above. For a front-fed reflector antenna, and double reflector system as well, the aperture field distribution is circularly symmetric. Hence, equation (8) is suitable to calculate the relative directive pattern for the unblocked aperture near the boresight. The same equation is to be used in calculating the effect of all circularly symmetric obstruction such as the flange of the aforementioned feed or the subreflector in the cassegrainian antenna. It is understood that this central blockage is quite small, (less than 1%) of the actual area of the aperture, and has a broader pattern than the unblocked aperture. Therefore, it will reduce the main beam as well as the even side

OPTIMUM ANGLE = 69.51
GF MULT. FACT.= 0.91938E 00

ANGLE	P--FEED	P--DBS	GF-DBS	ANT GAIN	%-SPILL
0	3.95421	5.97	5.61	0.00000	100.000
.2	3.96227	5.98	5.61	0.00111	99.889
.4	3.98606	6.01	5.64	0.00445	99.555
.6	4.02449	6.05	5.68	0.01005	98.995
.8	4.07571	6.10	5.74	0.01797	98.203
1.0	4.13721	6.17	5.80	0.02828	97.172
1.2	4.20588	6.24	5.87	0.04105	95.895
1.4	4.27820	6.31	5.95	0.05636	94.363
1.6	4.35043	6.39	6.02	0.07428	92.571
1.8	4.41712	6.45	6.09	0.09485	90.514
2.0	4.47216	6.51	6.14	0.11808	88.192
2.2	4.51039	6.54	6.18	0.14391	85.608
2.4	4.52754	6.56	6.19	0.17225	82.774
2.6	4.52063	6.55	6.19	0.20294	79.705
2.8	4.48846	6.52	6.16	0.23576	76.422
3.0	4.43601	6.47	6.10	0.27046	72.950
3.2	4.36555	6.40	6.04	0.30679	69.313
3.4	4.27562	6.31	5.94	0.34445	65.536
3.6	4.16592	6.20	5.83	0.38313	61.651
3.8	4.03682	6.16	5.70	0.42245	57.689
4.0	3.88929	5.90	5.53	0.46201	53.687
4.2	3.72479	5.71	5.35	0.50141	49.679
4.4	3.54519	5.50	5.13	0.54020	45.700
4.6	3.35274	5.25	4.89	0.57795	41.787
4.8	3.14993	4.98	4.62	0.61423	37.971
5.0	2.93947	4.68	4.32	0.64862	34.285
5.2	2.72417	4.35	3.99	0.68073	30.754
5.4	2.50685	3.99	3.63	0.71020	27.403
5.6	2.29029	3.60	3.23	0.73669	24.251
5.8	2.07710	3.17	2.81	0.75993	21.314
6.0	1.86971	2.72	2.35	0.77970	18.601
6.2	1.67025	2.23	1.86	0.79582	16.119
6.4	1.48058	1.70	1.34	0.80817	13.868
6.6	1.3217	1.15	0.78	0.81670	11.846
6.8	1.13618	0.55	0.19	0.82142	10.048
7.0	0.93337	-0.07	-0.44	0.82236	8.462
7.2	0.84417	-0.74	-1.10	0.81966	7.078
7.4	0.71870	-1.43	-1.80	0.81345	5.880
7.6	0.61677	-2.17	-2.53	0.80394	4.855
7.8	0.51795	-2.94	-3.31	0.79135	3.985
8.0	0.42159	-3.75	-4.12	0.77594	3.255
8.2	0.34690	-4.60	-4.96	0.75800	2.647
8.4	0.28295	-5.48	-5.85	0.73782	2.147
8.6	0.22978	-6.39	-6.75	0.71571	1.739
8.8	0.18660	-7.29	-7.66	0.69206	1.406
9.0	0.15154	-8.19	-8.56	0.66724	1.136

FREQUENCY = 12.000 GHZ
 INNER DIAMETER = 1.000 INS
 FLANGE RETARDATION = 0.000 INS
 2ED FLANGE RETARD. = 0.000 INS
 AVERAGE TO EGH MEASUREMENTS

COMPARISON OF THE POLYNOMIAL APPROXIMATION
WITH THE AVERAGE E&H-MEASUREMENTS OF THE
APERTURE FIELD DISTRIBUTION

RATIO	A.F.D. MEASURED	A.F.D. INTERPLOT
0.00	0.96942E 00	0.96942E 00
0.01	0.96953E 00	0.96952E 00
0.02	0.96983E 00	0.96983E 00
0.03	0.97034E 00	0.97033E 00
0.04	0.97103E 00	0.97103E 00
0.05	0.97191E 00	0.97191E 00
0.06	0.97296E 00	0.97297E 00
0.07	0.97418E 00	0.97419E 00
0.08	0.97554E 00	0.97555E 00
0.09	0.97703E 00	0.97704E 00
0.10	0.97863E 00	0.97864E 00
0.11	0.98032E 00	0.98033E 00
0.12	0.98209E 00	0.98209E 00
0.13	0.98389E 00	0.98390E 00
0.14	0.98572E 00	0.98572E 00
0.15	0.98755E 00	0.98754E 00
0.16	0.98935E 00	0.98934E 00
0.17	0.99110E 00	0.99108E 00
0.18	0.99276E 00	0.99274E 00
0.19	0.99434E 00	0.99430E 00
0.20	0.99578E 00	0.99572E 00
0.21	0.99709E 00	0.99699E 00
0.22	0.99818E 00	0.99807E 00
0.23	0.99906E 00	0.99893E 00
0.24	0.99965E 00	0.99956E 00
0.25	0.99997E 00	0.99992E 00
0.26	0.99994E 00	0.9999E 00
0.27	0.99960E 00	0.99973E 00
0.28	0.99886E 00	0.99913E 00
0.29	0.99777E 00	0.99816E 00
0.30	0.99625E 00	0.99679E 00
0.31	0.99433E 00	0.99500E 00
0.32	0.99198E 00	0.99277E 00
0.33	0.98921E 00	0.99009E 00
0.34	0.98601E 00	0.98692E 00
0.35	0.98237E 00	0.98327E 00
0.36	0.97833E 00	0.97911E 00
0.37	0.97385E 00	0.97445E 00
0.38	0.96904E 00	0.96928E 00
0.39	0.96392E 00	0.96360E 00
0.40	0.95855E 00	0.95742E 00
0.41	0.95287E 00	0.95075E 00
0.42	0.94690E 00	0.94361E 00
0.43	0.94065E 00	0.93603E 00
0.44	0.93408E 00	0.92803E 00
0.45	0.92724E 00	0.91964E 00
0.46	0.92009E 00	0.91091E 00
0.47	0.91267E 00	0.90187E 00
0.48	0.90498E 00	0.89258E 00
0.49	0.89699E 00	0.88307E 00

COEF00 = 0.96942E 00 COEF06 = -0.39414D 04
 COEF01 = 0.10252D 01 COEF07 = 0.64136D 04
 COEF02 = -0.10691D 02 COEF08 = -0.60353D 04
 COEF03 = 0.47258D 02 COEF09 = 0.30530D 04
 COEF04 = -0.29342D 03 COEF10 = -0.64313D 03
 COEF05 = 0.14086D 04 TMX = 0.257
 INFLX1 = 0.140 INFLX2 = 0.750

RATIO	A.F.D.MEASURED	A.F.D.INTERPLOT
0.50	0.88877E 00	0.87340E 00
0.51	0.88027E 00	0.86361E 00
0.52	0.87154E 00	0.85376E 00
0.53	0.86258E 00	0.84388E 00
0.54	0.85336E 00	0.83402E 00
0.55	0.84395E 00	0.82421E 00
0.56	0.83433E 00	0.81447E 00
0.57	0.82450E 00	0.80484E 00
0.58	0.81449E 00	0.79531E 00
0.59	0.80432E 00	0.78589E 00
0.60	0.79397E 00	0.77658E 00
0.61	0.78348E 00	0.76735E 00
0.62	0.77285E 00	0.75819E 00
0.63	0.76208E 00	0.74906E 00
0.64	0.75120E 00	0.73992E 00
0.65	0.74022E 00	0.73073E 00
0.66	0.72914E 00	0.72145E 00
0.67	0.71798E 00	0.71203E 00
0.68	0.70675E 00	0.70244E 00
0.69	0.69547E 00	0.69263E 00
0.70	0.68413E 00	0.68259E 00
0.71	0.67275E 00	0.67229E 00
0.72	0.66136E 00	0.66173E 00
0.73	0.64994E 00	0.65093E 00
0.74	0.63852E 00	0.63990E 00
0.75	0.62710E 00	0.62868E 00
0.76	0.61570E 00	0.61731E 00
0.77	0.60432E 00	0.60585E 00
0.78	0.59297E 00	0.59435E 00
0.79	0.58166E 00	0.58287E 00
0.80	0.57040E 00	0.57145E 00
0.81	0.55920E 00	0.56012E 00
0.82	0.54807E 00	0.54889E 00
0.83	0.53700E 00	0.53776E 00
0.84	0.52602E 00	0.52668E 00
0.85	0.51512E 00	0.51558E 00
0.86	0.50432E 00	0.50438E 00
0.87	0.49362E 00	0.49297E 00
0.88	0.48301E 00	0.48125E 00
0.89	0.47252E 00	0.46913E 00
0.90	0.46215E 00	0.45659E 00
0.91	0.45189E 00	0.44366E 00
0.92	0.44176E 00	0.43048E 00
0.93	0.43176E 00	0.41734E 00
0.94	0.42188E 00	0.40466E 00
0.95	0.41215E 00	0.39301E 00
0.96	0.40254E 00	0.38302E 00
0.97	0.39308E 00	0.37531E 00
0.98	0.38376E 00	0.37021E 00
0.99	0.37459E 00	0.36745E 00
1.00	0.36556E 00	0.36556E 00

0.9694169163703918D 00
 -0.2934235961553395D 03
 -0.6035292627303105D 04

0.1025198784615478D 01
 0.1408556949705347D 04
 0.3052956294389306D 04

-0.106913022821549
 -0.394143788053956
 -0.643127386241610

lobes while it raises the odd side lobes (first, third, etc.). Also as the size is greater than a wave length, the geometric shadow is justified in the application of the "zero field concept" without any weighing factor $A_{CB}=1$. Therefore, near the boresight (say $\leq 10^\circ$) equation 8 is a good approximation for both the unblocked (and the centrally blocked portion) relative directive pattern. The technique can be summarized as follows:

CENTRAL BLOCKING

Assume a circular area of radius r has the same centre as the main aperture. Then the relative directive pattern due to that area, when circular symmetry is observed, can be written as:

$$g_{CB}(\theta) = 2\pi \left(\frac{D}{2}\right)^2 \int_0^X F(t) J_0(ut)t dt \quad (11)$$

where,

$$X = \frac{2r}{D}, \quad u = \pi \frac{D}{\lambda}, \quad D \text{ is the diameter of the reflector.}$$

Upon substituting the polynomial fitting of the field distribution, as given by equation (10), the integral can be evaluated in terms of COEFF(I)'s.

The final outcome of this evaluation is:

$$\int_0^X F(t) J_0(ut)t dt = \sum_{r=0}^{\infty} (-1)^r A_r(x) \frac{(ux/2)^{2r}}{(r!)^2} + \sum_{r=0}^N (-1)^r B_r(x) \frac{A_{r+1}(ux)}{r+1} \quad (12)$$

where,

$$A_r(x) = \frac{x^2}{2} \sum_{p=0}^N \frac{\text{COEFF}(P+1) x^2}{(P+r+1)}$$

$$B_r(x) = \frac{x^2}{2} \sum_{p=r}^N \binom{P}{r} \text{COEFF}(P+1) x^{2p}$$

The first of the above possibilities of evaluation is suited for small argument (say $ux \leq 4$) where the series can be truncated after $r=9$ without any appreciable error, i.e.,

$$\sum_{r=0}^{\infty} (-1)^r A_r(x) \frac{(ux/2)^{2r}}{(r!)^2} \approx \sum_{r=0}^9 [(-1)^r A_r(x) \frac{2^r}{(r!)^2}] (ux/4)^{2r}, \quad ux \leq 4$$

For large values of ux , the second form is the acceptable one for the evaluation. Two subroutines "GTLT" and "CRSYM" are written to evaluate the needed ($A_r(x)$, $B_r(x)$, $\Lambda_{r+1}(ux)$) parameters and hence the evaluation of the integral for any arbitrary COEFF(I)'s and x . The relative directive pattern of the un-blocked aperture can also be extracted from those subroutines by the direct substitution of $x=1$. The subroutine "CRSYM" evaluates $\Lambda_1(ux)$ & $\Lambda_2(ux)$ from their Bessel's equivalent and their generate the needed higher order ones by their standard recursion formulas. Results have been checked with table (Jahnke & Emde, 1943) and are found satisfactory. The next step is to bend the wave guide section of the feed until it faces the reflection where it can come down in a straight portion to meet the parabolic surface at an arbitrary position R_1 as seen in the Figure below. The radius of curvature RC and R_1 are left as a variable parameter for the design to be flexible. The wave guide section can be a circular or rectangular type and the total width is taken as $(2W)$. The net effect of bringing the guide to the paraboloidal surface is to have both types of geometrical shadows. This is, R_1 is less than one, due to plane waves and spherical waves being blocked taking into consideration that the parameters R_1, W & $(R_2=x)$ are normalized to $(D=2)$, the plane wave shadow is generally rectangular with width $2W$ and length (R_1-R_2) .

PLANE WAVE BLOCKAGE

Let the rectangular shadow make an angle ϕ_o with respect to the main polarization (to be taken as the x axis of aperture). Then equation can be used with the same polynomial interpolation (10) to give

$$g_{PS}(\theta, \phi) = \left(\frac{D}{2}\right)^2 \int_{-w}^w \int_{R2}^{R1} \sum \text{COEFF}(I) [x'^2 + y'^2]^{I-1} \exp[juX' + jvY'] dy' dx'$$

where,

$$u = \left(\frac{\pi D}{\lambda}\right) \sin\theta \cos(\phi - \phi_o), \quad v = \left(\frac{\pi D}{\lambda}\right) \sin\theta \sin(\phi - \phi_o)$$

That is,

$$g_{PS}(\theta, \phi) = \left(\frac{D}{2}\right)^2 \left[\sum_1^N \text{COEFF}(I) \sum_{K=1}^I \binom{I-1}{K-1} \left(\int_{-w}^w y'^2 (K-1) \exp(juY') dy' \right) \left(\int_{R2}^{R1} x'^2 (I-K) \exp(juX') dx' \right) \right] \quad (13)$$

The complex exponential integral has been programmed in terms of a complex function "XPIY(M,A,S)" where M represents the degree of the variable square, A is the parameter (v or u) multiplying the variable in the exponentiation and S is the upper limit of the integral (taking the lower limit as zero). The double summation, without the factor $\left(\frac{D}{2}\right)^2$, has been programmed in the form of a subroutine "PSHRD". That is, the outcome of "PSHRD" is the contribution $g_{PS}(\theta, \phi)$ normalized to the value $\left(\frac{D}{2}\right)^2$. This subroutine is geared toward accepting cases of the plane shadow contribution due to the strut support of the subreflector in a cassegrainian system.

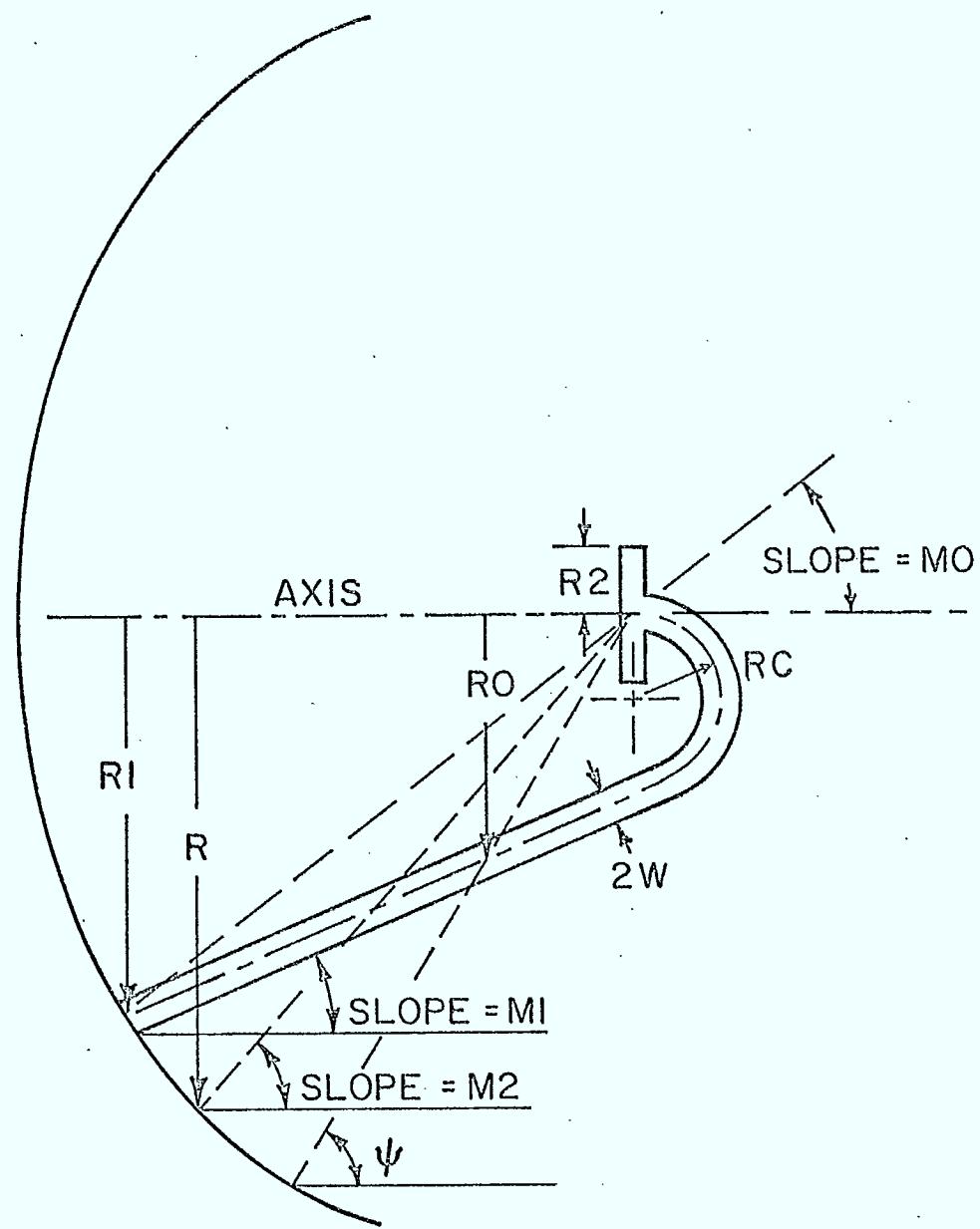


FIGURE 2: THE DIFFERENT PARAMETERS USED IN CALCULATING THE SHADOWS OF THE FEED AND ITS SUPPORT

Spherical Waves Blockage

The spherical waves shadow, of the feed's wave guide or the struts, was observed (Dijk & Maanders, 1968. Wested, 1966) to be very close to trapizoides in shape. This type of approximation is not considered here. Instead, the exact parametric equation of the shadow is derived in a straight forward mathematical equation and the final outcome (see Figure 3) is

$$x = \sqrt{1 - \gamma^2} R, \quad y = \gamma R, \quad \gamma = \frac{W}{R_1} \left(\frac{1 - \frac{M_1}{M_2}}{1 - \frac{M_1}{M_2}} \right)$$

where

$$M_2 = \tan [2 \tan^{-1} (R_x \tan \frac{\psi}{2})]$$

$$M_0 = \tan [2 \tan^{-1} (R_1 x \tan \frac{\psi}{2})]$$

and

$$M_1 = \begin{cases} \frac{R_1 - R_S}{R_1} \tan [2 x \tan^{-1} (R_1 x \tan \frac{\psi}{2})] & \text{cassegranian antenna} \\ \frac{\alpha \beta}{\beta^2 - 1} - \sqrt{\left(\frac{\alpha}{\beta^2 - 1}\right)^2 - \frac{1}{\beta^2 - 1}} \end{cases}$$

$$\alpha = \frac{R_1 - R_C}{R_C}, \quad \beta = \frac{R_1}{R_C} \cot [2 x \tan^{-1} (R_1 + \tan \frac{\psi}{2})]$$

R , R_1 , R_C and R_S are the same normalized ratio of the outer radius of the dish previously used. The above parametric form of the boundary of the shadows is programmed in terms of the subroutine "PRMSH".

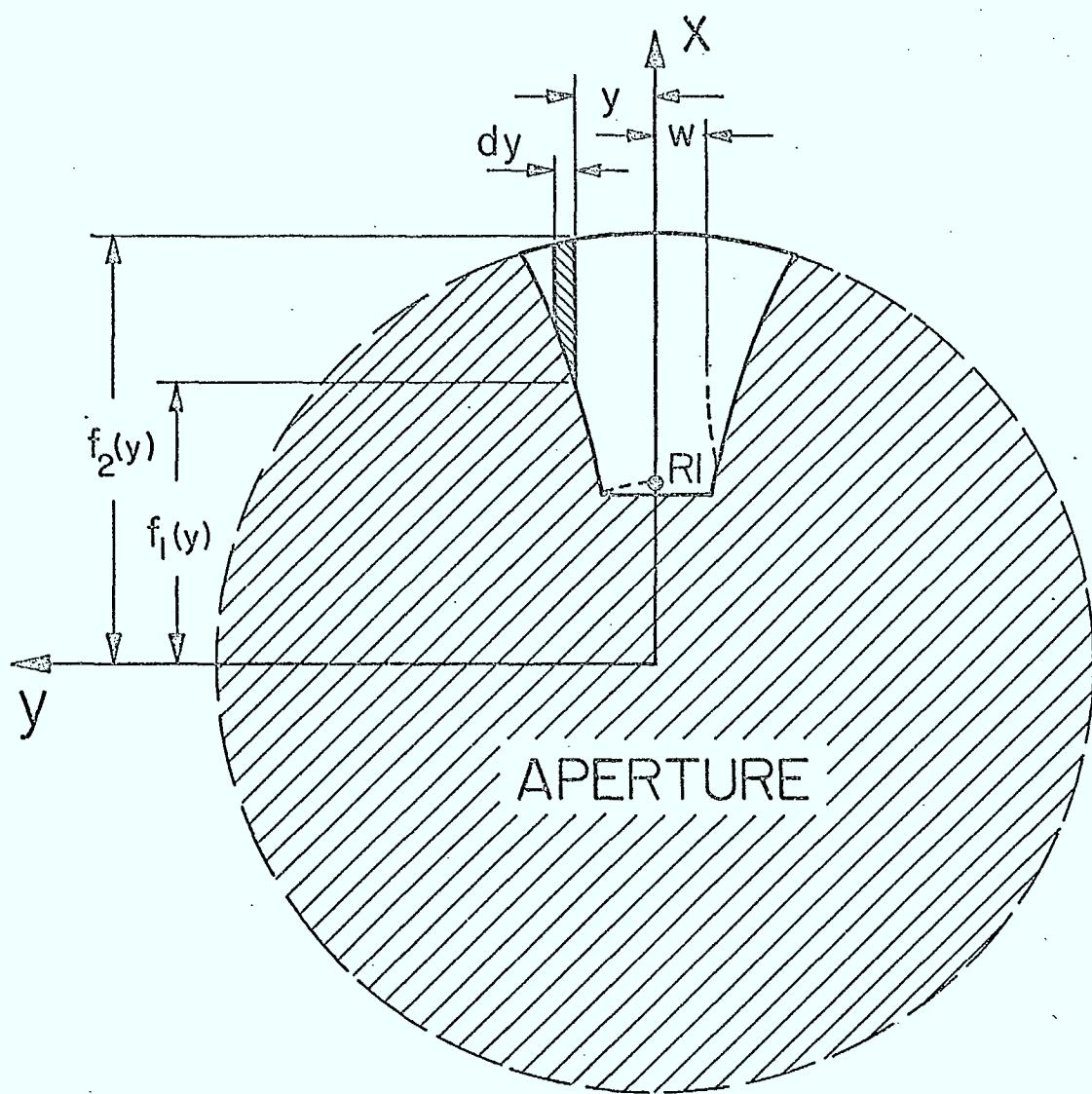


FIGURE 3: PARAMETERS INVOLVED IN DEFINING THE SPHERICAL-WAVE SHADOWS OF THE SUPPORT STRUCTURE

CASSEGRAIN ANTENNA SYSTEM

The performance of a cassegrain two reflector system is discussed and compared with the front-fed paraboloids. The stress is on the circularly symmetric dual reflector antenna, where the aperture of the main reflector is partly blocked by the sub-reflector and its support structure. The common support structure to be handled in the following analysis is the three street and the four street support. In the absence of a broad primary-feed radiation pattern for deep illumination (of a front-fed paraboloid), the classical form of the cassegrain system becomes appealing. This system employs a main dish which is a paraboloid metallic surface and an auxiliary reflector, called the sub-reflector or the subdish, with a hyperbolic contour as shown in the figure (4) below. The real focus P_1 is located near, or almost at the main dish while the virtual focus P_2 is at the focus of the paraboloid reflector. When the primary feed is situated at the real focus, according to geometric optics, the main dish is illuminated by the reflected rays from the sub-reflector. This is equivalent to a point source situated at the virtual focus, the paraboloid focus, and leads to rays emerging parallel from the main dish (i.e. plane wave front) in the form of a collimated beam. The accessibility of the primary feed (being almost at the center of the main reflector's surface) for adjustment and service plus the saving of return wave guide section to the amplifier (Attenuation and circuit noise), makes the system quite useful for primary-feeds with sharp radiation pattern (narrow beam width).

The main limitation of most double reflector systems is the blockage of the aperture by the subdish and its supporting legs. Although blockage does appear in the front-fed paraboloid as well, the consequences are less severe,

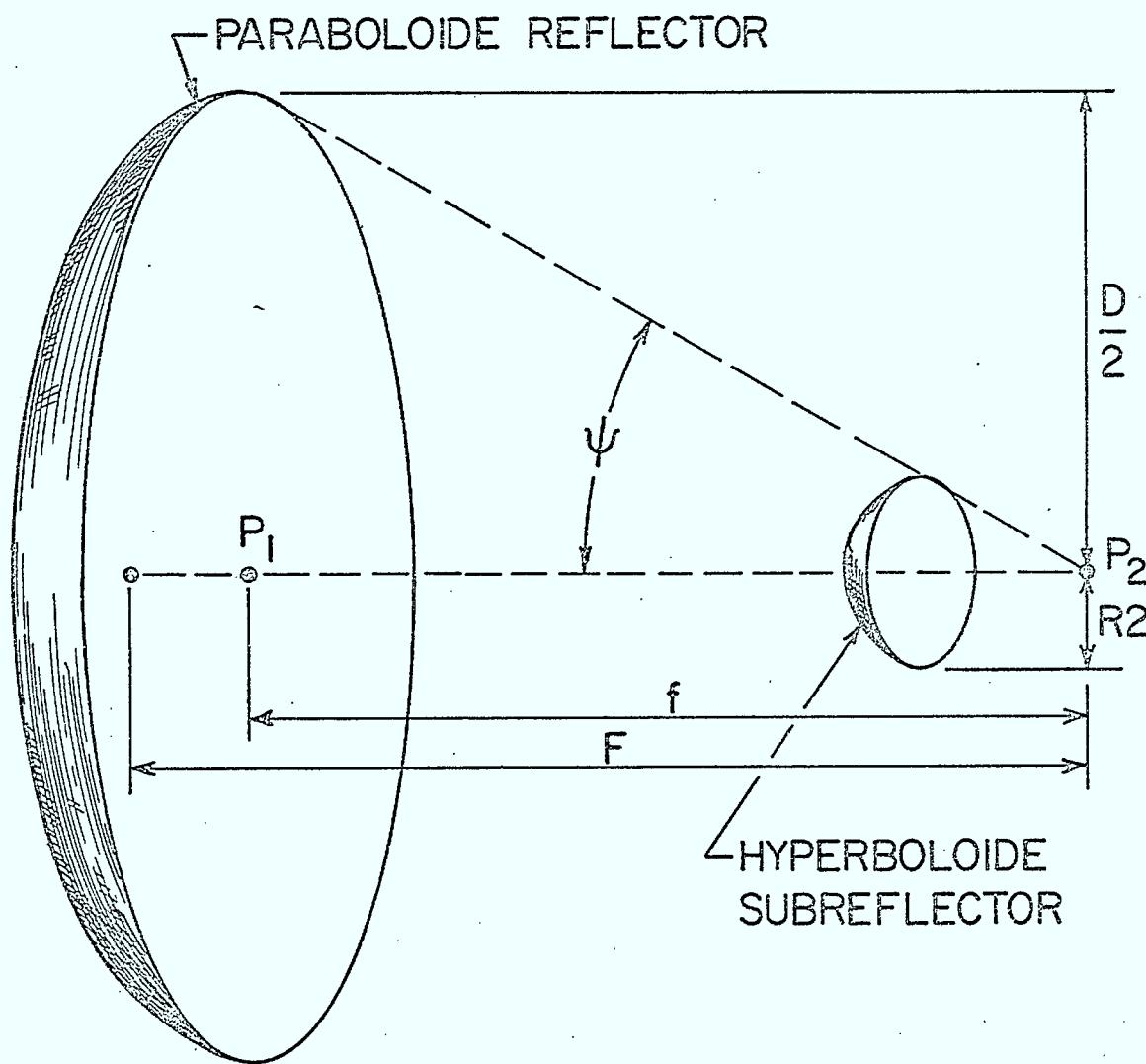


FIG. 4. CLASSICAL CASSEGRAIN SYSTEM

as the feed's flange is in the main smaller than the subreflector and the shadow due to its supporting structure is less than that of the dual reflector system. It is the purpose of this analysis to explain and calculate various effects with regard to antenna efficiency and to outline the advantage and limitations of the circularly symmetric cassegrain antenna as compared with front-fed paraboloid. The detailed calculation of the blockage as a function of several design parameters, such as F/D ratio or the illumination angle, dimensions of the subreflector and that of the struts, and the implantation of the struts on the main reflector are shown and computerized in the form of a general program written in WATFIV/FORTRAN IV and is simple to use by the designer. Clarification of the input variables to the program the necessary adjustments for the two cases of three or four struts, the outputs as they exist and their possible alteration are shown and test cases are listed for checking.

GEOMETRIC RELATIONS

The following is a summary of the common and useful relation that can be easily proved or checked in the references (Dijk et al., 1968; Silver, 1949). According to the notations given in Fig. 5, the polar equation of main dish and subreflector are:

$$\rho_p' = 2F/(1 + \cos \theta') = F/\cos^2(\frac{\theta'}{2})$$

$$\rho_h' = f(e^2 - 1)/[2e(e \cos \theta' + 1)]$$

where e is the hyperboloid eccentricity.

$$r_p' = 2F \tan(\frac{1}{2} \theta')$$

$$r_h' = f(e^2 - 1) \sin \theta' / [2e(e \cos \theta' + 1)]$$

$$\rho_h = -f(e^2 - 1) / [2e(e \cos \theta_h + 1)]$$

$$\tan \frac{\theta_h}{2} = \frac{e - 1}{e + 1} \tan \frac{\theta'}{2}$$

$$\cot \Psi_h + \cot \Psi = f/R^2$$

where Ψ_h and Ψ are the upper bound of θ_h and θ' from the horizontal axis as shown in Fig. 5.

The above geometric relations do provide the necessary interrelations between the different parameters and tells exactly that the reflected gain function of the hyperboloid surface is proportional to that of the primary feed at P_1 ,

$$G_r(\theta') = G_f(\theta_h) \sin^2 \theta_h / \sin^2 \theta', \quad \theta_h = 2 \tan^{-1} [\frac{e - 1}{e + 1} \tan \frac{1}{2} \theta'].$$

Most of the variation of the above relations are graphically documented in previous works (Dijk et al., 1968) and can be consulted for quick estimates.

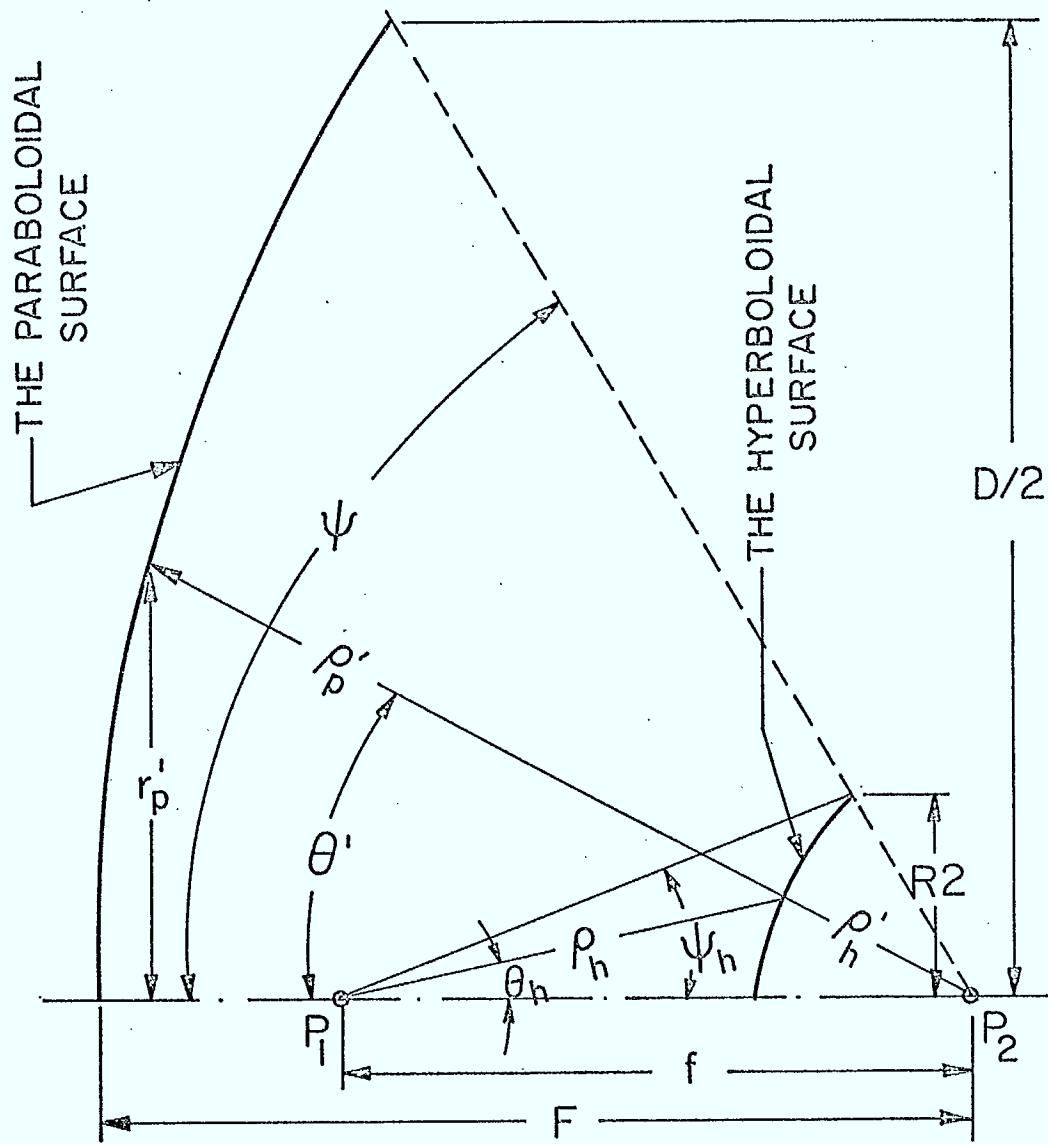


FIG. 5. PARAMETERS OF THE CLASSICAL
CASSEGRAIN SYSTEM

For accurate results, substitution is done directly in the corresponding equation.

BASIC EXPRESSIONS FOR THE EFFICIENCY

If A is the area of a non-blocked aperture that has a field distribution $F(X, Y)$, then the directivity (Silver, 1949) for $\theta = 0$ is calculated according to:

$$\frac{4\pi}{\lambda^2} \left| \iint_A F(X, Y) dX dY \right|^2 / \iint_A |F(X, Y)|^2 dX dY$$

where

$$\iint_A F(X, Y) dX dY = g(0, 0).$$

The illumination efficiency η_o of this non-blocked aperture is defined in the following way:

$$\eta_o = \left| \iint_A F(X, Y) dX dY \right|^2 / (A \iint_A |F(X, Y)|^2 dX dY). \quad (14)$$

For circularly symmetrical field distribution $F(t)$ where $t = 2r/D$, the element of area may be replaced by $2\pi R^2 t dt$ and the expression for the efficiency becomes:

$$\eta_o = 2 \left| \int_0^1 F(t) t dt \right|^2 / \int_0^1 |F(t)|^2 t dt \quad (15)$$

$$G_A = \left(\frac{\pi D}{\lambda} \right)^2 \eta_o \quad (\text{Aperture gain})$$

That is, given the aperture distribution in a polynomial form:

$$F(t) = \sum_1^N COEFF (I) (t^2)^{I-1}$$

$$|F(t)|^2 = \sum_1^{2N-1} SQPOL (I) (t^2)^{I-1}$$

Integration can be carried out accordingly to yield:

$$\eta_o = \left(\sum_1^N \text{COEFF.}(I)/I \right) / \left(\sum_1^{2N-1} \text{SQPOL.}(I)/I \right). \quad (16)$$

This part is contained in the general program under subroutine "UNBLK (N, EFFO)" where the squaring of the polynomial, the generation of the SQPOL (I) coefficients are being carried out, and the result is printed as a part of the output data (see the test cases).

ATENNA GAIN

The secondary field pattern of a radiating, circular and symmetrical aperture is generally represented analytically (Silver, 1949) in the neighbourhood of the boresight (main axis of radiation) by the expression:

$$E(\theta) = j \frac{2\pi}{\lambda} \int_0^{zD} E(r) J_0 \left(\frac{2\pi}{\lambda} r \sin \theta \right) r dr. \quad (17)$$

To obtain a better insight of the above equation, the aperture illumination $E(r)$ can be replaced by the gain function of the primary feed $G_f(\theta_h)$ or its equivalent $G_r(\theta')$. According to Silver (page 419), the interrelation is:

$$E(r) = C \frac{[G_r(\theta')]^{1/2}}{\rho_p} = \frac{C}{F} [G_r(\theta')]^{1/2} \cos^2 \left(\frac{1}{2} \theta' \right), \quad C = [2\sqrt{\frac{\mu}{\epsilon}} \frac{P_T}{4\pi}]^{1/2}$$

where P_T is the total radiated power by the feed.

In terms of the feed gain function (Dijk et al., 1968) the above relation reads:

$$E(r) = \frac{C}{F^*} G_f(\theta_h) \cos \left(\frac{1}{2} \theta_h \right), \quad F^* = F \frac{e + 1}{e - 1} \quad (18)$$

where e is the hyperboloid eccentricity.

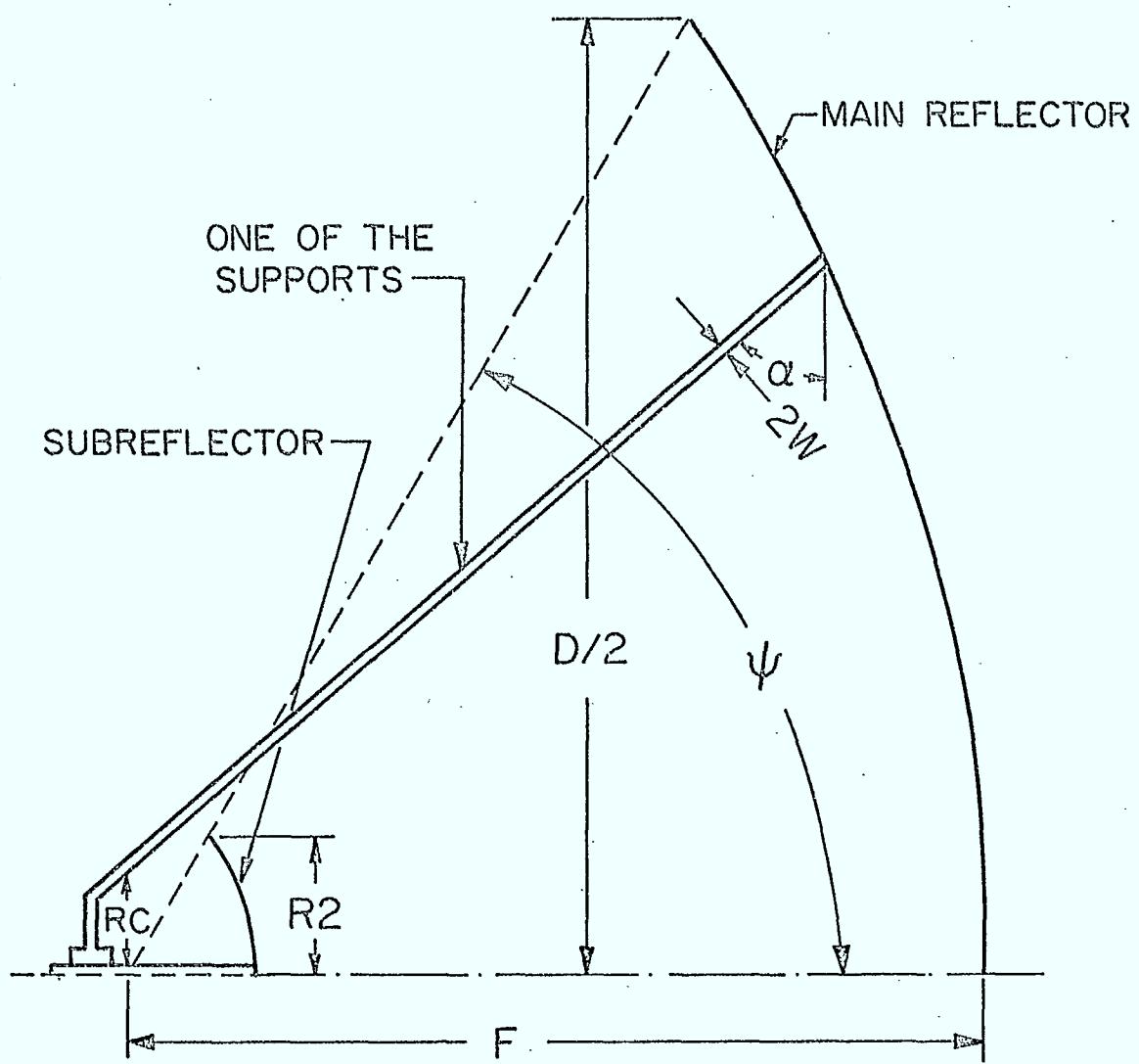


FIG. 6. CROSS-SECTION OF THE DUAL-REFLECTOR
SYSTEM IN THE PLANE OF ONE OF THE STRUTS

The same mentioned reference evaluates the antenna gain according to:

$$P(0, 0) = \frac{1}{2} \sqrt{\frac{\epsilon}{\mu}} |E(0, 0)|^2$$

$$G = 4\pi P(0, 0)/P_T = \left(\frac{\pi D}{\lambda}\right)^2 \cot^2\left(\frac{\psi_h}{2}\right) \left| \int_0^{\psi_h} [G_f(\theta_h)^{1/2} \tan(\frac{1}{2}\theta_h) d\theta_h]^2 \right| \quad (19)$$

where $G_0 = \left(\frac{\pi D}{\lambda}\right)^2$ is the gain of a uniform illuminated constant phase aperture, and the rest is the antenna gain factor $g(0, 0)$.

To connect the antenna gain with the aperture efficiency and aperture gain G_A of the previous section, attention should be given to the power balance. For example, if there is no spillover around the edge of the subreflector and all the reflected power has been intercepted by the main dish, then the aperture efficiency and the antenna gain factor would be the same. The literature does give the needed expressions (Dijk et al., 1968) for the power balance of the blocked and non-blocked aperture in the cassegrain antenna system.

IFR HYPOTHESIS

The "induced field ratio" (IFR) of an infinitely long cylindrical scatterer is a measure of its forward scattered field when it is immersed in an incident plane wave. The presence of a long thin mechanical support structures in front of a constant-phase aperture has its effect upon the RF performance of the aperture. The optical shadow (plane-wave shadow) and its aperture field cancellation does not show the effect of the tilt of this obstruction with main axis of radiation. As the tilt is mainly in the struts that support the subdish, a theory has been developed (Rusch, 1974) and proposed as a good first approximation. It assumes that the strut induced current due to the aperture field is almost the same that would flow on an

infinite cylindrical structure of the same strut's cross section when immersed in an infinite plane wave of the same polarization and direction of incident as the local aperture field.

This approximation is known as the IFR hypothesis, and it does permit the loss in the beresight gain, due to the plane-wave shadow of the struts, to be a function of the tilt as will as the cross section. The hypothesis seems to be physically reasonable, especially when the struts are long and thin relative to the operating wave length. The formulation of this hypothesis is outside the scope of this report and only the final effect on equation (1) is given. According to Rusch the weighting coefficient A_{PS} , instead of unity must be taken as:

$$A_{PS} = -(RES \cos^2 \phi_i + RHS \sin^2 \phi_i) \quad (20)$$

where ϕ_i = angle between the main polarization and the plane shadow of the i th strut.

and

$$RES = \frac{-1}{(ka \cos \alpha)} \sum_{-\infty}^{\infty} [J_n(ka \cos \alpha) / H_n^{(2)}(ka \cos \alpha)] \quad (21)$$

$$RHS = \frac{-1}{Ka \cos \alpha} \sum_{-\infty}^{\infty} [J'_n(ka \cos \alpha) / H'_n(ka \cos \alpha)] \quad (22)$$

where α = is the tilt angle of the strut relative to the aperture plane.

a = is the radius of the circular strut.

The calculation of these two factors, RES and RHS as given by their respective equations, are programmed in terms of the three SUBROUTINES IFRC(XS, RES, RHS), BESO(X, FJO, FYO) and BESI(X, FJI, FYI) where XS = $ka \cos \alpha$.

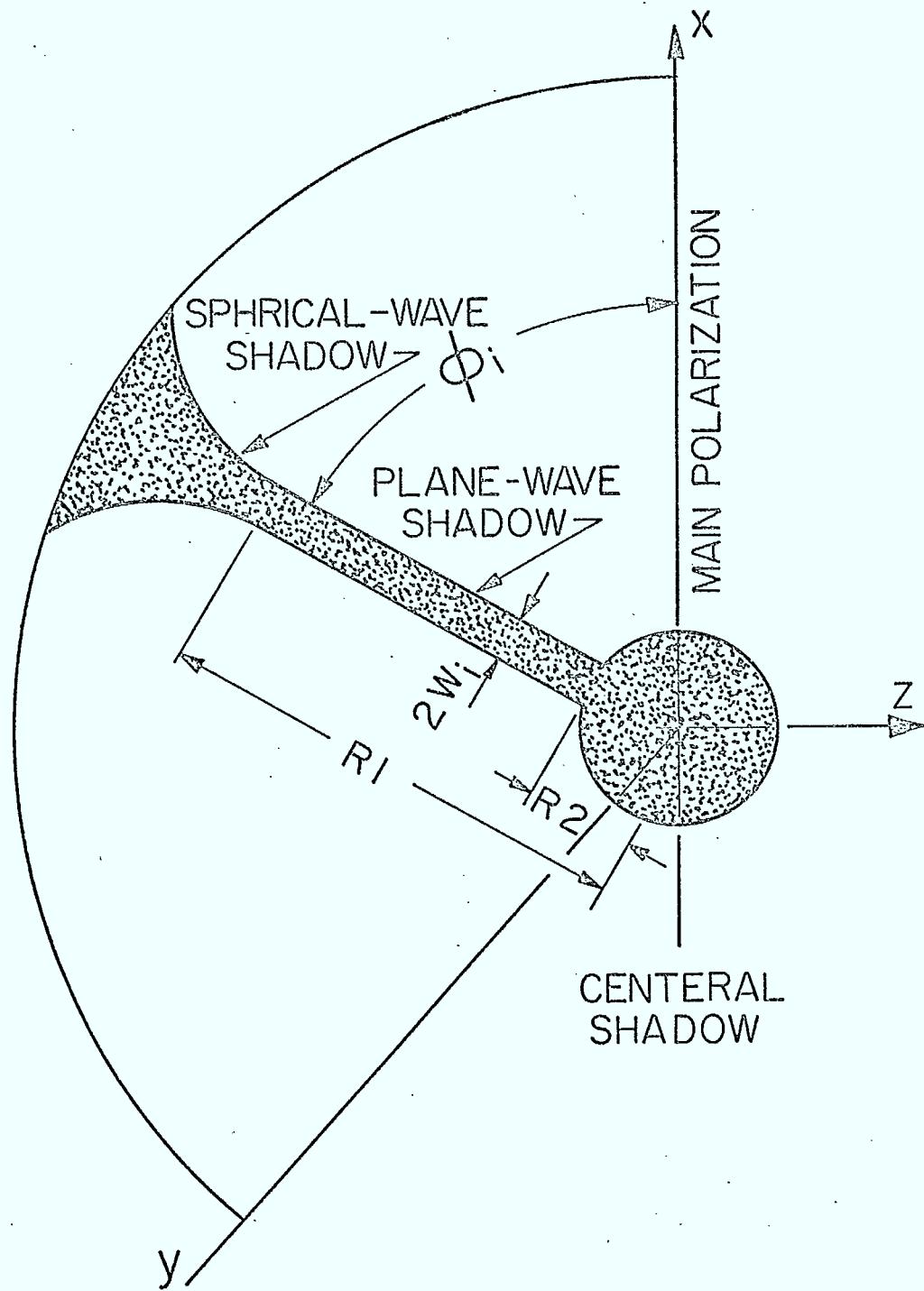


FIG. 7. THE SHADOWS PROJECTED BY THE
i.th. STRUT AND THE SUBREFLECTOR

APERTURE FIELD FOR DUAL REFLECTOR ANTENNA SYSTEMS

The blockage of the aperture by the subdish and support legs of most double reflector antennas, such as cassegrain antennas, is usually determined by the ray optics shadow of the obstacles on the aperture. These optical shadows are weighted by the aperture illumination to calculate the influence on antenna efficiency and sidelobes (Manders, 1975). The aperture field distribution for dual reflector antenna systems; consisting of either classical hyperboloid-paraboloid combination, or a combination consisting of shaped subreflector and paraboloid main-reflector, was obtained by using the procedure described below.

As a first step, the experimental power feed pattern is represented in the form:

$$F(\theta) = A (\cos \theta)^n.$$

The main reasons for this form of representations are the availability of efficiency curves as a function of n (Manders, 1975) and the simplicity.

The appropriate fitting to the feed used for cassegrain antenna, Demo. 1, was provided [CRC 6090-9(ST) P]. This feed was used to determine the aperture distribution for the standard cassegrain system and the shaped subreflector-paraboloid reflectors system.

The calculated data of the shaped subreflector can be used to obtain the equation for x_s , the distance from subreflector vertex, as a function of y in the form of:

$$x_s = \sum_{n=1}^M c_n y^{2(n-1)}. \quad M \leq 20 \quad (23)$$

The number of coefficients required for the curve fitting, according to the notation given in Fig. 8, is obtained by the program so that the total absolute error is less than or equal to 0.001 times the number of data points. In case the shaped subreflector is replaced by the hyperboloid reflector, the equation for x_s is:

$$x_s = \left[\frac{c^2}{e^2} + \frac{y^2}{e^2 - 1} \right]^{\frac{1}{2}} - \frac{c}{e} \quad (24)$$

where c and e are the semi-foci distance and eccentricity, respectively.

The equation of the subreflector and the angle of incidence from the feed can be used to determine the angle of reflection with the help of Snell's law of reflection:

$$\frac{dx_s}{dy} = \tan \left(\frac{\beta - \theta_1}{2} \right). \quad (25)$$

The reflected ray from the subreflector hits the paraboloid reflector of focal length f at the point:

$$y_2 = \frac{2f}{\tan \beta} \left[\left(1 + c_1' \frac{\tan \beta}{f} \right)^{\frac{1}{2}} - 1 \right] \quad (26)$$

where c_1' is the point of intersection of reflected ray from the subreflector with the x -axis. The angle of the final reflected ray from the paraboloid reflector can be determined using the Snell's law of reflection:

$$\frac{dy_2}{dx_2} = \cot \left(\frac{\beta + \theta_f}{2} \right). \quad (27)$$

The aperture point for the outgoing wave is found to be:

$$y_2' = y_2 + (H - x_2) \tan \theta_f$$

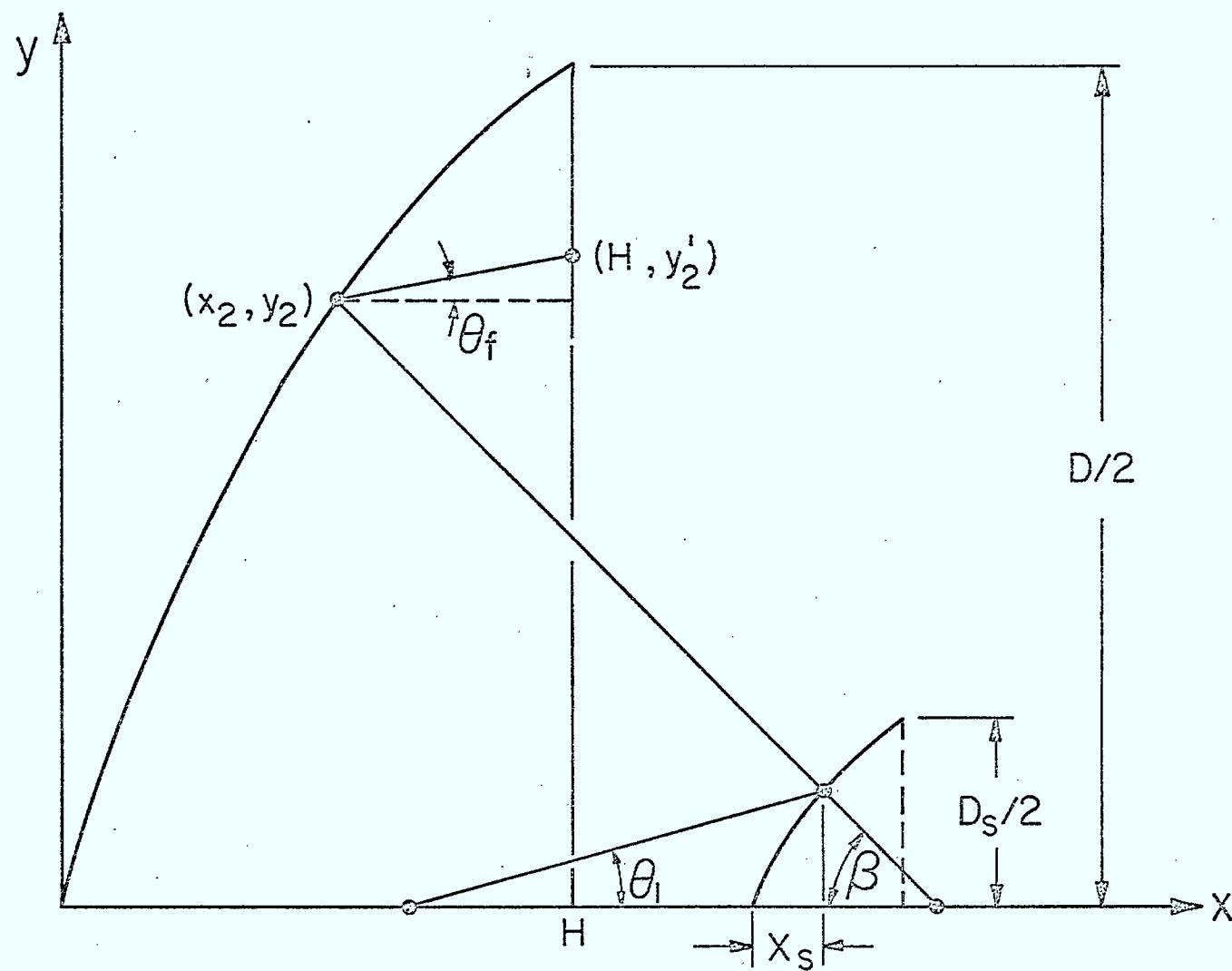


FIG. 8. GEOMETRY OF THE DUAL-REFLECTOR SYSTEM

where H is the x coordinate of the aperture plane. The calculated values of y_2' for various angles of incidence were fitted into an equation of the form:

$$y_2' = \sum_{n=1}^M d_n \sin b\theta_1. \quad M \leq 20 \quad (28)$$

where:

$$b = \frac{\pi}{2 \theta_{1 \text{ max}}}.$$

Again as for the subreflector curve fitting, the number of coefficients were chosen to provide total absolute error less than 0.001 times the number of data points.

The conservation of energy principle is expressed differentially as:

$$2\pi I_1(\theta_1) \sin \theta_1 d\theta_1 = 2\pi I_2(y_2') y_2' dy_2'. \quad (29)$$

The quantity $I_1(\theta_1)$ is the power density of the primary illumination. The quantity $I_2(y_2')$ is the power density flow normal to the aperture of the main-reflector. The above relation provides the relative aperture power distribution due to the absence of the normalization:

$$\int_{\theta_{1 \text{ min}}}^{\theta_{1 \text{ max}}} I_1(\theta_1) \sin \theta_1 d\theta_1 = \int_{y_{2 \text{ min}}}^{y_{2 \text{ max}}} I_2(y_2') y_2' dy_2'. \quad (30)$$

The aperture field distribution can be represented in the form:

$$f(r) = \sum_{n=1}^{NC} e_n r^{2(n-1)}. \quad NC \leq 20 \quad (31)$$

where:

$$r = 2y_2'/D.$$

The number of coefficients in this case being equal to the preset number.

The above mentioned relations and procedure are utilized in a computer program, listed at the back, to calculate the aperture field for standard cassegrain and the shaped subreflector-paraboloid system. The calculated data for the shaped subreflector was the one being used at Communications Research Centre [CRC 6090-9 (ST) P]. The aperture distribution obtained for these two cases is then used to calculate the effect of blockage.

CONCLUSION

At the time this report was submitted for typing the emphasis was on the numerical program, its accuracy, and operation. The types of antennas that can be studied by the designer are the symmetrical front-fed paraboloid, the classical cassegrain, and the shaped sub-reflector cassegrain. The report had no option in selecting an optimum design, as the two cases tested in here are already in operational state and the program only yielded the expected theoretical deterioration of efficiency, relative directive gain near the main radiation axis. The front-fed paraboloid (Shafai, technical memo-randum, serial No. 59/77, February 7, 1977, CRC) and the shaped subreflector (data received, January 4, 1977, from Mr. A. Kong, CRC) stands shoulder to shoulder with no appreciable difference. Should the subreflector be made smaller and the equiangular tripod thinner, in the shaped cassegrain, the result would have shown an improvement over the front-fed paraboloid mentioned above.

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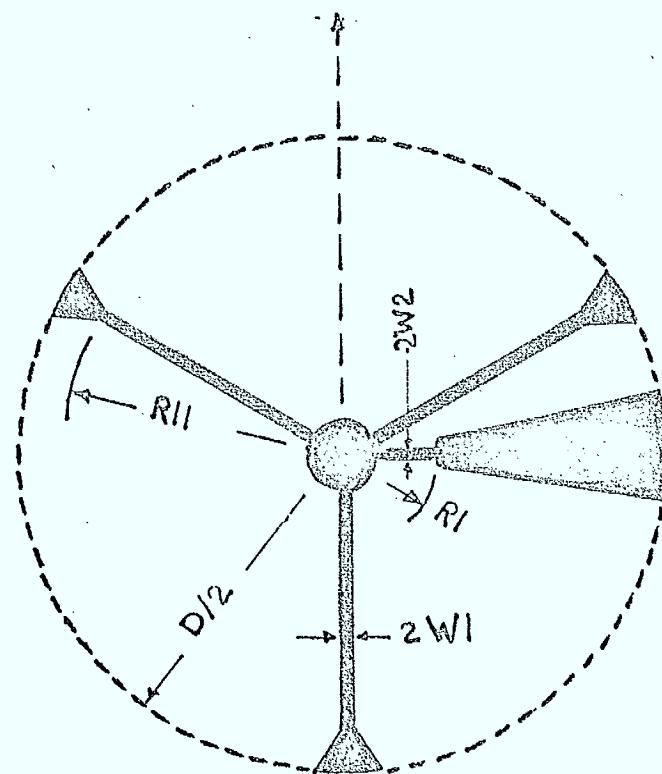
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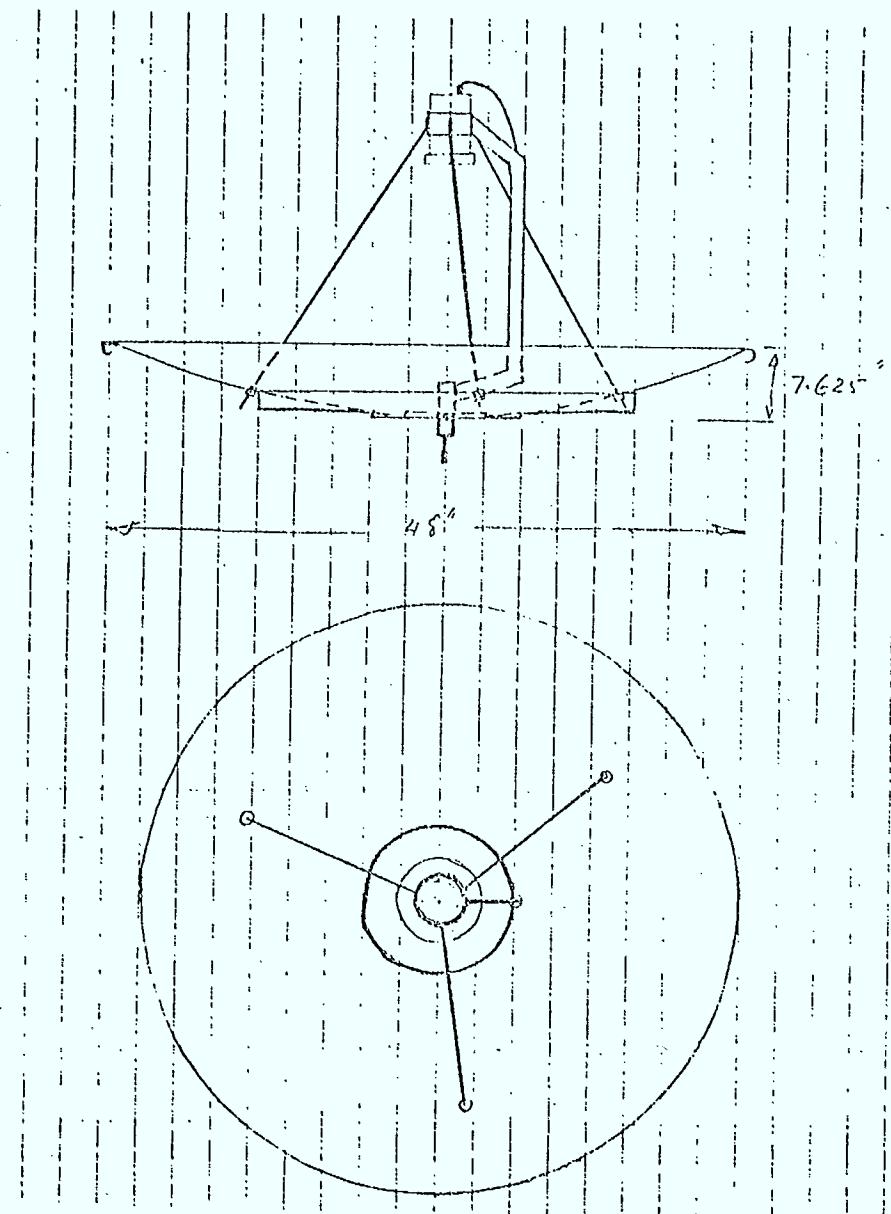
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TEST CASE

CALCULATION OF THIS (n_b/n_o) BLOCKAGE IS 7 PERCENT



*
FRONT-FED PARABOLOID
*
INPUT DATA

POLYNOMIAL COEFFICIENTS ARE:
COEFFICIENT(1) = 0.9694200E 00
COEFFICIENT(2) = 0.6254480E 00
COEFFICIENT(3) = -0.3062224E 01
COEFFICIENT(4) = 0.1833000E 01
ROT = 0.00 DEGREES
EPSI = 67.50 DEGREES
DIAM = 48.00 LAMDA
R1 = 0.2900 D/2 RATIO
R2 = 0.0938 D/2 RATIO
RC = 0.1450 D/2 RATIO
W = 0.0156 D/2 RATIO
R11 = 0.8333340 D/2 RATIO
RC1 = 0.0468750 D/2 RATIO
W1 = 0.0039063 D/2 RATIO
W2 = 0.0039069 D/2 RATIO
OUTPUT DATA

APERTURE EFFICIENCY = 90.60 %
BLOCKED EFFICIENCY = 84.24 %
APERTURE GAIN IN DBS = 43.14 DBS
LOSS DUE TO BLOCKAGE = 7.08 %
LOSS DUE TO BLOCKAGE = 0.32 DBS

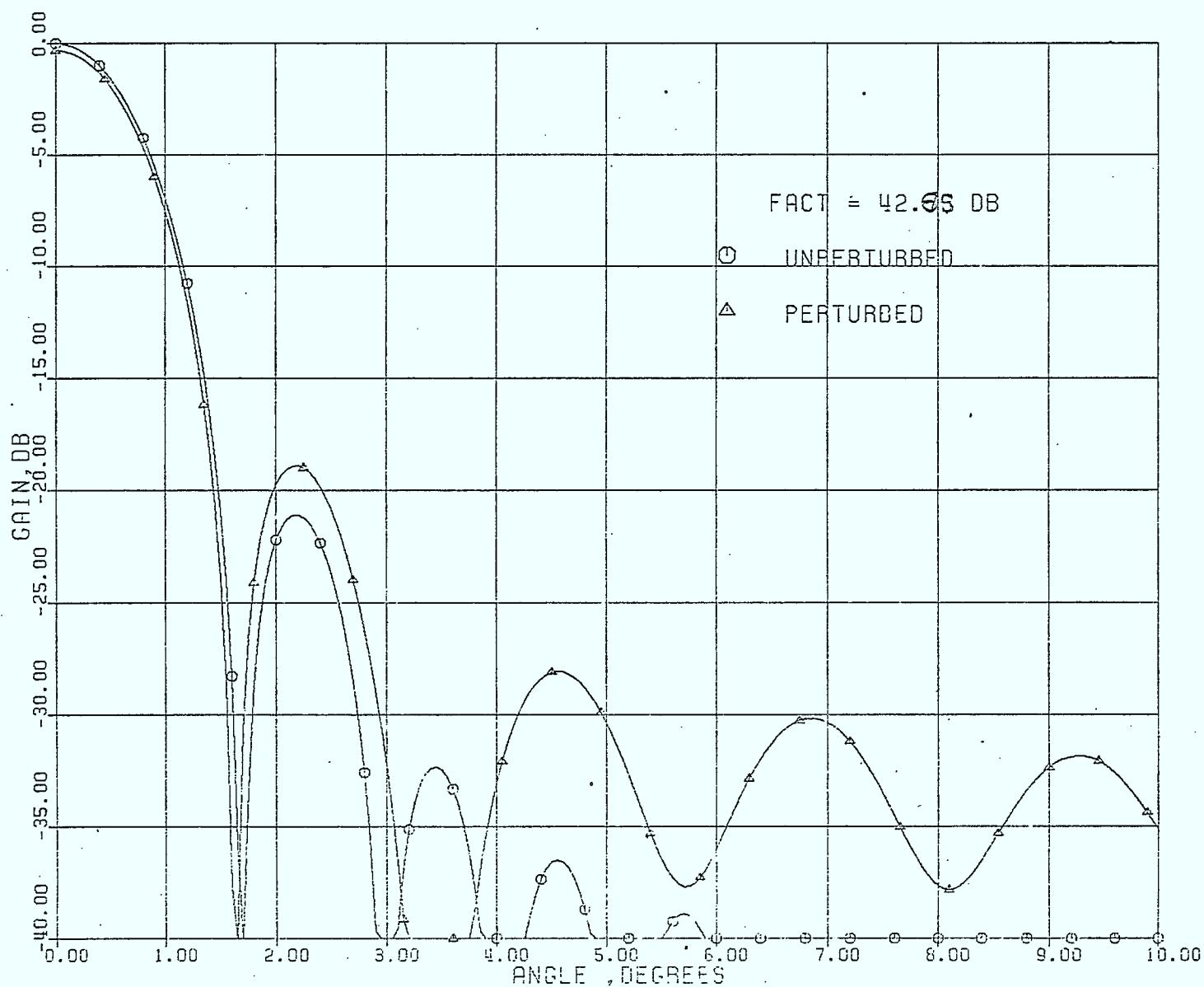
ANGLE	RAD.	PATTERN	RAD.	PATTERN
*****	*****	UNBLOCKED	*****	BLOCKED
0.00	0.51115E 01		0.47496E 01	
0.10	0.50395E 01		0.46844E 01	
0.20	0.48289E 01		0.44865E 01	
0.30	0.44946E 01		0.41704E 01	
0.40	0.40599E 01		0.37584E 01	
0.50	0.35542E 01		0.32788E 01	
0.60	0.30096E 01		0.27629E 01	
0.70	0.24586E 01		0.22419E 01	
0.80	0.19307E 01		0.17442E 01	
0.90	0.14500E 01		0.12933E 01	
1.00	0.10341E 01		0.90583E 00	
1.10	0.69300E 00		0.59132E 00	
1.20	0.42936E 00		0.35195E 00	
1.30	0.23929E 00		0.18359E 00	
1.40	0.11393E 00		0.77254E -01	
1.50	0.41189E -01		0.20816E -01	
1.60	0.76211E -02		0.86590E -03	
1.70	0.69453E -04		0.43424E -02	
1.80	0.69946E -02		0.19837E -01	
1.90	0.19326E -01		0.38438E -01	
2.00	0.30823E -01		0.54087E -01	
2.10	0.37998E -01		0.63501E -01	
2.20	0.39692E -01		0.65753E -01	
2.30	0.36446E -01		0.51640E -01	
2.40	0.29801E -01		0.22980E -01	
2.50	0.21645E -01		0.41956E -01	
2.60	0.13705E -01		0.30592E -01	
2.70	0.72224E -02		0.20419E -01	
2.80	0.28231E -02		0.12332E -01	
2.90	0.54889E -03		0.66077E -02	
3.00	0.67637E -05		0.30390E -02	
3.10	0.56896E -03		0.11353E -02	
3.20	0.15728E -02		0.31173E -03	
3.30	0.24764E -02		0.53169E -04	
3.40	0.29485E -02		0.61415E -05	
3.50	0.28867E -02		0.69553E -05	
3.60	0.23793E -02		0.52708E -04	
3.70	0.16299E -02		0.23713E -03	
3.80	0.87330E -03		0.67571E -03	
3.90	0.30278E -03		0.14419E -02	
4.00	0.24724E -04		0.25286E -02	
4.10	0.45862E -04		0.38410E -02	
4.20	0.28960E -03		0.52170E -02	
4.30	0.63160E -03		0.64652E -02	
4.40	0.94184E -03		0.74088E -02	
4.50	0.11211E -02		0.79236E -02	
4.60	0.11233E -02		0.79596E -02	
4.70	0.96027E -03		0.75453E -02	
4.80	0.68967E -03		0.67738E -02	
4.90	0.39316E -03		0.57777E -02	

ANGLE	RAD.	PATTERN	RAD.	PATTERN
*****	*****	UNBLOCKED	*****	BLOCKED
0.05	0.50934E 01		0.47341E 01	
0.15	0.49508E 01		0.46013E 01	
0.25	0.40759E 01		0.39747E 01	
0.35	0.42881E 01		0.35251E 01	
0.45	0.38140E 01		0.30234E 01	
0.55	0.32847E 01		0.25012E 01	
0.65	0.27330E 01		0.19882E 01	
0.75	0.21901E 01		0.15117E 01	
0.85	0.16831E 01		0.10908E 01	
0.95	0.12331E 00		0.73916E 00	
1.05	0.85386E 00		0.46237E 00	
1.15	0.55161E 00		0.25936E 00	
1.25	0.32558E 00		0.12338E 00	
1.35	0.16922E 00		0.43620E 01	-0.1
1.45	0.71809E -01		0.71210E 01	-0.1
1.55	0.20355E -01		0.43986E -01	-0.1
1.65	0.13648E -02		0.112910E -01	-0.1
1.75	0.23538E -02		0.29190E -01	-0.1
1.85	0.12942E -01		0.46898E -01	-0.4
1.95	0.25458E -01		0.59680E -01	-0.1
2.05	0.32071E -01		0.65505E -01	-0.1
2.15	0.39528E -01		0.57743E -01	-0.1
2.25	0.38605E -01		0.47629E -01	-0.1
2.35	0.33431E -01		0.36207E -01	-0.1
2.45	0.25795E -01		0.25285E -01	-0.1
2.55	0.17556E -01		0.91780E -02	-0.1
2.65	0.10228E -01		0.45805E -02	-0.2
2.75	0.47474E -02		0.19159E -02	-0.2
2.85	0.14369E -02		0.62367E -03	-0.3
2.95	0.97523E -04		0.13836E -04	-0.4
3.05	0.19294E -02		0.17783E -04	-0.4
3.15	0.10538E -02		0.12003E -04	-0.5
3.25	0.20633E -02		0.41847E -05	-0.5
3.35	0.27779E -02		0.10161E -04	-0.4
3.45	0.29825E -02		0.19492E -04	-0.4
3.55	0.26777E -02		0.45329E -04	-0.4
3.65	0.20199E -02		0.58690E -04	-0.2
3.75	0.12387E -02		0.41847E -05	-0.3
3.85	0.55579E -03		0.10161E -04	-0.4
3.95	0.12459E -03		0.19492E -04	-0.4
4.05	0.10817E -05		0.31655E -04	-0.2
4.15	0.14705E -03		0.45329E -04	-0.2
4.25	0.45680E -03		0.58690E -04	-0.2
4.35	0.79795E -03		0.69844E -04	-0.2
4.45	0.10521E -02		0.77248E -04	-0.2
4.55	0.11449E -02		0.80014E -02	-0.2
4.65	0.10597E -02		0.78042E -02	-0.2
4.75	0.83357E -03		0.71965E -02	-0.2
4.85	0.53935E -03		0.62948E -02	-0.2
4.95	0.26080E -03		0.52402E -02	-0.2

ANGLE	RAD.	PATTERN	RAD.	PATTERN
	UNBLOCKED		BLOCKED	
5.00	0.15041E-03		0.46990E-02	
5.10	0.17533E-04		0.36631E-02	
5.20	0.14367E-04		0.27602E-02	
5.30	0.12322E-03		0.20386E-02	
5.40	0.29783E-03		0.15091E-02	
5.50	0.47889E-03		0.11562E-02	
5.60	0.61152E-03		0.95295E-03	
5.70	0.65951E-03		0.87414E-03	
5.80	0.61329E-03		0.90437E-03	
5.90	0.48986E-03		0.10399E-02	
6.00	0.32575E-03		0.12845E-02	
6.10	0.16545E-03		0.16410E-02	
6.20	0.48774E-04		0.21033E-02	
6.30	0.72265E-05		0.26489E-02	
6.40	0.26048E-04		0.32380E-02	
6.50	0.10970E-03		0.38157E-02	
6.60	0.22245E-03		0.43208E-02	
6.70	0.32976E-03		0.46954E-02	
6.80	0.40128E-03		0.48957E-02	
6.90	0.41855E-03		0.48996E-02	
7.00	0.37889E-03		0.47101E-02	
7.10	0.29492E-03		0.43543E-02	
7.20	0.19010E-03		0.38774E-02	
7.30	0.91750E-04		0.33341E-02	
7.40	0.23633E-04		0.27789E-02	
7.50	0.66505E-09		0.22588E-02	
7.60	0.22530E-04		0.18068E-02	
7.70	0.80774E-04		0.14416E-02	
7.80	0.15574E-03		0.11683E-02	
7.90	0.22537E-03		0.98309E-03	
8.00	0.27055E-03		0.87789E-03	
8.10	0.27982E-03		0.84498E-03	
8.20	0.25186E-03		0.87950E-03	
8.30	0.19516E-03		0.97975E-03	
8.40	0.12519E-03		0.11454E-02	
8.50	0.59930E-04		0.13743E-02	
8.60	0.15049E-04		0.16595E-02	
8.70	0.15867E-07		0.19863E-02	
8.80	0.16024E-04		0.23322E-02	
8.90	0.56194E-04		0.26684E-02	
9.00	0.10784E-03		0.29633E-02	
9.10	0.15612E-03		0.31870E-02	
9.20	0.18793E-03		0.33162E-02	
9.30	0.19524E-03		0.33381E-02	
9.40	0.17683E-03		0.32519E-02	
9.50	0.13819E-03		0.30692E-02	
9.60	0.89749E-04		0.28112E-02	
9.70	0.43890E-04		0.25054E-02	
9.80	0.11658E-04		0.21808E-02	
9.90	0.41873E-08		0.18638E-02	

ANGLE	RAD.	PATTERN	RAD.	PATTERN
	UNBLOCKED		BLOCKED	
5.05	0.68078E-04		0.41691E-02	
5.15	0.22163E-07		0.31910E-02	
5.25	0.57175E-04		0.23753E-02	
5.35	0.20592E-03		0.17503E-02	
5.45	0.39128E-03		0.13421E-02	
5.55	0.59409E-03		0.10376E-02	
5.65	0.64735E-03		0.89924E-03	
5.75	0.64768E-03		0.87611E-03	
5.85	0.55928E-03		0.95885E-03	
5.95	0.41014E-03		0.11488E-02	
6.05	0.24239E-03		0.14448E-02	
6.15	0.99655E-04		0.18599E-02	
6.25	0.15377E-04		0.23678E-02	
6.35	0.47333E-05		0.29412E-02	
6.45	0.62168E-04		0.35320E-02	
6.55	0.16459E-03		0.40811E-02	
6.65	0.27889E-03		0.45276E-02	
6.75	0.37150E-03		0.49226E-02	
6.85	0.41725E-03		0.48278E-02	
6.95	0.40537E-03		0.45505E-02	
7.05	0.34116E-03		0.41277E-02	
7.15	0.24341E-03		0.36109E-02	
7.25	0.13847E-03		0.30548E-02	
7.35	0.52748E-04		0.29121E-02	
7.45	0.58461E-05		0.20228E-02	
7.55	0.58923E-05		0.16128E-02	
7.65	0.48232E-04		0.12936E-02	
7.75	0.17544E-03		0.10652E-02	
7.85	0.19259E-03		0.92101E-03	
7.95	0.25190E-03		0.85278E-03	
8.05	0.28001E-03		0.85398E-03	
8.15	0.27017E-03		0.92143E-03	
8.25	0.22625E-03		0.10544E-02	
8.35	0.16072E-03		0.12522E-02	
8.45	0.90888E-04		0.15106E-02	
8.55	0.34171E-04		0.18189E-02	
8.65	0.35237E-05		0.21585E-02	
8.75	0.43978E-05		0.25032E-02	
8.85	0.33781E-04		0.28230E-02	
8.95	0.81509E-04		0.30857E-02	
9.05	0.13330E-03		0.32649E-02	
9.15	0.17473E-03		0.33409E-02	
9.25	0.19489E-03		0.33080E-02	
9.35	0.18905E-03		0.31715E-02	
9.45	0.15947E-03		0.29480E-02	
9.55	0.11443E-03		0.26625E-02	
9.65	0.65740E-04		0.23437E-02	
9.75	0.25513E-04		0.20198E-02	
9.85	0.30368E-05		0.17151E-02	
9.95	0.25340E-05			

CORE USAGE OBJECT CODE= 31152 BYTES, ARRAY AREA= 30088 BYTES, TC
DIAGNOSTICS NUMBER OF ERRORS= 0, NUMBER OF WARNINGS= 0
COMPILE TIME= 0.77 SEC, EXECUTION TIME= 47.96 SEC, WATFIV - JUL 1



FRONT-FED PARABOLOID

INPUT DATA

POLYNOMIAL COEFFICIENTS ARE:
COEFFICIENT(1) = 0.9694200000
COEFFICIENT(2) = 0.02549800001
COEFFICIENT(3) = -0.30642224001
COEFFICIENT(4) = 0.18232000004
ROT = 90.00 DEGREES
EPSI = 07.50 DEGREES
DIAM = 48.00 LAMBDA
R1 = 0.2900 D/2 RATIO
R2 = 0.0938 D/2 RATIO
RC = 0.1490 D/2 RATIO
W = 0.0496 D/2 RATIO
R12 = 0.0335240 D/2 RATIO
RC2 = 0.0468750 D/2 RATIO
W1 = 0.039003 D/2 RATIO
W2 = 0.039009 D/2 RATIO

OUTPUT DATA

APERTURE EFFICIENCY = 90.00	%
BLOCKED EFFICIENCY = 84.24	%
APEKTURE GAIN IN DBS = 43.14	DBS
LOSS DUE TO BLOCKAGE = 7.68	%
LOSS DUE TO BLOCKAGE = 0.32	DBS

ANGLE	RAD.	PATTERN	RAD.	PATTERN	ANGLE	RAD.	PATTERN	RAD.	PATTERN
	UNBLOCKED	BLOCKED		UNBLOCKED		UNBLOCKED	BLOCKED		UNBLOCKED
***	***	***	***	***	***	***	***	***	***
2.0L	U.15044E-03	U.14833E-02	5.0L	U.08078E-04	U.16774E-02				
5.0L	U.47533E-04	U.13926E-02	5.15	U.22163E-07	U.11393E-02				
5.2L	U.14367E-04	U.90942E-03	5.20	U.57172E-04	U.71090E-03				
5.3L	U.12322E-03	U.52787E-03	5.35	U.20592E-03	U.43052E-03				
5.4L	U.29783E-03	U.33214E-03	5.45	U.39128E-03	U.23898E-03				
5.5L	U.47889E-03	U.26704E-03	5.50	U.59409E-03	U.17217E-03				
5.6L	U.01152E-03	U.15082E-03	5.65	U.64735E-03	U.43995E-03				
5.7L	U.65951E-03	U.13744E-03	5.75	U.04708E-03	U.17232E-03				
5.8L	U.04324E-03	U.9344E-03	5.85	U.5928E-03	U.43821E-03				
5.9L	U.48980E-03	U.20002E-03	5.95	U.41044E-03	U.33821E-03				
6.0L	U.32572E-03	U.28084E-03	6.00	U.24239E-03	U.35380E-03				
6.1L	U.16545E-03	U.43400E-03	6.15	U.94605E-04	U.32121E-03				
6.2L	U.48774L-04	U.54048E-03	6.20	U.13777E-04	U.77085E-03				
6.3L	U.72265E-03	U.92441E-03	6.30	U.47333E-03	U.67735E-03				
6.4L	U.20040E-03	U.14409E-02	6.40	U.02108E-04	U.14077E-02				
6.5L	U.10970E-03	U.12727E-02	6.50	U.40409E-03	U.47000E-02				
6.6L	U.22249E-03	U.20702E-02	6.60	U.27809E-03	U.20043E-02				
6.7L	U.32970E-03	U.21105E-02	6.70	U.37150E-03	U.21940E-02				
6.8L	U.41208E-03	U.22433E-02	6.80	U.41722E-03	U.22649E-02				
6.9L	U.41855E-03	U.24564E-02	6.90	U.40523E-03	U.22473E-02				
7.0L	U.37889E-03	U.21502E-02	7.00	U.34110E-03	U.20570E-02				
7.1L	U.29492E-03	U.19432E-02	7.10	U.24341E-03	U.18111E-02				
7.2L	U.19010E-03	U.16001E-02	7.20	U.13847E-03	U.19129E-02				
7.3L	U.91750E-04	U.13502E-02	7.30	U.52748E-04	U.42014E-02				
7.4L	U.23033E-04	U.15509E-02	7.40	U.84010E-04	U.90946E-02				
7.5L	U.60569E-03	U.77875E-03	7.50	U.28923E-04	U.60146E-03				
7.6L	U.22530E-03	U.58448E-03	7.60	U.40232E-04	U.47023E-03				
7.7L	U.87774E-04	U.39057E-03	7.70	U.13874E-03	U.33671E-03				
7.8L	U.15574E-03	U.28957E-03	7.80	U.19255E-03	U.23382E-03				
7.9L	U.22537E-03	U.28040E-03	7.90	U.29190E-03	U.210085E-03				
8.0L	U.27050E-03	U.20103E-03	8.00	U.28001E-03	U.19761E-03				
8.1L	U.27982E-03	U.14992E-03	8.10	U.27047E-03	U.20771E-03				
8.2L	U.25180E-03	U.22087E-03	8.20	U.24621E-03	U.23960E-03				
8.3L	U.19510L-03	U.26454E-03	8.30	U.10072E-03	U.24603E-03				
8.4L	U.12219E-03	U.33409E-03	8.40	U.90888E-04	U.38092E-03				
8.5L	U.59930E-04	U.43492E-03	8.50	U.34171E-04	U.49669E-03				
8.6L	U.15049E-04	U.56568E-03	8.60	U.3227E-05	U.54492E-03				
8.7L	U.19867E-07	U.72455E-03	8.70	U.43978E-05	U.80537E-03				
8.8L	U.16024E-04	U.89059E-03	8.80	U.30781E-04	U.97481E-03				
8.9L	U.26194E-04	U.11556E-02	8.90	U.81909E-04	U.11303E-02				
9.0L	U.10784E-03	U.11964E-02	9.00	U.13330E-03	U.12517E-02				
9.1L	U.15612E-03	U.12944E-02	9.10	U.17473E-03	U.13220E-02				
9.2L	U.18793E-03	U.13345E-02	9.20	U.19489E-03	U.13304E-02				
9.3L	U.19524E-03	U.13403E-02	9.30	U.18905E-03	U.12748E-02				
9.4L	U.17683E-03	U.12448E-02	9.40	U.10947E-03	U.11621E-02				
9.5L	U.13819E-03	U.11887E-02	9.50	U.14443E-03	U.10009E-02				
9.6L	U.89749E-04	U.91936E-03	9.60	U.60740E-04	U.82806E-03				
9.7L	U.43890E-04	U.73705E-03	9.70	U.22243E-04	U.64722E-03				
9.8L	U.11058E-04	U.56123E-03	9.80	U.30368E-03	U.48072E-03				
9.9L	U.41873E-08	U.40718E-03	9.90	U.20340E-03	U.34148E-03				

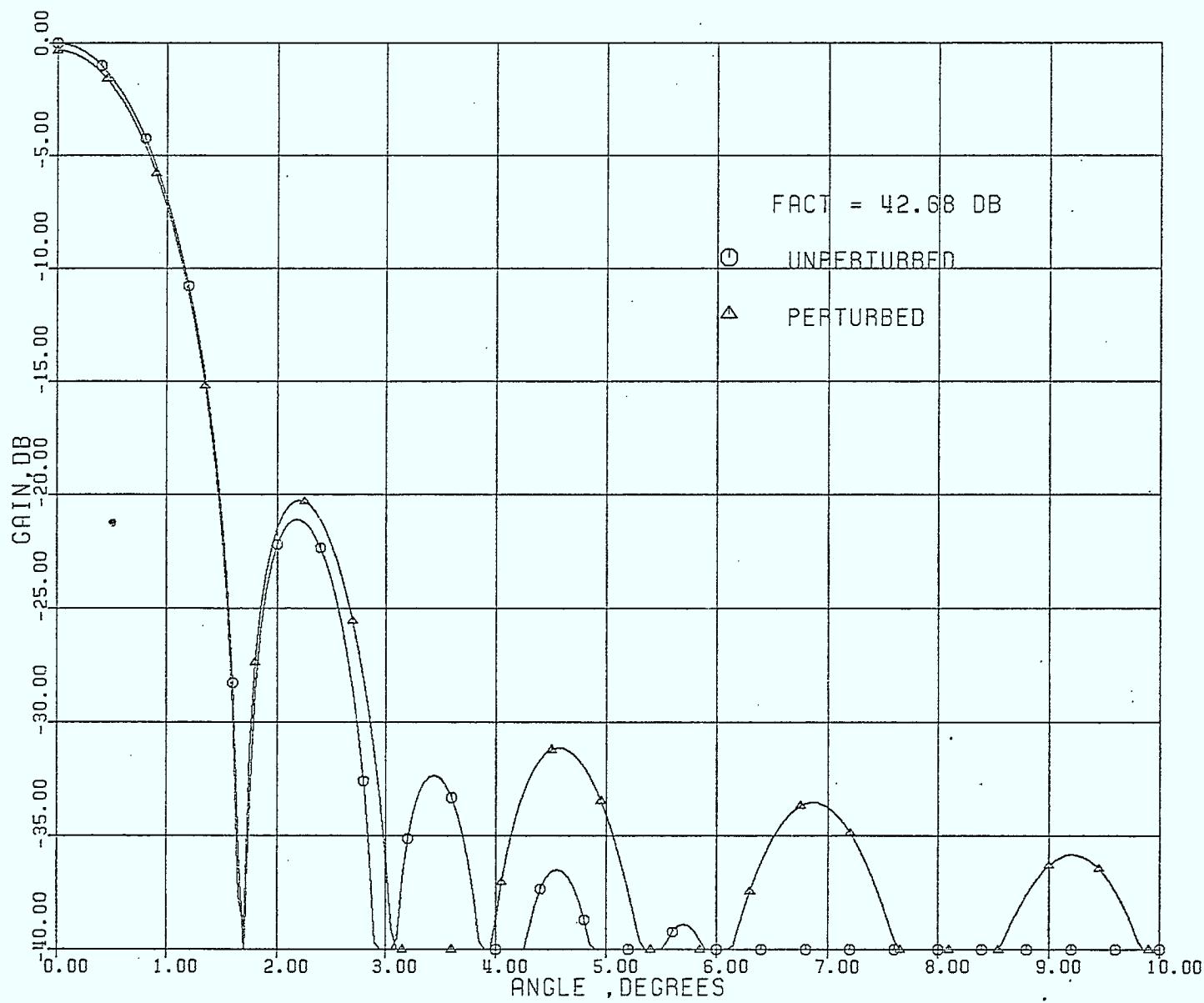
CORE USAGE OBJECT CODE= 30152 BYTES, ARRAY AREA= 30088 BYTES, TO

DIAGNOSTICS NUMBER OF ERRORS= 0, NUMBER OF WARNINGS= .

COMPILE TIME= 0.79 SEC, EXECUTION TIME= 48.47 SEC, WATFIV - JUL 1

ANGLE RAD.	PATTERN	RAD.	PATTERN
0.00	U.51112E+01	U.47496E+01	
0.10	U.505092E+01	U.40832E+01	
0.20	U.48284E+01	U.4482E+01	
0.30	U.44940E+01	U.37760E+01	
0.40	U.41599E+01	U.33071E+01	
0.50	U.35542E+01	U.30090E+01	
0.60	U.30090E+01	U.2818E+01	
0.70	U.24586E+01	U.22699E+01	
0.80	U.19307E+01	U.17488E+01	
0.90	U.14500E+01	U.1341E+01	
1.00	U.69300E+00	U.54448E+00	
1.10	U.42930E+00	U.39790E+00	
1.20	U.20429E+00	U.2224E+00	
1.30	U.11393E+00	U.1324E+00	
1.40	U.41289E+00	U.35924E+00	
1.50	U.70211E+00	U.58619E+00	
1.60	U.09455E+00	U.54512E+00	
1.70	U.69940E+00	U.43770E+00	
1.80	U.93205E+00	U.23553E+00	
1.90	U.30820E+00	U.30450E+00	
2.00	U.37990E+00	U.42904E+00	
2.10	U.34692E+00	U.45804E+00	
2.20	U.30440E+00	U.29801E+00	
2.30	U.29801E+00	U.24640E+00	
2.40	U.15700E+00	U.72224E+00	
2.50	U.67637E+00	U.28231E+00	
2.60	U.20890E+00	U.54889E+00	
2.70	U.12728E+00	U.24764E+00	
2.80	U.24764E+00	U.24482E+00	
2.90	U.28867E+00	U.23795E+00	
3.00	U.23795E+00	U.10299E+00	
3.10	U.87330E+00	U.80278E+00	
3.20	U.30278E+00	U.24724E+00	
3.30	U.45862E+00	U.28460E+00	
3.40	U.63164E+00	U.94184E+00	
3.50	U.14211E+00	U.94184E+00	
3.60	U.12233E+00	U.96027E+00	
3.70	U.96027E+00	U.08967E+00	
3.80	U.08967E+00	U.39310E+00	

ANGLE RAD.	PATTERN	RAD.	PATTERN
0.05	U.50434E+01	U.47329E+01	
0.15	U.44950E+01	U.40500E+01	
0.25	U.40754E+01	U.39874E+01	
0.35	U.42881E+01	U.35480E+01	
0.45	U.38145E+01	U.36574E+01	
0.55	U.32847E+01	U.25449E+01	
0.65	U.27330E+01	U.20402E+01	
0.75	U.21903E+01	U.14882E+01	
0.85	U.16831E+01	U.11488E+01	
0.95	U.12386E+01	U.79478E+00	
1.05	U.92160E+01	U.51229E+00	
1.15	U.32558E+00	U.30090E+00	
1.25	U.10924E+00	U.2478E+00	
1.35	U.71809E+00	U.17048E+00	
1.45	U.20355E+00	U.87158E+00	
1.55	U.13048E+00	U.38733E+00	
1.65	U.23338E+00	U.16124E+00	
1.75	U.12942E+00	U.30297E+00	
1.85	U.23428E+00	U.41507E+00	
1.95	U.30074E+00	U.47420E+00	
2.05	U.39520E+00	U.47634E+00	
2.15	U.33431E+00	U.55470E+00	
2.25	U.25795E+00	U.20584E+00	
2.35	U.17500E+00	U.18013E+00	
2.45	U.12020E+00	U.10843E+00	
2.55	U.47474E+00	U.22999E+00	
2.65	U.14509E+00	U.30010E+00	
2.75	U.97223E+00	U.62964E+00	
2.85	U.19254E+00	U.60189E+00	
2.95	U.10938E+00	U.74828E+00	
3.05	U.27779E+00	U.25830E+00	
3.15	U.29820E+00	U.30407E+00	
3.25	U.20777E+00	U.32024E+00	
3.35	U.12387E+00	U.18375E+00	
3.45	U.59579E+00	U.82170E+00	
3.55	U.12450E+00	U.14460E+00	
3.65	U.10817E+00	U.42105E+00	
3.75	U.44700E+00	U.17397E+00	
3.85	U.79792E+00	U.32327E+00	
3.95	U.10521E+00	U.37286E+00	
4.05	U.14449E+00	U.39387E+00	
4.15	U.10597E+00	U.38442E+00	
4.25	U.83557E+00	U.34833E+00	
4.35	U.53933E+00	U.29360E+00	
4.45	U.26236E+00	U.23021E+00	



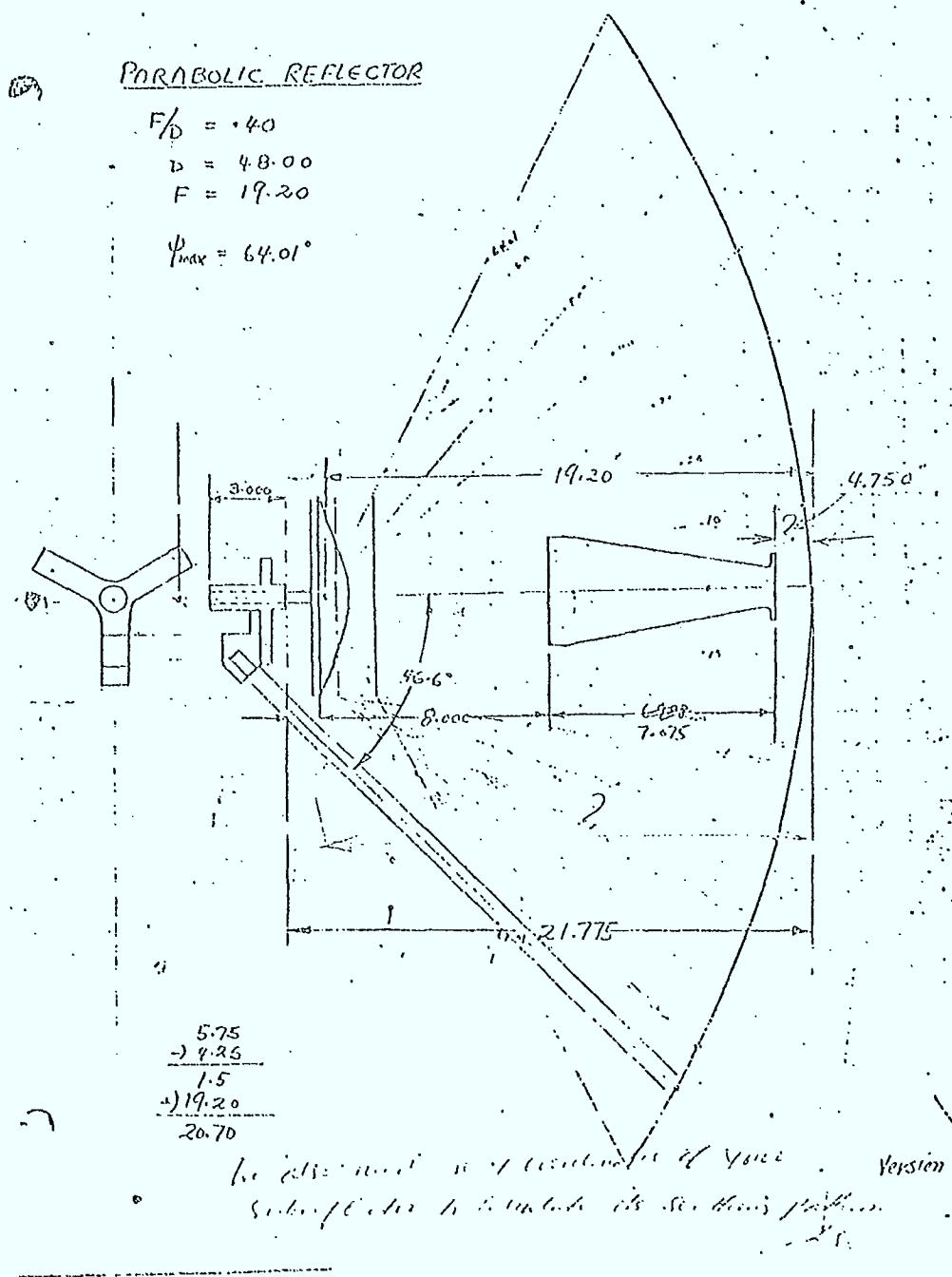
PARABOLIC REFLECTOR

$$F/D = .40$$

$$D = 48.00$$

$$F = 19.20$$

$$\psi_{\max} = 64.01^\circ$$



No adjustment of orientation of your version:
subject to a suitable site selection problem.

SHAPED SUBREFLECTOR WITH PARABOLOID MAIN-REFLECTOR

SUBREFLECTOR DIAMETER	= 8.000000
FOCAL LENGTH OF MAIN-REFLECTOR	= 19.200000
MAIN-REFLECTOR DIAMETER	= 48.000000
DISTANCE OF PHASE CENTRE	= 10.825000
DISTANCE OF SUBREFLECTOR VERTEX	= 18.616000
FEED POWER PATTERN	= 1.000000 COS(TH)** 29.925720

RAYS FOR INCIDENCE ANGLE GREATER THAN 0.346443 ARE GOING IN THE BACK LOBE DIRECTION
SPILL OVER LOSS = -0.734124 DB

LEAST SQUARE CURVE FITTING FOR APERTURE FIELD AS A FUNCTION OF APERTURE POINT

0 ORDER COEFFICIENT =	0.191221
1 ORDER COEFFICIENT =	3.135106
2 ORDER COEFFICIENT =	-15.080159
3 ORDER COEFFICIENT =	29.316938
4 ORDER COEFFICIENT =	-12.683862
5 ORDER COEFFICIENT =	-0.759322
ERROR IN LEAST SQUARE FIT =	16.001545

CASSEGRAIN ANTENNA SYSTEM

INPUT DATA

POLYNOMIAL COEFFICIENTS ARE:
COEFFICIENT(1) = 0.1912210E 00
COEFFICIENT(2) = 0.3135106E 01
COEFFICIENT(3) = -C.1508016E 02
COEFFICIENT(4) = 0.2531694E 02
COEFFICIENT(5) = -C.1268386E 02
COEFFICIENT(6) = -C.7593220E 00
ROT = 0.00 DEGREES
EPSI = 64.00 DEGREES
DIAM = 48.00 LAMDA
R1 = 1.0000 D/2 RATIO
R2 = 0.1557 D/2 RATIO
RC = C.1557 D/2 RATIO
W = 0.0200 D/2 RATIO

OUTPUT DATA

APERTURE EFFICIENCY = 94.84 %
BLOCKED EFFICIENCY = 86.15 %
APERTURE GAIN IN DBS = 43.34 DBS
LOSS DUE TO BLOCKAGE = 9.16 %
LOSS DUE TO BLOCKAGE = 0.42 DBS

ANGLE	RAD. PATTERN UNBLOCKED	RAD. PATTERN BLOCKED
*** ***	*** ***	*** ***
0.00	0.15631E+01	0.14199E+01
0.10	0.15345E+01	0.13962E+01
0.20	0.14514E+01	0.13218E+01
0.30	0.13211E+01	0.12333E+01
0.40	0.11547E+01	0.10511E+01
0.50	0.96626E+00	0.87810E+00
0.60	0.77035E+00	0.59799E+00
0.70	0.58106E+00	0.52394E+00
0.80	0.41027E+00	0.36715E+00
0.90	0.26664E+00	0.23574E+00
1.00	0.15498E+00	0.13427E+00
1.10	0.76220E-01	0.53611E-01
1.20	0.27850E-01	0.21377E-01
1.30	0.47486E-02	0.26864E-02
1.40	0.24308E-03	0.11833E-02
1.50	0.72280E-02	0.10086E-01
1.60	0.19173E-01	0.23159E-01
1.70	0.30859E-01	0.35420E-01
1.80	0.38842E-01	0.43597E-01
1.90	0.41515E-01	0.46194E-01
2.00	0.38911E-01	0.43305E-01
2.10	0.32263E-01	0.36201E-01
2.20	0.23459E-01	0.26800E-01
2.30	0.14502E-01	0.17138E-01
2.40	0.70534E-02	0.89269E-02
2.50	0.21507E-02	0.32653E-02
2.60	0.98987E-04	0.51997E-03
2.70	0.53929E-03	0.39130E-03
2.80	0.26449E-02	0.20933E-02
2.90	0.53844E-02	0.46094E-02
3.00	0.77860E-02	0.69576E-02
3.10	0.91471E-02	0.84002E-02
3.20	0.91534E-02	0.85723E-02
3.30	0.78927E-02	0.75071E-02
3.40	0.57775E-02	0.55593E-02
3.50	0.34032E-02	0.33227E-02
3.60	0.13827E-02	0.13695E-02
3.70	0.19702E-03	0.20112E-03
3.80	0.92134E-04	0.89676E-04
3.90	0.10413E-02	0.10423E-02
4.00	0.27731E-02	0.28192E-02
4.10	0.48530E-02	0.50063E-02
4.20	0.67937E-02	0.71202E-02
4.30	0.81682E-02	0.87184E-02
4.40	0.86992E-02	0.94922E-02
4.50	0.83077E-02	0.93207E-02
4.60	0.71141E-02	0.82813E-02
4.70	0.53953E-02	0.66152E-02
4.80	0.35122E-02	0.46624E-02
4.90	0.18254E-02	0.27817E-02

ANGLE	RAD. PATTERN UNBLOCKED	RAD. PATTERN BLOCKED
*** ***	*** ***	*** ***
0.05	0.15559E+01	0.14146E+01
0.15	0.14994E+01	0.13650E+01
0.25	0.13915E+01	0.12675E+01
0.35	0.12416E+01	0.11307E+01
0.45	0.10624E+01	0.96636E+00
0.55	0.86832E+00	0.78808E+00
0.65	0.67407E+00	0.60945E+00
0.75	0.49273E+00	0.44280E+00
0.85	0.33467E+00	0.29790E+00
0.95	0.20667E+00	0.18112E+00
1.05	0.11157E+00	0.95169E-01
1.15	0.48507E-01	0.39199E-01
1.25	0.13535E-01	0.94630E-02
1.35	0.61803E-03	0.21262E-03
1.45	0.27314E-02	0.47465E-02
1.55	0.12946E-01	0.16450E-01
1.65	0.25308E-01	0.29638E-01
1.75	0.35456E-01	0.40154E-01
1.85	0.40875E-01	0.45621E-01
1.95	0.40818E-01	0.45378E-01
2.05	0.35983E-01	0.40169E-01
2.15	0.28002E-01	0.31657E-01
2.25	0.18884E-01	0.21882E-01
2.35	0.10507E-01	0.12766E-01
2.45	0.42476E-02	0.57378E-02
2.55	0.77717E-03	0.15327E-02
2.65	0.51264E-04	0.16917E-03
2.75	0.14468E-02	0.10746E-02
2.85	0.40004E-02	0.33144E-02
2.95	0.66795E-02	0.58583E-02
3.05	0.86261E-02	0.78245E-02
3.15	0.93231E-02	0.86520E-02
3.25	0.86618E-02	0.81780E-02
3.35	0.69071E-02	0.66149E-02
3.45	0.45829E-02	0.44459E-02
3.55	0.23140E-02	0.22745E-02
3.65	0.66387E-03	0.66424E-03
3.75	0.47811E-05	0.65300E-05
3.85	0.44691E-03	0.44278E-03
3.95	0.18340E-02	0.18506E-02
4.05	0.38001E-02	0.38914E-02
4.15	0.58700E-02	0.61022E-02
4.25	0.75734E-02	0.80071E-02
4.35	0.85490E-02	0.92207E-02
4.45	0.86156E-02	0.95242E-02
4.55	0.77968E-02	0.88976E-02
4.65	0.62988E-02	0.75068E-02
4.75	0.44508E-02	0.56517E-02
4.85	0.26240E-02	0.36921E-02
4.95	0.11487E-02	0.19666E-02

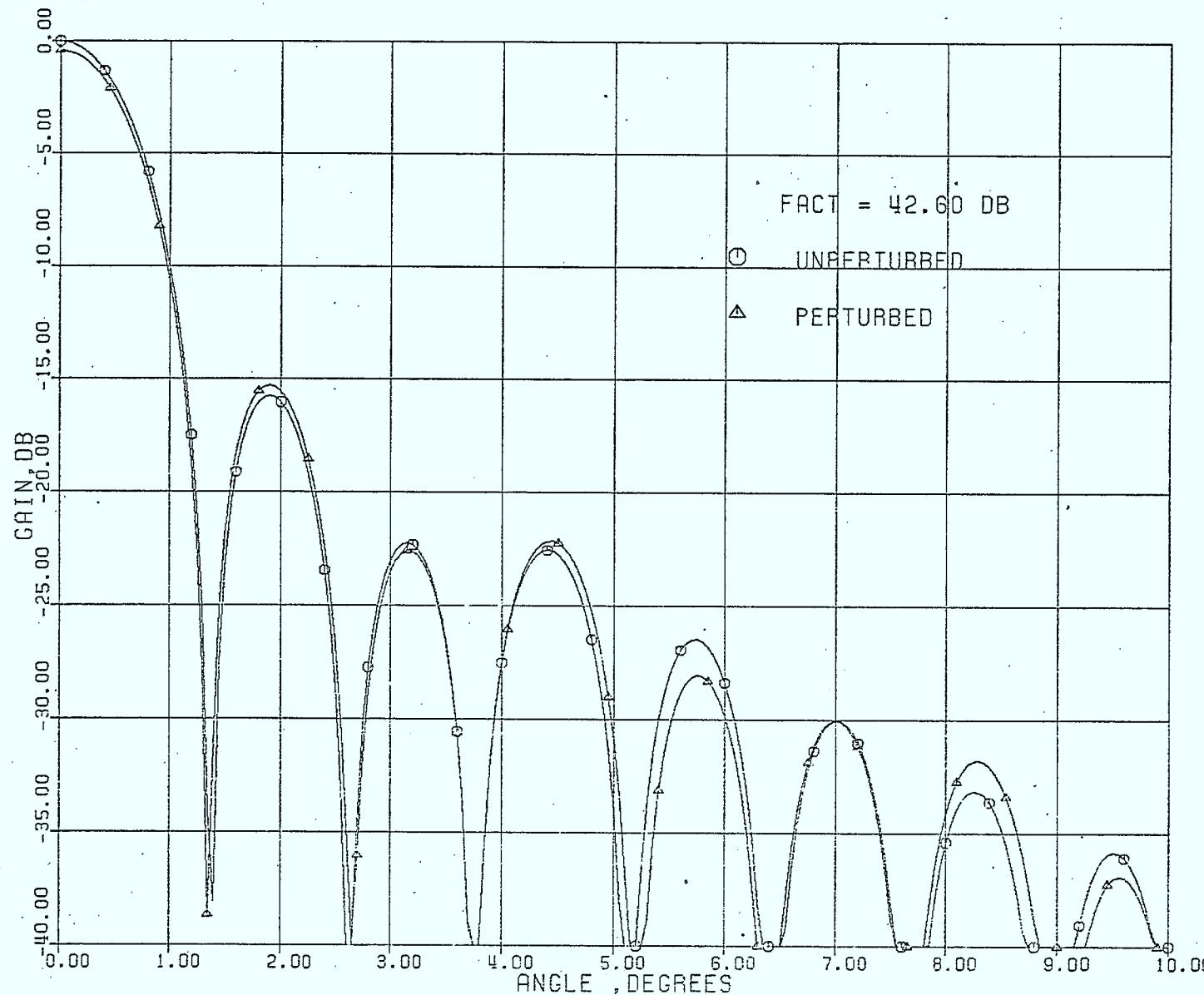
ANGLE	RAD.	PATTERN	RAD.	PATTERN
	UNBLOCKED		BLOCKED	
5.00	0.61825E-03		0.12748E-02	
5.10	0.45495E-04		0.33115E-03	
5.20	0.11267E-03		0.15020E-05	
5.30	0.69095E-03		0.20492E-03	
5.40	0.15591E-02		0.76273E-03	
5.50	0.24610E-02		0.14496E-02	
5.60	0.31648E-02		0.20491E-02	
5.70	0.35108E-02		0.23997E-02	
5.80	0.34378E-02		0.24247E-02	
5.90	0.29861E-02		0.21378E-02	
6.00	0.22768E-02		0.16291E-02	
6.10	0.14758E-02		0.10340E-02	
6.20	0.75224E-03		0.49634E-03	
6.30	0.23991E-03		0.13302E-03	
6.40	0.11283E-04		0.85458E-05	
6.50	0.67821E-04		0.12468E-03	
6.60	0.34737E-03		0.42647E-03	
6.70	0.74525E-03		0.81896E-03	
6.80	0.11425E-02		0.11944E-02	
6.90	0.14344E-02		0.14579E-02	
7.00	0.15533E-02		0.15491E-02	
7.10	0.14793E-02		0.14528E-02	
7.20	0.12404E-02		0.11991E-02	
7.30	0.90051E-03		0.85275E-03	
7.40	0.54057E-03		0.49509E-03	
7.50	0.23842E-03		0.20420E-03	
7.60	0.50592E-04		0.37072E-04	
7.70	0.14314E-05		0.18362E-04	
7.80	0.80641E-04		0.13740E-03	
7.90	0.24924E-03		0.35352E-03	
8.00	0.45160E-03		0.60770E-03	
8.10	0.63020E-03		0.83744E-03	
8.20	0.73934E-03		0.99085E-03	
8.30	0.75480E-03		0.10375E-02	
8.40	0.67732E-03		0.97267E-03	
8.50	0.53008E-03		0.81650E-03	
8.60	0.35086E-03		0.50645E-03	
8.70	0.18171E-03		0.38746E-03	
8.80	0.58403E-04		0.20107E-03	
8.90	0.25994E-05		0.76643E-04	
9.00	0.17849E-04		0.26107E-04	
9.10	0.90512E-04		0.43442E-04	
9.20	0.19459E-03		0.10828E-03	
9.30	0.29909E-03		0.19244E-03	
9.40	0.37595E-03		0.26748E-03	
9.50	0.40648E-03		0.31159E-03	
9.60	0.38504E-03		0.31394E-03	
9.70	0.31920E-03		0.27606E-03	
9.80	0.22675E-03		0.20995E-03	
9.90	0.13047E-03		0.13393E-03	

ANGLE	RAD.	PATTERN	RAD.	PATTERN
	UNBLOCKED		BLOCKED	
5.05	0.24875E-03		0.72608E-03	
5.15	0.43719E-05		0.91823E-04	
5.25	0.35021E-03		0.45999E-04	
5.35	0.11047E-02		0.45317E-03	
5.45	0.20215E-02		0.11044E-02	
5.55	0.28498E-02		0.17721E-02	
5.65	0.33888E-02		0.22625E-02	
5.75	0.35264E-02		0.24541E-02	
5.85	0.32533E-02		0.23161E-02	
5.95	0.26538E-02		0.19034E-02	
6.05	0.18768E-02		0.13331E-02	
6.15	0.10948E-02		0.74964E-03	
6.25	0.46352E-03		0.28744E-03	
6.35	0.88385E-04		0.39322E-04	
6.45	0.64898E-05		0.38874E-04	
6.55	0.18558E-03		0.25776E-03	
6.65	0.53897E-03		0.61811E-03	
6.75	0.95111E-03		0.10149E-02	
6.85	0.13069E-02		0.15271E-02	
6.95	0.15179E-02		0.15235E-02	
7.05	0.15397E-02		0.13422E-02	
7.15	0.13772E-02		0.10326E-02	
7.25	0.10782E-02		0.67018E-03	
7.35	0.71787E-03		0.33708E-03	
7.45	0.37808E-03		0.10279E-03	
7.55	0.12786E-03		0.90304E-05	
7.65	0.85463E-05		0.62612E-04	
7.75	0.26869E-04		0.23675E-03	
7.85	0.15702E-03		0.47986E-03	
7.95	0.34992E-03		0.72924E-03	
8.05	0.54713E-03		0.92617E-03	
8.15	0.62554E-03		0.10284E-02	
8.25	0.75931E-03		0.10183E-02	
8.35	0.72669E-03		0.90398E-03	
8.45	0.61030E-03		0.71546E-03	
8.55	0.44182E-03		0.49527E-03	
8.65	0.26252E-03		0.28798E-03	
8.75	0.11257E-03		0.12994E-03	
8.85	0.21410E-04		0.42117E-04	
8.95	0.18325E-05		0.27294E-04	
9.05	0.48420E-04		0.71595E-04	
9.15	0.14054E-03		0.14980E-03	
9.25	0.24869E-03		0.23268E-03	
9.35	0.34243E-03		0.29437E-03	
9.45	0.39768E-03		0.31817E-03	
9.55	0.40207E-03		0.29949E-03	
9.65	0.35674E-03		0.24548E-03	
9.75	0.27492E-03		0.17193E-03	
9.85	0.17763E-03		0.98325E-04	
9.95	0.87905E-04			

CORE USAGE OBJECT CODE= 35688 BYTES, ARRAY AREA= 30088 BYTES, TOT

DIAGNOSTICS NUMBER OF ERRORS= 0, NUMBER OF WARNINGS= 0

COMPILE TIME= 0.80 SEC, EXECUTION TIME= 5.84 SEC, WATFIV - JUL 19



CASSEGRAIN ANTENNA SYSTEM

INPUT DATA

POLYNOMIAL COEFFICIENTS ARE:
COEFFICIENT(1) = C.1912210E-00
COEFFICIENT(2) = C.3135106E-01
COEFFICIENT(3) = -0.1508016E-02
COEFFICIENT(4) = 0.2531694E-02
COEFFICIENT(5) = -0.1268386E-02
COEFFICIENT(6) = -0.7593220E-00
ROT = 0.00 DEGREES
EPSI = 64.00 DEGREES
DIAM = 48.00 LAMDA
R1 = 0.9000 D/2 RATIO
R2 = 0.1567 D/2 RATIO
RC = C.1567 D/2 RATIO
W = 0.0200 D/2 RATIO

OUTPUT DATA

APERTURE EFFICIENCY = 94.84 %
BLOCKED EFFICIENCY = 85.80 %
APEKTURE GAIN IN DBS = 43.34 DBS
LOSS DUE TO BLOCKAGE = 9.53 %
LOSS DUE TO BLOCKAGE = 0.43 DBS

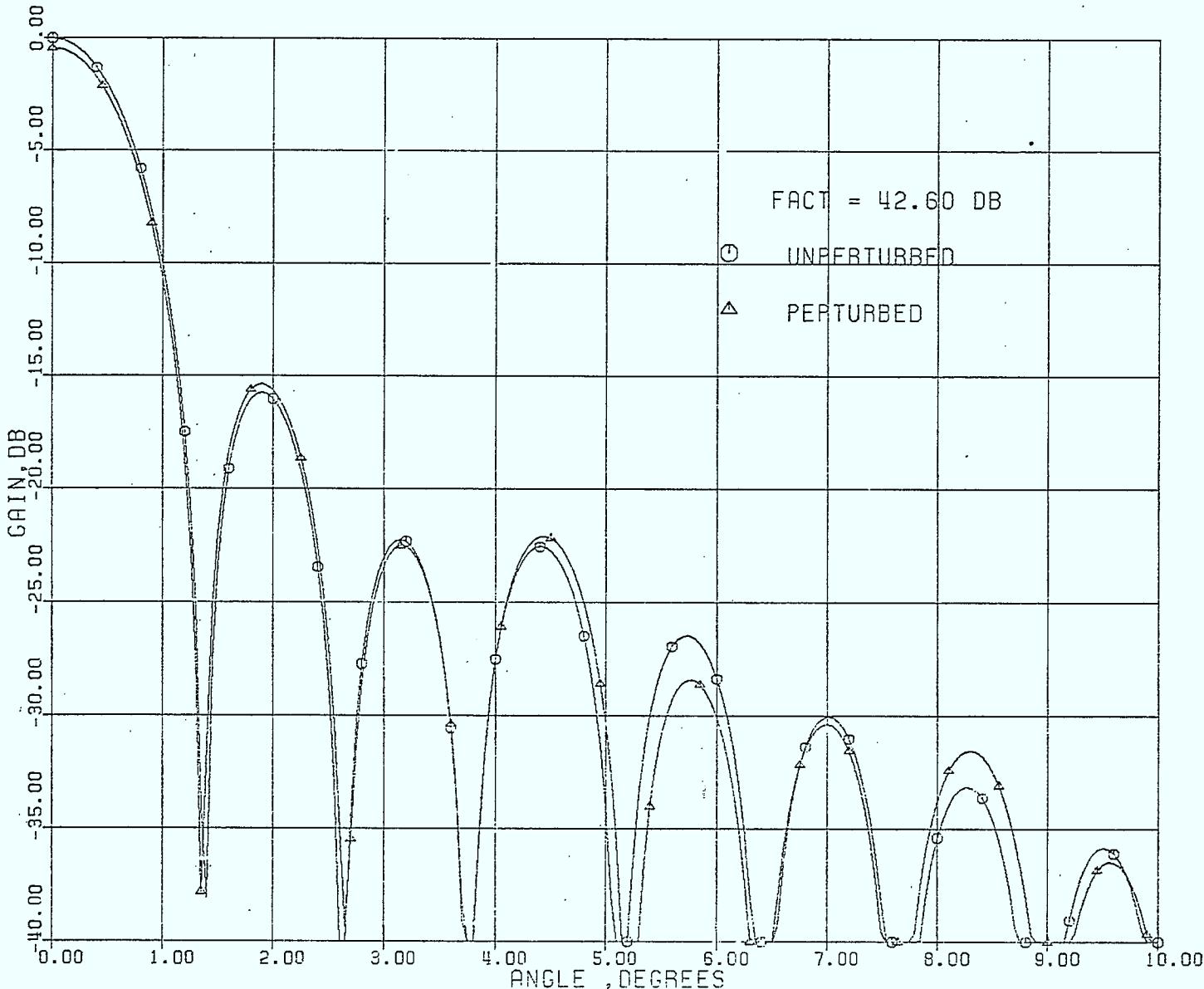
ANGLE	RAD.	PATTERN	RAD.	PATTERN
	UNBLOCKED		BLOCKED	
0.00	0.15631E+01		0.14141E+01	
0.10	0.15345E+01		0.13902E+01	
0.20	0.14514E+01		0.13156E+01	
0.30	0.13211E+01		0.11973E+01	
0.40	0.11547E+01		0.10497E+01	
0.50	0.95626E+00		0.87337E+00	
0.60	0.77035E+00		0.69414E+00	
0.70	0.58106E+00		0.52103E+00	
0.80	0.41027E+00		0.36514E+00	
0.90	0.26664E+00		0.23452E+00	
1.00	0.15498E+00		0.13367E+00	
1.10	0.76220E-01		0.53439E-01	
1.20	0.27850E-01		0.21423E-01	
1.30	0.47486E-02		0.27688E-02	
1.40	0.24308E-03		0.11633E-02	
1.50	0.72228E-03		0.98783E-02	
1.60	0.19173E-01		0.22734E-01	
1.70	0.30859E-01		0.34797E-01	
1.80	0.38842E-01		0.42831E-01	
1.90	0.41515E-01		0.45359E-01	
2.00	0.38911E-01		0.42482E-01	
2.10	0.32263E-01		0.35458E-01	
2.20	0.23459E-01		0.26186E-01	
2.30	0.14502E-01		0.16680E-01	
2.40	0.70534E-02		0.86289E-02	
2.50	0.21507E-02		0.31130E-02	
2.60	0.98987E-04		0.48579E-03	
2.70	0.53929E-03		0.44464E-03	
2.80	0.26444E-02		0.22224E-02	
2.90	0.53844E-02		0.47535E-02	
3.00	0.77860E-02		0.71160E-02	
3.10	0.91471E-02		0.85600E-02	
3.20	0.91534E-02		0.87252E-02	
3.30	0.78927E-02		0.76452E-02	
3.40	0.57775E-02		0.56885E-02	
3.50	0.34032E-02		0.34164E-02	
3.60	0.13827E-02		0.14333E-02	
3.70	0.19702E-03		0.23300E-03	
3.80	0.92134E-04		0.91961E-104	
3.90	0.10413E-02		0.10228E-02	
4.00	0.27731E-02		0.27910E-02	
4.10	0.48530E-02		0.49867E-02	
4.20	0.67937E-02		0.71276E-02	
4.30	0.81682E-02		0.87693E-02	
4.40	0.86992E-02		0.95969E-02	
4.50	0.83077E-02		0.94812E-02	
4.60	0.71141E-02		0.84891E-02	
4.70	0.53953E-02		0.58927E-02	
4.80	0.35122E-02		0.49044E-02	
4.90	0.18254E-02		0.30000E-02	

ANGLE	RAD.	PATTERN	RAD.	PATTERN
	UNBLOCKED		BLOCKED	
0.05	0.15559E+01		0.14086E+01	
0.15	0.14994E+01		0.13588E+01	
0.25	0.13915E+01		0.12613E+01	
0.35	0.12416E+01		0.11249E+01	
0.45	0.10624E+01		0.96125E+00	
0.55	0.86832E+00		0.78377E+00	
0.65	0.67407E+00		0.60606E+00	
0.75	0.49273E+00		0.44035E+00	
0.85	0.33467E+00		0.29639E+00	
0.95	0.20667E+00		0.18024E+00	
1.05	0.11157E+00		0.94812E-01	
1.15	0.48507E-01		0.39160E-01	
1.25	0.13535E-01		0.95472E-02	
1.35	0.61803E-03		0.25802E-03	
1.45	0.27314E-02		0.46399E-02	
1.55	0.12946E-02		0.16134E-02	
1.65	0.25308E-01		0.29150E-01	
1.75	0.35456E-01		0.39450E-01	
1.85	0.40875E-01		0.44810E-01	
1.95	0.40818E-01		0.39378E-01	
2.05	0.35983E-01		0.30974E-01	
2.15	0.28002E-01		0.21345E-01	
2.25	0.18884E-01		0.12389E-01	
2.35	0.10507E-01		0.55158E-02	
2.45	0.42476E-02		0.14431E-02	
2.55	0.77717E-03		0.18260E-03	
2.65	0.51264E-04		0.11603E-02	
2.75	0.14468E-02		0.34474E-02	
2.85	0.40004E-02		0.60114E-02	
2.95	0.66795E-02		0.79848E-02	
3.05	0.86261E-02		0.88092E-02	
3.15	0.93231E-02		0.83246E-02	
3.25	0.86618E-02		0.67446E-02	
3.35	0.69071E-03		0.45530E-02	
3.45	0.45829E-02		0.23537E-02	
3.55	0.23140E-02		0.71208E-03	
3.65	0.66387E-03		0.22993E-04	
3.75	0.47811E-05		0.43283E-03	
3.85	0.44691E-03		0.18249E-02	
3.95	0.18340E-02		0.38651E-02	
4.05	0.38001E-02		0.60939E-02	
4.15	0.58700E-02		0.80345E-02	
4.25	0.75734E-02		0.92976E-02	
4.35	0.85490E-02		0.96572E-02	
4.45	0.86156E-02		0.90835E-02	
4.55	0.77968E-02		0.77322E-02	
4.65	0.62988E-02		0.58949E-02	
4.75	0.44508E-02		0.39258E-02	
4.85	0.26240E-02		0.21627E-02	
4.95	0.11487E-02			

ANGLE	RAD.	PATTERN	RAD.	PATTERN
	UNBLOCKED		BLOCKED	
5.00	0.61825E-03	0.14425E-02		
5.10	0.45495E-04	0.42732E-03		
5.20	0.11267E-03	0.14856E-04		
5.30	0.69095E-03	0.13561E-03		
5.40	0.15591E-02	0.62216E-03		
5.50	0.24610E-02	0.12583E-02		
5.60	0.31648E-02	0.18328E-02		
5.70	0.35108E-02	0.21854E-02		
5.80	0.34378E-02	0.22355E-02		
5.90	0.29861E-02	0.19900E-02		
6.00	0.22768E-02	0.15299E-02		
6.10	0.14758E-02	0.98135E-03		
6.20	0.75224E-03	0.48036E-03		
6.30	0.23991E-03	0.13855E-03		
6.40	0.11283E-04	0.18641E-04		
6.50	0.67821E-04	0.12405E-03		
6.60	0.34737E-03	0.40352E-03		
6.70	0.74525E-03	0.76837E-03		
6.80	0.11425E-02	0.11168E-02		
6.90	0.14344E-02	0.13593E-02		
7.00	0.15533E-02	0.14399E-02		
7.10	0.14793E-02	0.13423E-02		
7.20	0.12404E-02	0.1C988E-02		
7.30	0.90051E-03	0.77104E-03		
7.40	0.54057E-03	0.43725E-03		
7.50	0.23842E-03	0.17215E-03		
7.60	0.50592E-04	0.29776E-04		
7.70	0.14314E-05	0.32696E-04		
7.80	0.80641E-04	0.16912E-03		
7.90	0.24924E-03	0.39815E-03		
8.00	0.45160E-03	0.66118E-03		
8.10	0.63020E-03	0.39641E-03		
8.20	0.73934E-03	0.10527E-02		
8.30	0.75480E-03	0.10999E-02		
8.40	0.67732E-03	0.10339E-02		
8.50	0.53008E-03	0.87467E-03		
8.60	0.35086E-03	0.65983E-03		
8.70	0.18171E-03	0.43460E-03		
8.80	0.58403E-04	0.24107E-03		
8.90	0.25994E-05	0.10949E-03		
9.00	0.17849E-04	0.52810E-04		
9.10	0.90512E-04	0.65990E-04		
9.20	0.19459E-03	0.12937E-03		
9.30	0.29909E-03	0.21493E-03		
9.40	0.37595E-03	0.29381E-03		
9.50	0.40648E-03	0.34312E-03		
9.60	0.38504E-03	0.35051E-03		
9.70	0.31920E-03	0.31582E-03		
9.80	0.22675E-03	0.24958E-03		
9.90	0.13047E-03	0.16909E-03		

ANGLE	RAD.	PATTERN	RAD.	PATTERN
	UNBLOCKED		BLOCKED	
5.05	0.24875E-03	0.86007E-03		
5.15	0.43719E-05	0.14730E-03		
5.25	0.35021E-03	0.17272E-04		
5.35	0.11047E-02	0.34617E-03		
5.45	0.20215E-02	0.93544E-03		
5.55	0.28498E-02	0.15649E-02		
5.65	0.33888E-02	0.20439E-02		
5.75	0.35264E-02	0.22498E-02		
5.85	0.32533E-02	0.21461E-02		
5.95	0.26538E-02	0.17795E-02		
6.05	0.18768E-02	0.12580E-02		
6.15	0.10948E-02	0.71701E-03		
6.25	0.46352E-03	0.28431E-03		
6.35	0.88385E-04	0.49236E-04		
6.45	0.64898E-05	0.45248E-04		
6.55	0.18558E-03	0.24696E-03		
6.65	0.53897E-03	0.58163E-03		
6.75	0.95111E-03	0.95077E-03		
6.85	0.13069E-02	0.12558E-02		
6.95	0.15179E-02	0.14214E-02		
7.05	0.15397E-02	0.14118E-02		
7.15	0.13772E-02	0.12356E-02		
7.25	0.10782E-02	0.94071E-03		
7.35	0.71787E-03	0.59993E-03		
7.45	0.37808E-03	0.29209E-03		
7.55	0.12786E-03	0.83394E-04		
7.65	0.85463E-05	0.13033E-04		
7.75	0.26869E-04	0.86202E-04		
7.85	0.15702E-03	0.27547E-03		
7.95	0.34992E-03	0.522939E-03		
8.05	0.54713E-03	0.78586E-03		
8.15	0.69554E-03	0.98687E-03		
8.25	0.75931E-03	0.10908E-02		
8.35	0.72669E-03	0.10804E-02		
8.45	0.61030E-03	0.96391E-03		
8.55	0.44182E-03	0.77144E-03		
8.65	0.26252E-03	0.54568E-03		
8.75	0.11257E-03	0.33162E-03		
8.85	0.21410E-04	0.16630E-03		
8.95	0.18325E-05	0.71701E-04		
9.05	0.48420E-04	0.51615E-04		
9.15	0.14054E-03	0.93050E-04		
9.25	0.24869E-03	0.17124E-03		
9.35	0.34243E-03	0.25685E-03		
9.45	0.39768E-03	0.32322E-03		
9.55	0.40207E-03	0.35234E-03		
9.65	0.35674E-03	0.33799E-03		
9.75	0.27492E-03	0.28567E-03		
9.85	0.17763E-03	0.20990E-03		
9.95	0.87905E-04	0.12953E-03		

DRE USAGE OBJECT CODE= 35538 BYTES, ARRAY AREA= 30088 BYTES, TO
 DIAGNOSTICS NUMBER OF ERRORS= 0, NUMBER OF WARNINGS= 0
 DMPILE TIME= 0.78 SEC, EXECUTION TIME= 66.92 SEC, WATFIV - JUL 1



CASSEGRAIN ANTENNA SYSTEM

INPUT DATA

POLYNOMIAL COEFFICIENTS ARE:
COEFFICIENT(1) = 0.1912210E 00
COEFFICIENT(2) = 0.3135106E 01
COEFFICIENT(3) = -0.1508016E 02
COEFFICIENT(4) = 0.2531694E 02
COEFFICIENT(5) = -0.1268386E 02
COEFFICIENT(6) = -0.7593220E 00
ROT = 0.00 DEGREES
EPSI = 64.00 DEGREES
DIAM = 48.00 LAMDA
R1 = 0.8000 D/2 RATIO
R2 = 0.1567 D/2 RATIO
RC = 0.1537 D/2 RATIO
W = 0.0200 D/2 RATIO

OUTPUT DATA

APERTURE EFFICIENCY = 94.84 %
BLOCKED EFFICIENCY = 84.67 %
APERTURE GAIN IN DBS = 43.34 DBS
LOSS DUE TO BLOCKAGE = 10.73 %
LOSS DUE TO BLOCKAGE = 0.49 DBS

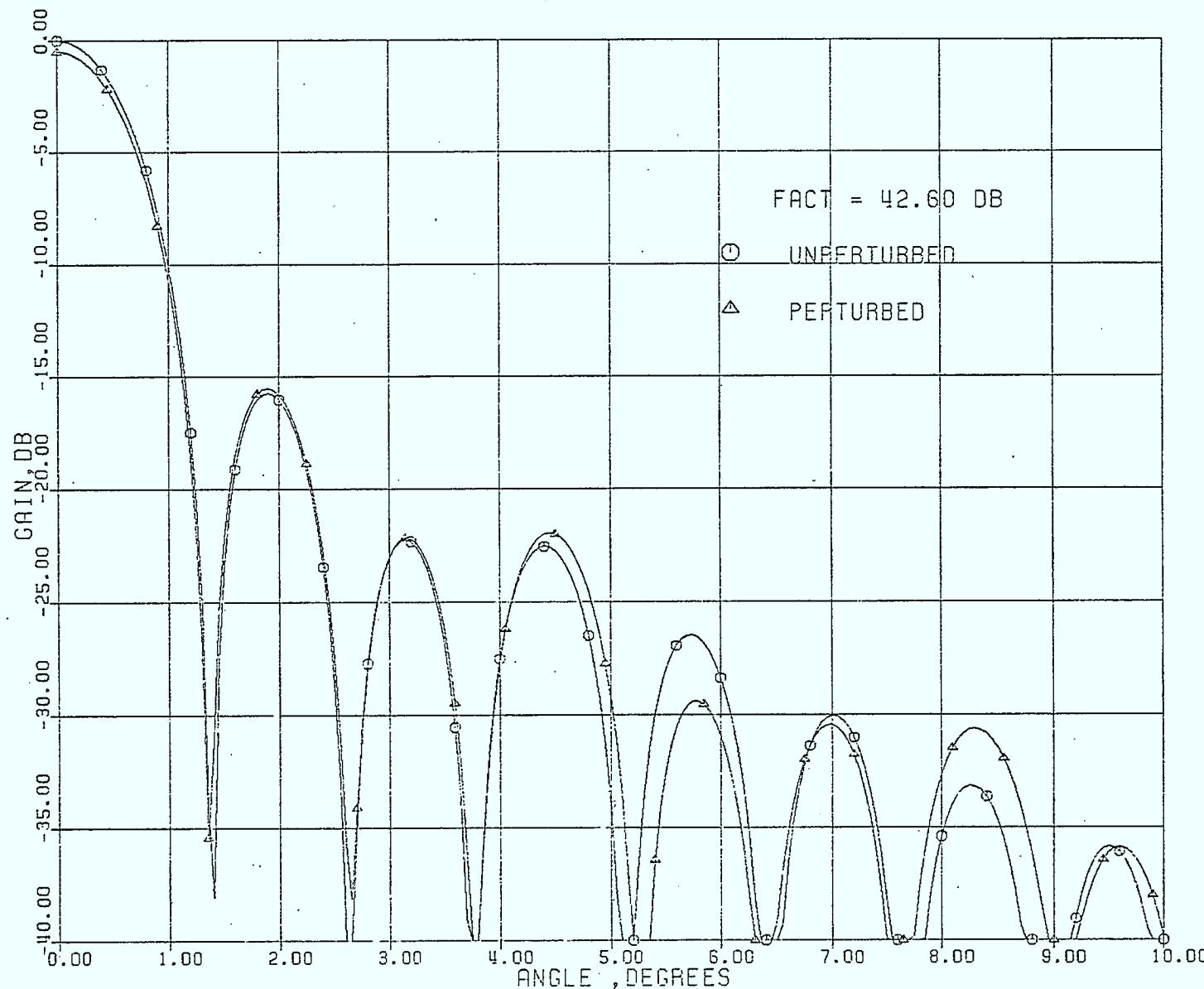
ANGLE	RAD.	PATTERN UNBLOCKED	RAD.	PATTERN BLOCKED
*** ***	*** ***	*** ***	*** ***	*** ***
0.00	0.15631E+01	0.13954E+01	0.05	0.15559E+01
0.10	0.15345E+01	0.13712E+01	0.15	0.14994E+01
0.20	0.14514E+01	0.12974E+01	0.25	0.13915E+01
0.30	0.13211E+01	0.11806E+01	0.35	0.12416E+01
0.40	0.11547E+01	0.10315E+01	0.45	0.10624E+01
0.50	0.96626E+00	0.86123E+00	0.55	0.86832E+00
0.60	0.77035E+00	0.68468E+00	0.65	0.67407E+00
0.70	0.58106E+00	0.51420E+00	0.75	0.49273E+00
0.80	0.41027E+00	0.36068E+00	0.85	0.33467E+00
0.90	0.26664E+00	0.23201E+00	0.95	0.20667E+00
1.00	0.15498E+00	0.13261E+00	1.05	0.11157E+00
1.10	0.76220E-01	0.63287E-01	1.15	0.48507E-01
1.20	0.27850E-01	0.21693E-01	1.25	0.13535E-01
1.30	0.47486E-02	0.30612E-02	1.35	0.61803E-03
1.40	0.24308E-03	0.11197E-02	1.45	0.27314E-02
1.50	0.72228E-02	0.95005E-02	1.55	0.12946E+01
1.60	0.19173E-01	0.21908E-01	1.65	0.25308E+01
1.70	0.30859E-01	0.33580E-01	1.75	0.35456E+01
1.80	0.38842E-01	0.41343E-01	1.85	0.40875E+01
1.90	0.41515E-01	0.43749E-01	1.95	0.40813E+01
2.00	0.38911E-01	0.40895E-01	2.05	0.35983E+01
2.10	0.32263E-01	0.34018E-01	2.15	0.28002E+01
2.20	0.23459E-01	0.24982E-01	2.25	0.18884E+01
2.30	0.14502E-01	0.15762E-01	2.35	0.10507E+01
2.40	0.70534E-02	0.80116E-02	2.45	0.42476E+02
2.50	0.21507E-02	0.27865E-02	2.55	0.77717E+03
2.60	0.98987E-04	0.42252E-03	2.65	0.51264E+04
2.70	0.53929E-03	0.60813E-03	2.75	0.14468E+02
2.80	0.26449E-03	0.25555E-03	2.85	0.40004E+02
2.90	0.53844E-02	0.52516E-02	2.95	0.66795E+02
3.00	0.77860E-02	0.77198E-02	3.05	0.86261E+02
3.10	0.91471E-02	0.92274E-02	3.15	0.93231E+02
3.20	0.91534E-02	0.94095E-02	3.25	0.86618E+02
3.30	0.78927E-02	0.83004E-02	3.35	0.69071E+02
3.40	0.57775E-02	0.62676E-02	3.45	0.45829E+02
3.50	0.34032E-02	0.38820E-02	3.55	0.23140E+02
3.60	0.13827E-02	0.17597E-02	3.65	0.66387E+03
3.70	0.19702E-03	0.41240E-03	3.75	0.47811E+05
3.80	0.92134E-04	0.13755E-03	3.85	0.44691E+03
3.90	0.10413E-02	0.96811E-03	3.95	0.18340E+02
4.00	0.27731E-02	0.26860E-02	4.05	0.38001E+02
4.10	0.48530E-02	0.48902E-02	4.15	0.58700E+02
4.20	0.67937E-02	0.70977E-02	4.25	0.75734E+02
4.30	0.81682E-02	0.88531E-02	4.35	0.85490E+02
4.40	0.86992E-02	0.98222E-02	4.45	0.86156E+02
4.50	0.83077E-02	0.98511E-02	4.55	0.77968E+02
4.60	0.71141E-02	0.89808E-02	4.65	0.62988E+02
4.70	0.53053E-02	0.74205E-02	4.75	0.44508E+02
4.80	0.35122E-02	0.54878E-02	4.85	0.26240E+02
4.90	0.18254E-02	0.35326E-02	4.95	0.11487E-02

ANGLE	RAD.	PATTERN UNBLOCKED	RAD.	PATTERN BLOCKED
*** ***	*** ***	*** ***	*** ***	*** ***
0.05	0.15559E+01	0.13897E+01	0.15	0.13432E+01
0.15	0.14994E+01	0.12438E+01	0.25	0.11092E+01
0.35	0.13915E+01	0.94782E+00	0.45	0.77297E+00
0.55	0.12416E+01	0.59794E+00	0.65	0.43475E+00
0.75	0.10624E+01	0.29288E+00	0.85	0.17852E+00
0.95	0.86832E+00	0.94268E-01	1.05	0.39276E-01
1.15	0.67407E+00	0.98716E-02	1.25	0.44871E-02
1.35	0.49273E+00	0.44796E-02	1.45	0.15530E-01
1.55	0.33467E+00	0.28076E-01	1.65	0.38081E-01
1.75	0.20667E+00	0.42923E-01	1.85	0.37851E-01
1.95	0.11157E+00	0.42944E-01	2.05	0.29644E-01
2.15	0.48507E-01	0.20280E-01	2.25	0.11621E-01
2.35	0.13535E-01	0.11621E-01	2.45	0.50468E-02
2.55	0.61803E-03	0.12526E-03	2.65	0.23750E-03
2.75	0.27314E-02	0.14225E-02	2.85	0.38742E-02
2.95	0.12946E-01	0.65679E-02	3.05	0.86262E-02
3.15	0.86261E-02	0.94909E-02	3.25	0.90000E-02
3.35	0.93231E-02	0.73669E-02	3.45	0.50795E-02
3.55	0.86618E-02	0.27519E-02	3.65	0.96465E-03
3.75	0.69071E-02	0.13252E-03	3.85	0.42294E-03
3.95	0.45829E-02	0.17381E-02	4.05	0.37569E-02
4.15	0.38001E-02	0.60239E-02	4.25	0.80565E-02
4.35	0.58700E-02	0.94502E-02	4.45	0.99561E-02
4.55	0.75734E-02	0.95186E-02	4.65	0.82688E-02
4.75	0.85490E-02	0.64787E-02	4.85	0.44920E-02
4.95	0.11487E-02	0.26464E-02		

ANGLE	RAD.	PATTERN UNBLOCKED	RAD.	PATTERN BLOCKED
5.00	0.61825E-03	0.18634E-02		
5.10	0.45495E-04	0.59010E-03		
5.20	0.11267E-03	0.94440E-04		
5.30	0.69095E-03	0.31228E-04		
5.40	0.15591E-02	0.35615E-03		
5.50	0.24610E-02	0.37136E-03		
5.60	0.31648E-02	0.13767E-02		
5.70	0.35108E-02	0.17145E-02		
5.80	0.34378E-02	0.17990E-02		
5.90	0.29861E-02	0.16255E-02		
6.00	0.22768E-02	0.12595E-02		
6.10	0.14758E-02	0.81137E-03		
6.20	0.75224E-03	0.40270E-03		
6.30	0.23991E-03	0.13456E-03		
6.40	0.11283E-04	0.53797E-04		
6.50	0.67821E-04	0.19275E-03		
6.60	0.34737E-03	0.47310E-03		
6.70	0.74525E-03	0.82184E-03		
6.80	0.11425E-02	0.11442E-02		
6.90	0.14344E-02	0.13576E-02		
7.00	0.15533E-02	0.14112E-02		
7.10	0.14793E-02	0.12958E-02		
7.20	0.12404E-02	0.12437E-02		
7.30	0.90051E-03	0.71843E-03		
7.40	0.54057E-03	0.39829E-03		
7.50	0.23842E-03	0.15697E-03		
7.60	0.50592E-04	0.46938E-04		
7.70	0.14314E-05	0.88646E-04		
7.80	0.80641E-04	0.26774E-03		
7.90	0.24924E-03	0.54031E-03		
8.00	0.45160E-03	0.84435E-03		
8.10	0.63020E-03	0.11145E-02		
8.20	0.73934E-03	0.12962E-02		
8.30	0.75480E-03	0.13566E-02		
8.40	0.67732E-03	0.12900E-02		
8.50	0.53008E-03	0.11163E-02		
8.60	0.35086E-03	0.87478E-03		
8.70	0.18171E-03	0.61379E-03		
8.80	0.58403E-04	0.37993E-03		
8.90	0.25994E-05	0.20840E-03		
9.00	0.17849E-04	0.11692E-03		
9.10	0.90512E-04	0.10423E-03		
9.20	0.19459E-03	0.15283E-03		
9.30	0.29909E-03	0.23496E-03		
9.40	0.37595E-03	0.32015E-03		
9.50	0.40648E-03	0.38232E-03		
9.60	0.38504E-03	0.40508E-03		
9.70	0.31920E-03	0.38408E-03		
9.80	0.22675E-03	0.32627E-03		
9.90	0.13047E-03	0.24661E-03		

ANGLE	RAD.	PATTERN JNBLOCKED	RAD.	PATTERN BLOCKED
5.05	0.24875E-03	0.12065E-02		
5.15	0.43719E-05	0.32012E-03		
5.25	0.35021E-03	0.34576E-05		
5.35	0.11047E-02	0.15688E-03		
5.45	0.20215E-02	0.60299E-03		
5.55	0.28498E-02	0.11366E-02		
5.65	0.33888E-02	0.15738E-02		
5.75	0.35264E-02	0.17906E-02		
5.85	0.32533E-02	0.17418E-02		
5.95	0.26538E-02	0.14603E-02		
6.05	0.18768E-02	0.10380E-02		
6.15	0.10948E-02	0.59496E-03		
6.25	0.46352E-03	0.24629E-03		
6.35	0.88385E-04	0.73057E-04		
6.45	0.64898E-05	0.10527E-03		
6.55	0.18558E-03	0.31862E-03		
6.65	0.53897E-03	0.64486E-03		
6.75	0.95111E-03	0.99200E-03		
6.85	0.13069E-02	0.12686E-02		
6.95	0.15179E-02	0.14060E-02		
7.05	0.15397E-02	0.13735E-02		
7.15	0.13772E-02	0.11834E-02		
7.25	0.10782E-02	0.88541E-03		
7.35	0.71787E-03	0.55281E-03		
7.45	0.37808E-03	0.26384E-03		
7.55	0.12786E-03	0.83435E-04		
7.65	0.85463E-05	0.48931E-04		
7.75	0.26869E-04	0.16318E-03		
7.85	0.15702E-03	0.39595E-03		
7.95	0.34992E-03	0.69258E-03		
8.05	0.54713E-03	0.98746E-03		
8.15	0.69554E-03	0.12190E-02		
8.25	0.75931E-03	0.13426E-02		
8.35	0.72669E-03	0.13385E-02		
8.45	0.61030E-03	0.12145E-02		
8.55	0.44182E-03	0.10011E-02		
8.65	0.26252E-03	0.74362E-03		
8.75	0.11257E-03	0.49091E-03		
8.85	0.21410E-04	0.28484E-03		
8.95	0.18325E-05	0.15230E-03		
9.05	0.48420E-04	0.10150E-03		
9.15	0.14054E-03	0.12244E-03		
9.25	0.24869E-03	0.19163E-03		
9.35	0.34243E-03	0.27899E-03		
9.45	0.39768E-03	0.35541E-03		
9.55	0.40207E-03	0.39918E-03		
9.65	0.35674E-03	0.39986E-03		
9.75	0.27492E-03	0.35898E-03		
9.85	0.17763E-03	0.28805E-03		
9.95	0.87905E-04	0.20430E-03		

CORE USAGE OBJECT CODE= 35688 BYTES, ARRAY AREA= 30088 BYTES, TO
 DIAGNOSTICS NUMBER OF ERRORS= 0, NUMBER OF WARNINGS=
 COMPILE TIME= 0.77 SEC, EXECUTION TIME= 66.96 SEC, WATFIV - JUL 1



STANDARD CASSEGRAINIAN SYSTEM

SUBREFLECTOR DIAMETER	=	8.000000
FOCAL LENGTH OF MAIN-REFLECTOR	=	19.200000
MAIN-REFLECTOR DIAMETER	=	48.000000
DISTANCE OF PHASE CENTRE	=	10.825000
DISTANCE OF SUBREFLECTOR VERTEX	=	16.571656
FEED POWER PATTERN	=	1.000000 COS(TH)** 29.925720
SPILL OVER LOSS =	-0.053512	DB

LEAST SQUARE CURVE FITTING FOR APERTURE FIELD AS A FUNCTION OF APERTURE POINT

0 ORDER COEFFICIENT =	1.000017
1 ORDER COEFFICIENT =	-2.523651
2 ORDER COEFFICIENT =	3.150043
3 ORDER COEFFICIENT =	-2.477787
4 ORDER COEFFICIENT =	1.25810
5 ORDER COEFFICIENT =	-0.274853
ERROR IN LEAST SQUARE FIT =	0.006269

CASSEGRAIN ANTENNA SYSTEM

INPUT DATA

POLYNOMIAL COEFFICIENTS ARE:
COEFFICIENT(1) = 0.1000017E 01
COEFFICIENT(2) = -0.2523651E 01
COEFFICIENT(3) = 0.3150043E 01
COEFFICIENT(4) = -0.2477787E 01
COEFFICIENT(5) = 0.1205810E 01
COEFFICIENT(6) = -0.2748530E 00
ROT = 0.00 DEGREES
EPSI = 64.00 DEGREES
DIAM = 48.00 LAMDA
R1 = 1.0000 D/2 RATIO
R2 = 0.1667 D/2 RATIO
RC = 0.1557 D/2 RATIO
W = 0.0200 D/2 RATIO

OUTPUT DATA

APERTURE EFFICIENCY = 67.42 %
BLOCKED EFFICIENCY = 52.99 %
APERTURE GAIN IN DBS = 41.86 DBS
LOSS DUE TO BLOCKAGE = 21.40 %
LOSS DUE TO BLOCKAGE = 1.05 DBS

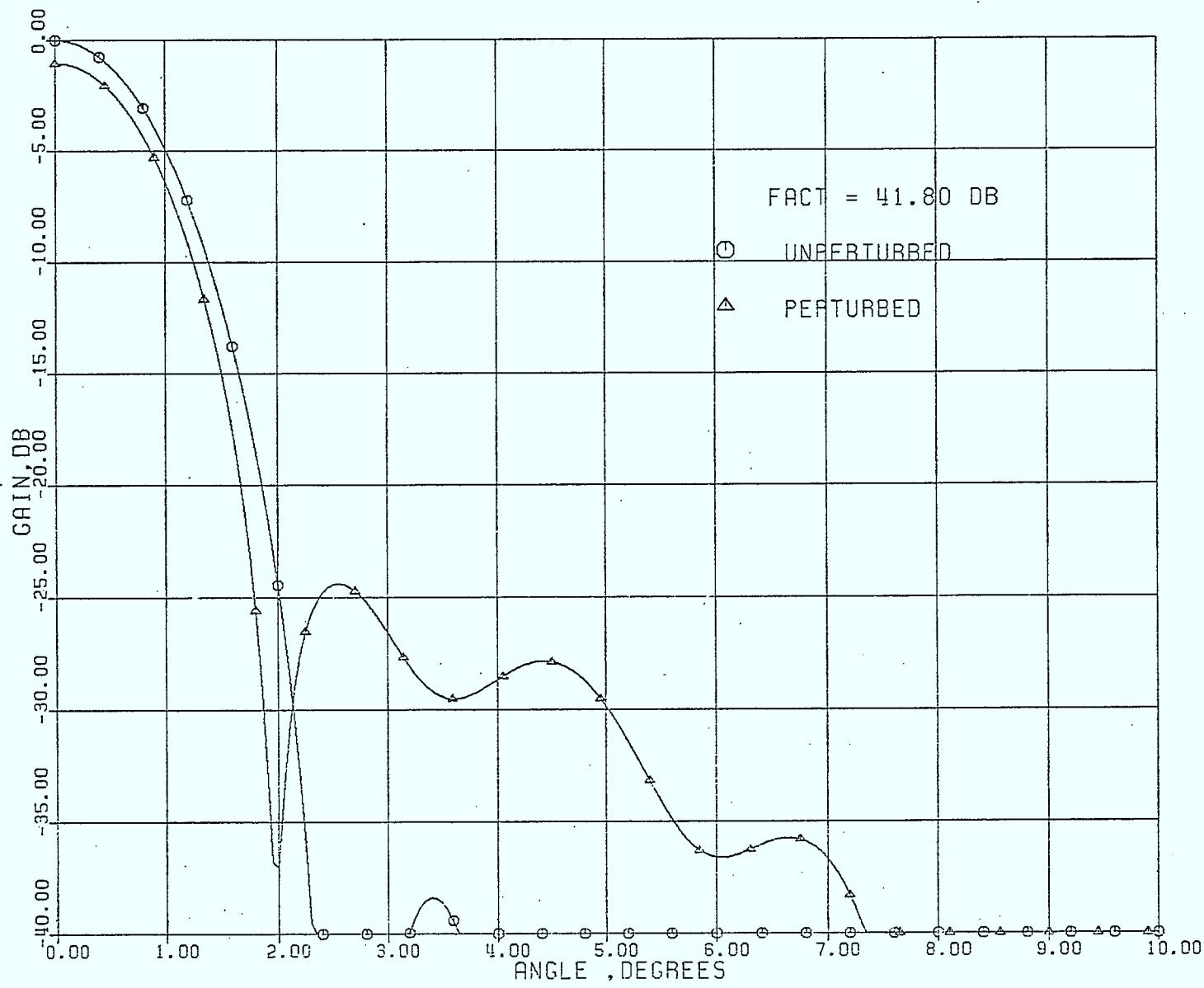
ANGLE	RAD. PATTERN UNBLOCKED	RAD. PATTERN BLOCKED
0.00	0.13085E 01	0.10285E 01
0.10	0.12946E 01	0.10186E 01
0.20	0.12536E 01	0.98563E 00
0.30	0.11879E 01	0.93151E 00
0.40	0.11012E 01	0.85946E 00
0.50	0.99829E 00	0.77364E 00
0.60	0.88440E 00	0.67874E 00
0.70	0.76512E 00	0.57965E 00
0.80	0.64578E 00	0.48107E 00
0.90	0.53114E 00	0.38716E 00
1.00	0.42507E 00	0.30127E 00
1.10	0.33044E 00	0.22581E 00
1.20	0.24895E 00	0.16218E 00
1.30	0.18129E 00	0.11080E 00
1.40	0.12717E 00	0.71232E -01
1.50	0.85547E -01	0.42381E -01
1.60	0.54880E -01	0.22694E -01
1.70	0.33318E -01	0.10382E -01
1.80	0.18944E -01	0.36259E -02
1.90	0.99373E -02	0.73427E -03
2.00	0.47002E -02	0.25816E -03
2.10	0.19301E -02	0.10548E -02
2.20	0.64106E -03	0.23029E -02
2.30	0.14611E -03	0.34797E -02
2.40	0.12325E -04	0.43120E -02
2.50	0.14362E -05	0.47133E -02
2.60	0.81174E -05	0.47187E -02
2.70	0.50010E -05	0.44279E -02
2.80	0.11938E -07	0.39597E -02
2.90	0.81542E -05	0.34224E -02
3.00	0.36912E -04	0.28980E -02
3.10	0.82379E -04	0.24380E -02
3.20	0.13224E -03	0.20673E -02
3.30	0.17174E -03	0.17917E -02
3.40	0.18946E -03	0.16057E -02
3.50	0.18099E -03	0.14993E -02
3.60	0.14971E -03	0.14617E -02
3.70	0.10500E -03	0.14822E -02
3.80	0.58901E -04	0.15504E -02
3.90	0.22449E -04	0.16543E -02
4.00	0.27841E -05	0.17796E -02
4.10	0.17117E -05	0.19094E -02
4.20	0.15915E -04	0.20257E -02
4.30	0.38512E -04	0.21109E -02
4.40	0.61356E -04	0.21506E -02
4.50	0.77366E -04	0.21355E -02
4.60	0.82268E -04	0.20631E -02
4.70	0.75363E -04	0.19372E -02
4.80	0.59259E -04	0.17680E -02
4.90	0.38766E -04	0.15695E -02

ANGLE	RAD. PATTERN UNBLOCKED	RAD. PATTERN BLOCKED
0.05	0.13050E 01	0.10265E 01
0.15	0.12773E 01	0.10049E 01
0.25	0.12236E 01	0.96103E 00
0.35	0.11469E 01	0.89748E 00
0.45	0.10515E 01	0.81799E 00
0.55	0.94237E 00	0.72701E 00
0.65	0.82509E 00	0.62941E 00
0.75	0.70514E 00	0.53002E 00
0.85	0.58761E 00	0.43303E 00
0.95	0.47683E 00	0.34303E 00
1.05	0.37619E 00	0.2612E 00
1.15	0.28798E 00	0.19247E 00
1.25	0.21339E 00	0.13497E 00
1.35	0.15259E 00	0.89594E -01
1.45	0.10488E 00	0.55556E -01
1.55	0.68956E -01	0.31501E -01
1.65	0.43081E -01	0.15731E -01
1.75	0.25350E -01	0.64197E -01
1.85	0.13876E -01	0.17943E -01
1.95	0.69364E -02	0.27327E -01
2.05	0.30758E -02	0.55615E -01
2.15	0.11500E -02	0.16616E -01
2.25	0.32668E -03	0.29224E -01
2.35	0.52787E -04	0.39479E -01
2.45	0.55491E -05	0.47602E -01
2.55	0.77138E -05	0.46029E -01
2.65	0.17365E -05	0.42087E -01
2.75	0.19945E -04	0.36939E -01
2.85	0.58194E -04	0.31547E -01
2.95	0.10770E -03	0.26578E -01
3.05	0.15414E -03	0.22408E -01
3.15	0.18379E -03	0.19178E -01
3.25	0.18846E -03	0.16881E -01
3.35	0.16772E -03	0.15432E -01
3.45	0.12830E -03	0.14726E -01
3.55	0.81372E -04	0.14653E -01
3.65	0.38907E -04	0.15111E -01
3.75	0.10275E -04	0.15988E -01
3.85	0.24088E -07	0.17153E -01
3.95	0.72754E -05	0.18450E -01
4.05	0.26673E -04	0.19704E -01
4.15	0.50395E -04	0.21371E -01
4.25	0.70562E -04	0.21502E -01
4.35	0.81335E -04	0.21063E -01
4.45	0.80196E -04	0.18572E -01
4.55	0.49216E -04	0.16715E -01
4.65	0.28598E -04	0.14642E -01

ANGLE	RAD.	PATTERN	RAD.	PATTERN
	UNBLOCKED		BLOCKED	
*****	*****	*****	*****	*****
5.00	0.19345E-04	0.13574E-02	5.05	0.11539E-04
5.10	0.55841E-05	0.11469E-02	5.15	0.17312E-05
5.20	0.75156E-07	0.95044E-03	5.25	0.55281E-06
5.30	0.29585E-05	0.77709E-03	5.35	0.69658E-05
5.40	0.12157E-04	0.63172E-03	5.45	0.18055E-04
5.50	0.24164E-04	0.51564E-03	5.55	0.30000E-04
5.60	0.35126E-04	0.42743E-03	5.65	0.39178E-04
5.70	0.41889E-04	0.36403E-03	5.75	0.43097E-04
5.80	0.42756E-04	0.32175E-03	5.85	0.40929E-04
5.90	0.37781E-04	0.29692E-03	5.95	0.33561E-04
6.00	0.28579E-04	0.28624E-03	6.05	0.23186E-04
6.10	0.17742E-04	0.28673E-03	6.15	0.12597E-04
6.20	0.80619E-05	0.29550E-03	6.25	0.43936E-05
6.30	0.17772E-05	0.30950E-03	6.35	0.31837E-06
6.40	0.38817E-07	0.32533E-03	6.45	0.87897E-06
6.50	0.27066E-05	0.33493E-03	6.55	0.53276E-05
6.60	0.85039E-05	0.34785E-03	6.65	0.11971E-04
6.70	0.15455E-04	0.34775E-03	6.75	0.18696E-04
6.80	0.21462E-04	0.33686E-03	6.85	0.23563E-04
6.90	0.24864E-04	0.31443E-03	6.95	0.25291E-04
7.00	0.24833E-04	0.28130E-03	7.05	0.23541E-04
7.10	0.21519E-04	0.23980E-03	7.15	0.18920E-04
7.20	0.15927E-04	0.19345E-03	7.25	0.12747E-04
7.30	0.95859E-05	0.14629E-03	7.35	0.66452E-05
7.40	0.41011E-05	0.10233E-03	7.45	0.20977E-05
7.50	0.73576E-06	0.64821E-04	7.55	0.69620E-07
7.60	0.10441E-06	0.35855E-04	7.65	0.79775E-06
7.70	0.20649E-05	0.16158E-04	7.75	0.37857E-05
7.80	0.58144E-05	0.51537E-05	7.85	0.79897E-05
7.90	0.10147E-04	0.12449E-05	7.95	0.12131E-04
8.00	0.13801E-04	0.22529E-05	8.05	0.15046E-04
8.10	0.15787E-04	0.58903E-05	8.15	0.15981E-04
8.20	0.15625E-04	0.10173E-04	8.25	0.14754E-04
8.30	0.13436E-04	0.13692E-04	8.35	0.11766E-04
8.40	0.98601E-05	0.19719E-04	8.45	0.78480E-05
8.50	0.58594E-05	0.16144E-04	8.55	0.40202E-05
8.60	0.24406E-05	0.15303E-04	8.65	0.12107E-05
8.70	0.39381E-06	0.13753E-04	8.75	0.23084E-07
8.80	0.10130E-06	0.12069E-04	8.85	0.60077E-06
8.90	0.14670E-05	0.10705E-04	8.95	0.26224E-05
9.00	0.39730E-05	0.99471E-05	9.05	0.54151E-05
9.10	0.68424E-05	0.99568E-05	9.15	0.81531E-05
9.20	0.92565E-05	0.10860E-04	9.25	0.10079E-04
9.30	0.10570E-04	0.12849E-04	9.35	0.10699E-04
9.40	0.10465E-04	0.16249E-04	9.45	0.98886E-05
9.50	0.90138E-05	0.21514E-04	9.55	0.79033E-05
9.60	0.66335E-05	0.20160E-04	9.65	0.52892E-05
9.70	0.39574E-05	0.39633E-04	9.75	0.27221E-05
9.80	0.16582E-05	0.53142E-04	9.85	0.82657E-06
9.90	0.27140E-06	0.69555E-04	9.95	0.16810E-07

ANGLE	RAD.	PATTERN	RAD.	PATTERN
	UNBLOCKED		BLOCKED	
*****	*****	*****	*****	*****
5.05	0.11539E-04	0.12511E-02		
5.15	0.17312E-05	0.10462E-02		
5.25	0.55281E-06	0.86049E-03		
5.35	0.69658E-05	0.70075E-03		
5.45	0.18055E-04	0.57006E-03		
5.55	0.30000E-04	0.46822E-03		
5.65	0.39178E-04	0.39285E-03		
5.75	0.43097E-04	0.34049E-03		
5.85	0.40929E-04	0.30737E-03		
5.95	0.33561E-04	0.29000E-03		
6.05	0.23186E-04	0.28527E-03		
6.15	0.12597E-04	0.29027E-03		
6.25	0.43936E-05	0.31741E-03		
6.35	0.31837E-06	0.33278E-03		
6.45	0.87897E-06	0.34448E-03		
6.55	0.53276E-05	0.34904E-03		
6.65	0.11971E-04	0.34374E-03		
6.75	0.18696E-04	0.32708E-03		
6.85	0.23563E-04	0.29909E-03		
6.95	0.25291E-04	0.26140E-03		
7.05	0.23541E-04	0.21699E-03		
7.15	0.18920E-04	0.16970E-03		
7.25	0.12747E-04	0.12369E-03		
7.35	0.66452E-05	0.82609E-04		
7.45	0.20977E-05	0.49191E-04		
7.55	0.69620E-07	0.24855E-04		
7.65	0.79775E-06	0.96499E-05		
7.75	0.37857E-05	0.24405E-05		
7.85	0.79897E-05	0.12801E-05		
7.95	0.12131E-04	0.38780E-05		
8.05	0.15046E-04	0.80544E-05		
8.15	0.15981E-04	0.12089E-04		
8.25	0.14754E-04	0.14912E-04		
8.35	0.11766E-04	0.16119E-04		
8.45	0.78480E-05	0.15850E-04		
8.55	0.40202E-05	0.14579E-04		
8.65	0.12107E-05	0.12896E-04		
8.75	0.23084E-07	0.11325E-04		
8.85	0.60077E-06	0.10238E-04		
8.95	0.26224E-05	0.98486E-05		
9.05	0.54151E-05	0.10287E-04		
9.15	0.81531E-05	0.11702E-04		
9.25	0.10079E-04	0.14347E-04		
9.35	0.10699E-04	0.18616E-04		
9.45	0.98886E-05	0.25008E-04		
9.55	0.79033E-05	0.34021E-04		
9.65	0.52892E-05	0.46006E-04		
9.75	0.27221E-05	0.61012E-04		
9.85	0.82657E-06	0.78687E-04		
9.95	0.16810E-07	0.78687E-04		

DRE USAGE OBJECT CODE= 35538 BYTES, ARRAY AREA= 30088 BYTES, TO
 DIAGNOSTICS NUMBER OF ERRORS= 0, NUMBER OF WARNINGS= 0
 DMPILE TIME= 0.78 SEC, EXECUTION TIME= 5.80 SEC, WATFIV - JUL 1



CASSEGRAIN ANTENNA SYSTEM

INPUT DATA

POLYNOMIAL COEFFICIENTS ARE:
COEFFICIENT(1) = 0.1000017E 01
COEFFICIENT(2) = -0.2523651E 01
COEFFICIENT(3) = 0.3150043E 01
COEFFICIENT(4) = -0.2477787E 01
COEFFICIENT(5) = 0.1205810E 01
COEFFICIENT(6) = -0.2748530E 00
ROT = 0.0 DEGREES
EPSI = 64.00 DEGREES
DIAM = 48.00 LAMDA
R1 = 0.9000 D/2 RATIO
R2 = 0.1667 D/2 RATIO
RC = 0.1567 D/2 RATIO
W = 0.0200 D/2 RATIO

OUTPUT DATA

APERTURE EFFICIENCY = 67.42 %
BLOCKED EFFICIENCY = 52.94 %
APERTURE GAIN IN DBS = 41.86 DBS
LOSS DUE TO BLOCKAGE = 21.48 %
LOSS DUE TO BLOCKAGE = 1.05 DBS

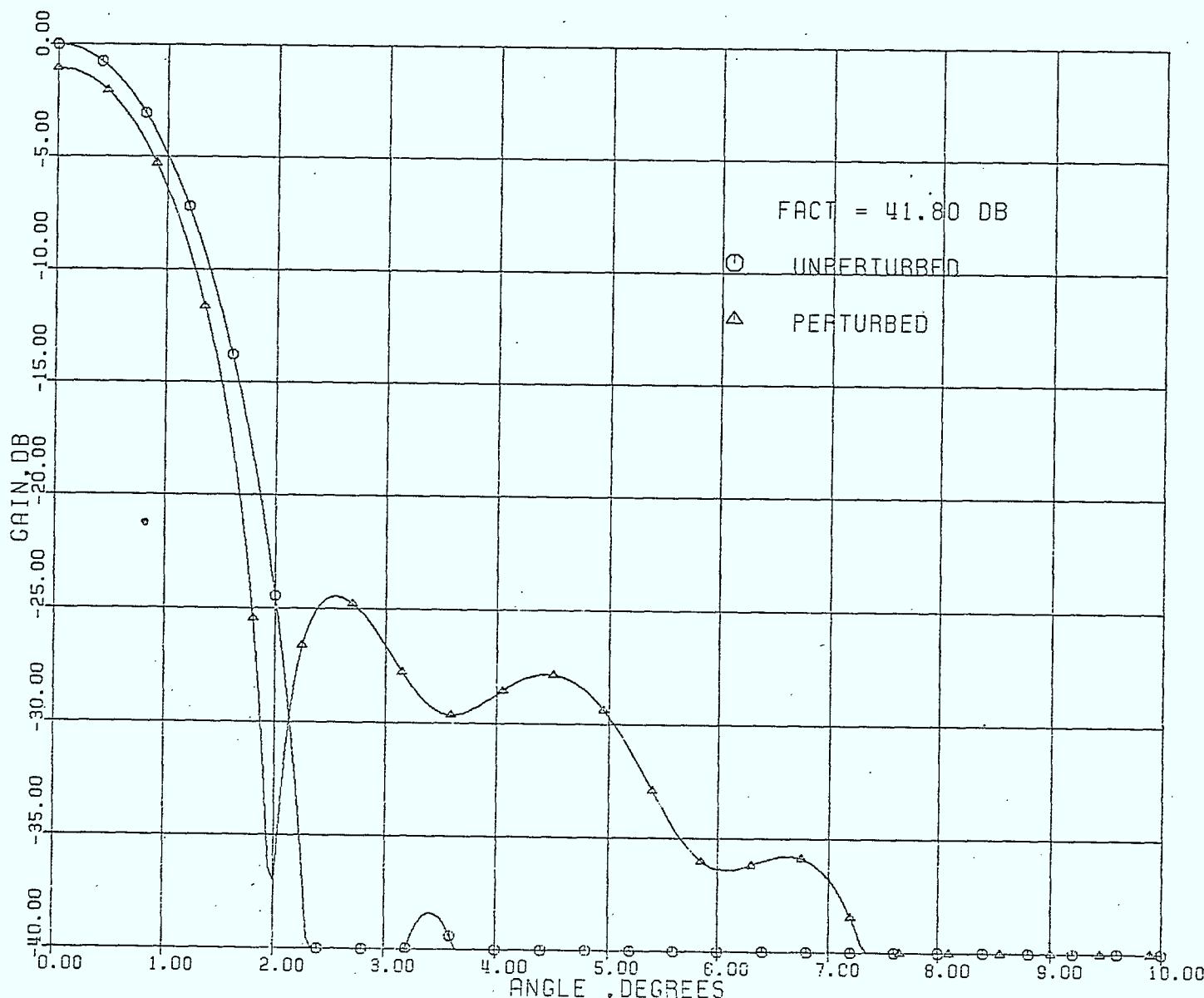
ANGLE	RAD.	PATTERN UNBLOCKED	RAD.	PATTERN BLOCKED
*** * *	*** * *** * ***	*** * *** * ***	*** * *** * ***	*** * *** * ***
0.00	0.13085E+01	0.10274E+01	0.13050E+01	0.10254E+01
0.10	0.12946E+01	0.10175E+01	0.12773E+01	0.10038E+01
0.20	0.12536E+01	0.98457E+00	0.12236E+01	0.96001E+00
0.30	0.11879E+01	0.93053E+00	0.11469E+01	0.89657E+00
0.40	0.11012E+01	0.85862E+00	0.10515E+01	0.81723E+00
0.50	0.99829E+00	0.77296E+00	0.94237E+00	0.72643E+00
0.60	0.88440E+00	0.57825E+00	0.82509E+00	0.62902E+00
0.70	0.76512E+00	0.57936E+00	0.70514E+00	0.52982E+00
0.80	0.64578E+00	0.48096E+00	0.58761E+00	0.43328E+00
0.90	0.53114E+00	0.38721E+00	0.47683E+00	0.34316E+00
1.00	0.42507E+00	0.30146E+00	0.37619E+00	0.26237E+00
1.10	0.33044E+00	0.22610E+00	0.28798E+00	0.19279E+00
1.20	0.24895E+00	0.16252E+00	0.21339E+00	0.13532E+00
1.30	0.18129E+00	0.11116E+00	0.15259E+00	0.89950E+00
1.40	0.12717E+00	0.71576E-01	0.10488E+00	0.55882E+01
1.50	0.85547E-01	0.42683E-01	0.68956E-01	0.31776E-01
1.60	0.54880E-01	0.22938E-01	0.43081E-01	0.15942E-01
1.70	0.33318E-01	0.10560E-01	0.25350E-01	0.65639E-02
1.80	0.18944E-01	0.37372E-02	0.13876E-01	0.18743E-02
1.90	0.99373E-02	0.78515E-03	0.69364E-02	0.29762E-03
2.00	0.47002E-02	0.25892E-03	0.30758E-02	0.53644E-03
2.10	0.19301E-02	0.10178E-02	0.15000E-02	0.16104E-02
2.20	0.64106E-03	0.22406E-02	0.32668E-03	0.28517E-02
2.30	0.14611E-03	0.34032E-02	0.52787E-04	0.38678E-02
2.40	0.12325E-04	0.42302E-02	0.52292E-06	0.44848E-02
2.50	0.14362E-05	0.46432E-02	0.55491E-05	0.46817E-02
2.60	0.81174E-05	0.46431E-02	0.77138E-05	0.45305E-02
2.70	0.50010E-05	0.43588E-02	0.17365E-05	0.41430E-02
2.80	0.11938E-07	0.38974E-02	0.17089E-05	0.36348E-02
2.90	0.81542E-05	0.33662E-02	0.19945E-04	0.31011E-02
3.00	0.36912E-04	0.28468E-02	0.58194E-04	0.26086E-02
3.10	0.82379E-04	0.23905E-02	0.10770E-03	0.21949E-02
3.20	0.13224E-03	0.20227E-02	0.15414E-03	0.18743E-02
3.30	0.17174E-03	0.17493E-02	0.18379E-03	0.16466E-02
3.40	0.18946E-03	0.15651E-02	0.18846E-03	0.15035E-02
3.50	0.18099E-03	0.14605E-02	0.16772E-03	0.14347E-02
3.60	0.14971E-03	0.14248E-02	0.12830E-03	0.14297E-02
3.70	0.10500E-03	0.14479E-02	0.81372E-04	0.14783E-02
3.80	0.58901E-04	0.15194E-02	0.38907E-04	0.15697E-02
3.90	0.22449E-04	0.16275E-02	0.10275E-04	0.16910E-02
4.00	0.27841E-05	0.17581E-02	0.24088E-07	0.18268E-02
4.10	0.17117E-05	0.18946E-02	0.72754E-05	0.19593E-02
4.20	0.15915E-04	0.20187E-02	0.26673E-04	0.20709E-02
4.30	0.38512E-04	0.21127E-02	0.50395E-04	0.21436E-02
4.40	0.61356E-04	0.21619E-02	0.70562E-04	0.21663E-02
4.50	0.77366E-04	0.21563E-02	0.81335E-04	0.21317E-02
4.60	0.82268E-04	0.20928E-02	0.80196E-04	0.20401E-02
4.70	0.75363E-04	0.19747E-02	0.68194E-04	0.18981E-02
4.80	0.59259E-04	0.18117E-02	0.49216E-04	0.17174E-02
4.90	0.38766E-04	0.16172E-02	0.28598E-04	0.15131E-02

ANGLE	RAD.	PATTERN UNBLOCKED	RAD.	PATTERN BLOCKED
*** * *	*** * *** * ***	*** * *** * ***	*** * *** * ***	*** * *** * ***
0.05	0.13050E+01	0.10254E+01	0.12773E+01	0.10038E+01
0.15	0.12236E+01	0.96001E+00	0.11469E+01	0.89657E+00
0.25	0.11469E+01	0.89657E+00	0.10515E+01	0.81723E+00
0.35	0.10515E+01	0.81723E+00	0.94237E+00	0.72643E+00
0.45	0.94237E+00	0.72643E+00	0.82509E+00	0.62902E+00
0.55	0.82509E+00	0.62902E+00	0.70514E+00	0.52982E+00
0.65	0.70514E+00	0.52982E+00	0.58761E+00	0.43328E+00
0.75	0.58761E+00	0.43328E+00	0.47683E+00	0.34316E+00
0.85	0.47683E+00	0.34316E+00	0.37619E+00	0.26237E+00
0.95	0.37619E+00	0.26237E+00	0.28798E+00	0.19279E+00
1.05	0.28798E+00	0.19279E+00	0.21339E+00	0.13532E+00
1.15	0.21339E+00	0.13532E+00	0.15259E+00	0.89950E+01
1.25	0.15259E+00	0.89950E+01	0.10488E+00	0.55882E+01
1.35	0.10488E+00	0.55882E+01	0.68956E-01	0.31776E-01
1.45	0.68956E-01	0.31776E-01	0.43081E-01	0.15942E-01
1.55	0.43081E-01	0.15942E-01	0.25350E-01	0.65639E-02
1.65	0.25350E-01	0.65639E-02	0.13876E-01	0.18743E-02
1.75	0.13876E-01	0.18743E-02	0.69364E-02	0.29762E-03
1.85	0.69364E-02	0.29762E-03	0.30758E-02	0.53644E-03
1.95	0.30758E-02	0.53644E-03	0.15000E-02	0.16104E-02
2.05	0.15000E-02	0.16104E-02	0.32668E-03	0.28517E-02
2.15	0.32668E-03	0.28517E-02	0.11500E-02	0.16104E-02
2.25	0.11500E-02	0.16104E-02	0.52787E-04	0.38678E-02
2.35	0.52787E-04	0.38678E-02	0.52292E-06	0.44848E-02
2.45	0.52292E-06	0.44848E-02	0.55491E-05	0.46817E-02
2.55	0.55491E-05	0.46817E-02	0.77138E-05	0.45305E-02
2.65	0.77138E-05	0.45305E-02	0.17365E-05	0.41430E-02
2.75	0.17365E-05	0.41430E-02	0.17089E-05	0.36348E-02
2.85	0.17089E-05	0.36348E-02	0.19945E-04	0.31011E-02
2.95	0.19945E-04	0.31011E-02	0.58194E-04	0.26086E-02
3.05	0.58194E-04	0.26086E-02	0.10770E-03	0.21949E-02
3.15	0.10770E-03	0.21949E-02	0.15414E-03	0.18743E-02
3.25	0.15414E-03	0.18743E-02	0.18379E-03	0.16466E-02
3.35	0.18379E-03	0.16466E-02	0.18846E-03	0.15035E-02
3.45	0.18846E-03	0.15035E-02	0.16772E-03	0.14347E-02
3.55	0.16772E-03	0.14347E-02	0.12830E-03	0.14297E-02
3.65	0.12830E-03	0.14297E-02	0.81372E-04	0.14783E-02
3.75	0.81372E-04	0.14783E-02	0.38907E-04	0.15697E-02
3.85	0.38907E-04	0.15697E-02	0.10275E-04	0.16910E-02
3.95	0.10275E-04	0.16910E-02	0.24088E-07	0.18268E-02
4.05	0.24088E-07	0.18268E-02	0.72754E-05	0.19593E-02
4.15	0.72754E-05	0.19593E-02	0.26673E-04	0.20709E-02
4.25	0.26673E-04	0.20709E-02	0.50395E-04	0.21436E-02
4.35	0.50395E-04	0.21436E-02	0.70562E-04	0.21663E-02
4.45	0.70562E-04	0.21663E-02	0.81335E-04	0.21317E-02
4.55	0.81335E-04	0.21317E-02	0.80196E-04	0.20401E-02
4.65	0.80196E-04	0.20401E-02	0.68194E-04	0.18981E-02
4.75	0.68194E-04	0.18981E-02	0.49216E-04	0.17174E-02
4.85	0.49216E-04	0.17174E-02	0.28598E-04	0.15131E-02
4.95	0.28598E-04	0.15131E-02	0.0	0.0

ANGLE	RAD. PATTERN UNBLOCKED	RAD. PATTERN BLOCKED
*****	*****	*****
5.00	0.19345E-04	0.14070E-02
5.10	0.55841E-05	0.11963E-02
5.20	0.75156E-07	0.99782E-03
5.30	0.29585E-05	0.82198E-03
5.40	0.12157E-04	0.57146E-03
5.50	0.24164E-04	0.55075E-03
5.60	0.35126E-04	0.45793E-03
5.70	0.41889E-04	0.39021E-03
5.80	0.42756E-04	0.34402E-03
5.90	0.37781E-04	0.31568E-03
6.00	0.28579E-04	0.30179E-03
6.10	0.17742E-04	0.29925E-03
6.20	0.80619E-05	0.30504E-03
6.30	0.17772E-05	0.31606E-03
6.40	0.38817E-07	0.32893E-03
6.50	0.27066E-05	0.34008E-03
6.60	0.85039E-05	0.34601E-03
6.70	0.15455E-04	0.34373E-03
6.80	0.21462E-04	0.33120E-03
6.90	0.24864E-04	0.30775E-03
7.00	0.24833E-04	0.27423E-03
7.10	0.21519E-04	0.23292E-03
7.20	0.15927E-04	0.18721E-03
7.30	0.95859E-05	0.14098E-03
7.40	0.41011E-05	0.98102E-04
7.50	0.73576E-06	0.61666E-04
7.60	0.10441E-06	0.33671E-04
7.70	0.20649E-05	0.14791E-04
7.80	0.58144E-05	0.44326E-05
7.90	0.10147E-04	0.10209E-05
8.00	0.13801E-04	0.24151E-05
8.10	0.15787E-04	0.63672E-05
8.20	0.15625E-04	0.10925E-04
8.30	0.13436E-04	0.14694E-04
8.40	0.98601E-05	0.16950E-04
8.50	0.58594E-05	0.17572E-04
8.60	0.24406E-05	0.16886E-04
8.70	0.39381E-06	0.15441E-04
8.80	0.10130E-06	0.13802E-04
8.90	0.14670E-05	0.12420E-04
9.00	0.39730E-05	0.11575E-04
9.10	0.68424E-05	0.11413E-04
9.20	0.92565E-05	0.12034E-04
9.30	0.10570E-04	0.13590E-04
9.40	0.10465E-04	0.16358E-04
9.50	0.90138E-05	0.20749E-04
9.60	0.66335E-05	0.27245E-04
9.70	0.39574E-05	0.36285E-04
9.80	0.16582E-05	0.48118E-04
9.90	0.27140E-06	0.62676E-04

ANGLE	RAD. PATTERN UNBLOCKED	RAD. PATTERN BLOCKED
*****	*****	*****
5.05	0.11539E-04	0.13008E-02
5.15	0.17312E-05	0.10948E-02
5.25	0.55281E-06	0.90631E-03
5.35	0.69658E-05	0.74269E-03
5.45	0.18055E-04	0.60750E-03
5.55	0.30000E-04	0.50100E-03
5.65	0.39178E-04	0.42115E-03
5.75	0.43097E-04	0.36466E-03
5.85	0.40929E-04	0.32784E-03
5.95	0.33561E-04	0.30713E-03
6.05	0.23186E-04	0.29929E-03
6.15	0.12597E-04	0.30129E-03
6.25	0.43936E-05	0.32249E-03
6.35	0.31837E-06	0.33495E-03
6.45	0.87897E-06	0.34390E-03
6.55	0.53276E-05	0.34605E-03
6.65	0.11971E-04	0.33882E-03
6.75	0.18696E-04	0.32082E-03
6.85	0.23563E-04	0.29213E-03
6.95	0.25291E-04	0.25436E-03
7.05	0.23541E-04	0.21037E-03
7.15	0.18920E-04	0.16390E-03
7.25	0.12747E-04	0.11891E-03
7.35	0.66452E-05	0.78924E-04
7.45	0.20977E-05	0.46540E-04
7.55	0.69620E-07	0.23102E-04
7.65	0.79775E-06	0.86265E-05
7.75	0.37857E-05	0.19843E-05
7.85	0.79897E-05	0.12604E-05
7.95	0.12131E-04	0.42044E-05
8.05	0.15046E-04	0.86726E-05
8.15	0.15981E-04	0.12969E-04
8.25	0.14754E-04	0.16032E-04
8.35	0.11766E-04	0.17453E-04
8.45	0.78480E-05	0.17362E-04
8.55	0.40202E-05	0.16221E-04
8.65	0.12107E-05	0.14614E-04
8.75	0.23084E-07	0.13057E-04
8.85	0.60077E-06	0.11919E-04
8.95	0.26224E-05	0.11403E-04
9.05	0.54151E-05	0.11619E-04
9.15	0.81531E-05	0.12681E-04
9.25	0.10079E-04	0.14800E-04
9.35	0.10699E-04	0.18321E-04
9.45	0.98886E-05	0.23704E-04
9.55	0.79033E-05	0.31425E-04
9.65	0.52892E-05	0.41849E-04
9.75	0.27221E-05	0.55077E-04
9.85	0.82657E-06	0.70849E-04
9.95	0.16810E-07	0.70849E-04

IRE USAGE OBJECT CODE= 35538 BYTES, ARRAY AREA= 30088 BYTES, TO
 DIAGNOSTICS NUMBER OF ERRORS= 0, NUMBER OF WARNINGS= 0
 IMPILE TIME= 0.78 SEC, EXECUTION TIME= 66.77 SEC, WATFIV - JUL 1



CASSEGRAIN ANTENNA SYSTEM

INPUT DATA

POLYNOMIAL COEFFICIENTS ARE:
COEFFICIENT(1) = 0.1000017E 01
COEFFICIENT(2) = -C.2523651E 01
COEFFICIENT(3) = 0.3150043E 01
COEFFICIENT(4) = -0.2477787E 01
COEFFICIENT(5) = 0.1205810E 01
COEFFICIENT(6) = -0.274853CE 00
ROT = 0.00 DEGREES
EPSI = 64.00 DEGREES
DIAM = 48.00 LAMDA
R1 = 0.8000 D/2 RATIO
R2 = 0.1667 D/2 RATIO
RC = 0.1557 D/2 RATIO
W = 0.0200 D/2 RATIO

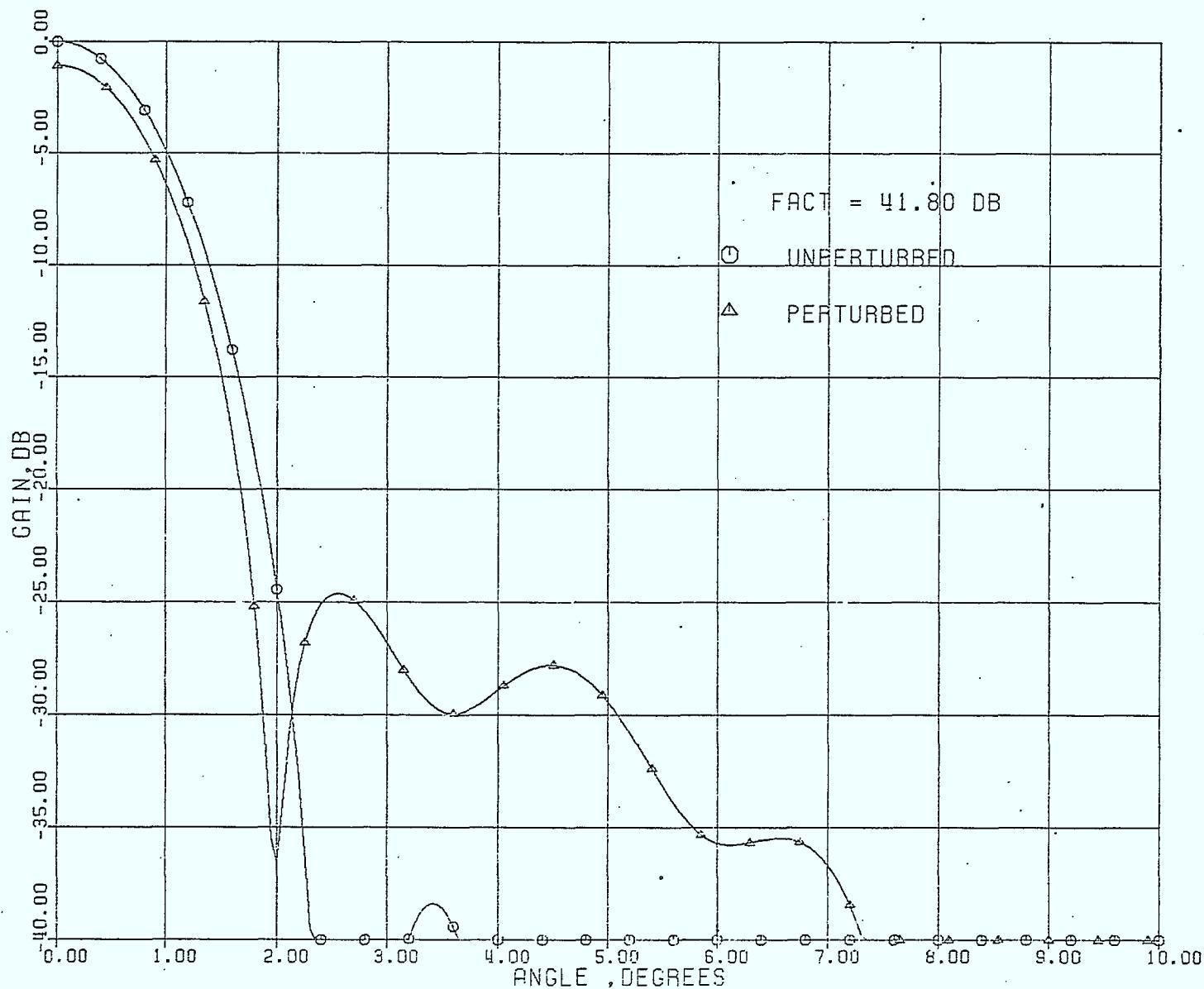
OUTPUT DATA

APERATURE EFFICIENCY	= 67.42	%
BLOCKED EFFICIENCY	= 52.73	%
APERATURE GAIN IN DBS	= 41.86	DBS
LOSS DUE TO BLOCKAGE	= 21.89	%
LOSS DUE TO BLOCKAGE	= 1.07	DBS

ANGLE	RAD.	PATTERN	RAD.	PATTERN	ANGLE	RAD.	PATTERN	RAD.	PATTERN
	UNBLOCKED	BLOCKED		UNBLOCKED	BLOCKED		UNBLOCKED	BLOCKED	
*** * * *	*** * * * * * * * * *	*** * * * * * * * * *	*** * * *	*** * * * * * * * * *	*** * * *	*** * * * * * * * * *	*** * * *	*** * * * * * * * * *	*** * * *
0.00	0.13085E+01	0.10233E+01	0.05	0.13050E+01	0.10213E+01	0.10	0.99981E+00	0.99981E+00	0.10
0.10	0.12946E+01	0.10134E+01	0.15	0.12773E+01	0.99981E+00	0.20	0.95623E+00	0.95623E+00	0.20
0.20	0.12536E+01	0.98065E+00	0.25	0.12236E+01	0.89315E+00	0.30	0.89315E+00	0.89315E+00	0.30
0.30	0.11879E+01	0.92692E+00	0.35	0.11469E+01	0.81428E+00	0.40	0.81428E+00	0.81428E+00	0.40
0.40	0.11012E+01	0.85543E+00	0.45	0.10515E+01	0.72403E+00	0.50	0.72403E+00	0.72403E+00	0.50
0.50	0.99829E+00	0.77028E+00	0.55	0.94237E+00	0.62719E+00	0.60	0.62719E+00	0.62719E+00	0.60
0.60	0.88440E+00	0.57613E+00	0.65	0.82509E+00	0.43286E+00	0.70	0.43286E+00	0.43286E+00	0.70
0.70	0.76512E+00	0.57781E+00	0.75	0.70514E+00	0.34286E+00	0.80	0.34286E+00	0.34286E+00	0.80
0.80	0.64578E+00	0.47997E+00	0.85	0.58761E+00	0.26242E+00	0.90	0.26242E+00	0.26242E+00	0.90
0.90	0.53114E+00	0.38670E+00	0.95	0.47683E+00	0.19310E+00	1.00	0.19310E+00	0.19310E+00	1.00
1.00	0.42507E+00	0.30135E+00	1.15	0.37619E+00	0.13580E+00	1.10	0.13580E+00	0.13580E+00	1.10
1.20	0.33044E+00	0.22633E+00	1.25	0.21339E+00	0.90493E+00	1.30	0.90493E+00	0.90493E+00	1.30
1.40	0.24895E+00	0.16293E+00	1.35	0.15259E+00	0.56422E+00	1.50	0.56422E+00	0.56422E+00	1.50
1.50	0.12717E+00	0.72125E-01	1.45	0.10488E+00	0.32259E+00	1.60	0.32259E+00	0.32259E+00	1.60
1.60	0.85547E-01	0.43200E-01	1.55	0.68956E-C1	0.16333E+00	1.70	0.16333E+00	0.68465E+00	1.70
1.70	0.54880E-01	0.23378E-01	1.65	0.43081E-C1	0.20476E+00	1.80	0.20476E+00	0.37138E+00	1.80
1.80	0.33318E-C1	0.10897E-01	1.75	0.25350E-C1	0.52731E+00	1.90	0.52731E+00	0.99364E+00	1.90
1.90	0.99373E-02	0.90693E-03	1.85	0.13876E-01	0.27354E+00	2.00	0.27354E+00	0.63964E+00	2.00
2.00	0.47002E-02	0.28889E-03	1.95	0.69364E-02	0.37247E+00	2.10	0.37247E+00	0.19301E-02	2.10
2.20	0.19301E-02	0.97452E-03	2.05	0.30758E-02	0.27354E+00	2.30	0.27354E+00	0.32668E+00	2.30
2.40	0.64106E-03	0.21439E-02	2.15	0.11500E-02	0.32668E+00	2.50	0.32668E+00	0.52292E+00	2.50
2.50	0.14611E-03	0.32715E-02	2.25	0.32668E-03	0.43286E+00	2.60	0.43286E+00	0.55491E+00	2.60
2.60	0.12325E-04	0.40790E-02	2.35	0.52787E-04	0.45222E+00	2.70	0.45222E+00	0.77138E+00	2.70
2.70	0.14362E-05	0.44739E-02	2.45	0.52292E-06	0.43740E+00	2.80	0.43740E+00	0.39929E+00	2.80
2.80	0.81174E-05	0.44845E-02	2.55	0.77138E-05	0.34929E+00	2.90	0.34929E+00	0.17365E+00	2.90
2.90	0.50010E-05	0.42051E-02	2.65	0.17365E-05	0.29670E+00	3.00	0.29670E+00	0.19945E+00	3.00
3.00	0.11938E-07	0.37512E-02	2.75	0.17089E-05	0.24819E+00	3.10	0.24819E+00	0.58194E+00	3.10
3.10	0.81542E-05	0.32281E-02	2.85	0.19945E-04	0.20747E+00	3.20	0.20747E+00	0.10770E+00	3.20
3.20	0.36912E-04	0.27165E-02	2.95	0.58194E-04	0.17598E+00	3.30	0.17598E+00	0.15414E+00	3.30
3.30	0.82379E-04	0.22672E-02	3.05	0.10770E+00	0.15369E+00	3.40	0.15369E+00	0.18379E+00	3.40
3.40	0.13224E-03	0.19055E-02	3.15	0.15414E+00	0.13386E+00	3.50	0.13386E+00	0.18846E+00	3.50
3.50	0.17174E-03	0.16373E-02	3.25	0.18379E+00	0.13331E+00	3.60	0.13331E+00	0.16772E+00	3.60
3.60	0.18946E-03	0.14576E-02	3.35	0.18846E+00	0.12830E+00	3.70	0.12830E+00	0.12830E+00	3.70
3.70	0.18099E-03	0.13573E-02	3.45	0.18846E+00	0.11598E+00	3.80	0.11598E+00	0.38907E+00	3.80
3.80	0.14971E-03	0.13259E-02	3.55	0.16772E+00	0.11333E+00	3.90	0.11333E+00	0.16772E+00	3.90
3.90	0.10500E-03	0.13539E-02	3.65	0.12830E+00	0.13387E+00	4.00	0.13387E+00	0.81372E+00	4.00
4.00	0.58901E-04	0.14317E-02	3.75	0.81372E+00	0.14858E+00	4.10	0.14858E+00	0.38907E+00	4.10
4.10	0.22449E-04	0.15480E-02	3.85	0.10275E+00	0.16165E+00	4.20	0.16165E+00	0.10275E+00	4.20
4.20	0.27841E-05	0.16894E-02	3.95	0.24088E+C7	0.17644E+00	4.30	0.17644E+00	0.72754E+C5	4.30
4.30	0.17117E-05	0.18393E-02	4.05	0.24088E+C7	0.20406E+00	4.40	0.20406E+00	0.21616E+00	4.40
4.40	0.15915E-04	0.19797E-02	4.15	0.72754E+C5	0.19119E+00	4.50	0.19119E+00	0.21333E+00	4.50
4.50	0.38512E-04	0.20924E-02	4.25	0.26673E+00	0.21766E+00	4.60	0.21766E+00	0.50395E+00	4.60
4.60	0.61356E-04	0.21618E-02	4.35	0.50395E+00	0.21625E+00	4.70	0.21625E+00	0.70562E+00	4.70
4.70	0.77366E-04	0.21770E-02	4.45	0.70562E+00	0.21333E+00	4.80	0.21333E+00	0.81335E+00	4.80
4.80	0.82268E-04	0.21334E-02	4.55	0.81335E+00	0.20900E+00	4.90	0.20900E+00	0.80196E+00	4.90
4.90	0.75363E-04	0.20334E-02	4.65	0.80196E+00	0.19646E+00		0.19646E+00	0.68194E+00	
	0.59259E-04	0.18852E-02	4.75	0.68194E+00	0.17970E+00		0.17970E+00	0.49216E+00	
	0.38766E-04	0.17019E-02	4.85	0.49216E+00	0.16018E+00		0.16018E+00	0.28598E+00	
			4.95	0.28598E+00					

ANGLE	RAD.	PATTERN UNBLOCKED	RAD.	PATTERN BLOCKED	ANGLE	RAD.	PATTERN UNBLOCKED	RAD.	PATTERN BLOCKED
*****	*****	*****	*****	*****	*****	*****	*****	*****	*****
5.00	0.19345E-04	0.14986E-02	5.05	0.111539E-04	0.13943E-02				
5.10	0.55841E-05	0.12907E-02	5.15	0.17312E-05	0.11893E-02				
5.20	0.75156E-07	0.10916E-02	5.25	0.55281E-06	0.99859E-03				
5.30	0.29585E-05	0.91129E-03	5.35	0.69658E-05	0.83035E-03				
5.40	0.12157E-04	0.75620E-03	5.45	0.18055E-04	0.68907E-03				
5.50	0.24164E-04	0.52900E-03	5.55	0.30000E-04	0.57588E-03				
5.60	0.35126E-04	0.52946E-03	5.65	0.39178E-04	0.48943E-03				
5.70	0.41889E-04	0.45537E-03	5.75	0.43097E-04	0.42687E-03				
5.80	0.42756E-04	0.40348E-03	5.85	0.40929E-04	0.38473E-03				
5.90	0.37781E-04	0.37018E-03	5.95	0.33561E-04	0.35940E-03				
6.00	0.28579E-04	0.35197E-03	6.05	0.23186E-04	0.34747E-03				
6.10	0.17742E-04	0.34555E-03	6.15	0.12597E-04	0.34565E-03				
6.20	0.80619E-05	0.34751E-03	6.25	0.43936E-05	0.35064E-03				
6.30	0.17772E-05	0.35462E-03	6.35	0.31837E-06	0.35898E-03				
6.40	0.38817E-07	0.36329E-03	6.45	0.87897E-06	0.36708E-03				
6.50	0.27066E-05	0.36990E-03	6.55	0.53276E-05	0.37134E-03				
6.60	0.85039E-05	0.37103E-03	6.65	0.111971E-04	0.36855E-03				
6.70	0.15455E-04	0.36372E-03	6.75	0.18696E-04	0.35633E-03				
6.80	0.21462E-04	0.34625E-03	6.85	0.23563E-04	0.33349E-03				
6.90	0.24864E-04	0.31812E-03	6.95	0.25291E-04	0.30034E-03				
7.00	0.24833E-04	0.28043E-03	7.05	0.23541E-04	0.25866E-03				
7.10	0.21519E-04	0.23554E-03	7.15	0.18920E-04	0.21151E-03				
7.20	0.15927E-04	0.18707E-03	7.25	0.12747E-04	0.16269E-03				
7.30	0.95859E-05	0.13893E-03	7.35	0.66452E-05	0.11624E-03				
7.40	0.41011E-05	0.95018E-04	7.45	0.20977E-05	0.75637E-04				
7.50	0.73576E-06	0.58375E-04	7.55	0.69620E-07	0.43427E-04				
7.60	0.10441E-06	0.30906E-04	7.65	0.79775E-06	0.20835E-04				
7.70	0.20649E-05	0.13151E-04	7.75	0.37857E-05	0.77210E-05				
7.80	0.58144E-05	0.43452E-04	7.85	0.79897E-05	0.27739E-05				
7.90	0.10147E-04	0.27215E-04	7.95	0.12131E-04	0.38820E-05				
8.00	0.13801E-04	0.59431E-05	8.05	0.15046E-04	0.86025E-05				
8.10	0.15787E-04	0.11579E-04	8.15	0.15981E-04	0.14623E-04				
8.20	0.15625E-04	0.17525E-04	8.25	0.14754E-04	0.20119E-04				
8.30	0.13436E-04	0.22287E-04	8.35	0.11766E-04	0.23956E-04				
8.40	0.98601E-05	0.25094E-04	8.45	0.78450E-05	0.25712E-04				
8.50	0.58594E-05	0.25848E-04	8.55	0.40202E-05	0.25567E-04				
8.60	0.24406E-05	0.24947E-04	8.65	0.12107E-05	0.24079E-04				
8.70	0.39381E-06	0.23052E-04	8.75	0.23084E-07	0.21951E-04				
8.80	0.10130E-06	0.20855E-04	8.85	0.60077E-06	0.19828E-04				
8.90	0.14670E-05	0.18923E-04	8.95	0.26224E-05	0.18178E-04				
9.00	0.39730E-05	0.17620E-04	9.05	0.54151E-05	0.17265E-04				
9.10	0.68424E-05	0.17124E-04	9.15	0.81531E-05	0.17203E-04				
9.20	0.92565E-05	0.17511E-04	9.25	0.10079E-04	0.18059E-04				
9.30	0.10570E-04	0.18864E-04	9.35	0.10699E-04	0.19951E-04				
9.40	0.10465E-04	0.21355E-04	9.45	0.98886E-05	0.23115E-04				
9.50	0.90138E-05	0.25279E-04	9.55	0.79033E-05	0.27899E-04				
9.60	0.66335E-05	0.31023E-04	9.65	0.52892E-05	0.34698E-04				
9.70	0.39574E-05	0.38964E-04	9.75	0.27221E-05	0.43842E-04				
9.80	0.16582E-05	0.49341E-04	9.85	0.82657E-06	0.55450E-04				
9.90	0.27140E-06	0.62133E-04	9.95	0.16810E-07	0.69334E-04				

CORE USAGE OBJECT CODE= 35538 BYTES, ARRAY AREA= 30088 BYTES, TO
DIAGNOSTICS NUMBER OF ERRORS= 0, NUMBER OF WARNINGS= 1
COMPILE TIME= 0.77 SEC, EXECUTION TIME= 66.74 SEC, WATFIV - JUL 1



APPENDIX ACOMPUTER PROGRAM FOR THE TOTAL DIRECTIVE GAIN PATTERNPurpose:

This program computes the total directive gain pattern near the main axis of radiation for front-fed paraboloid/dual reflector antenna systems when blocked by the feed-subreflector and n equi-angular struts.

Language:

WATFIV/FORTRAN IV

Author:

O. Aboul-Atta, Department of Electrical Engineering,
University of Manitoba.

Description:

The directive gain pattern has been calculated according to

$$gt(\theta, \phi) = g_0(\theta, \phi) - g_{CB}(\theta, \phi) - A_{PS}g_{PS}(\theta, \phi) - g_{SS}(\theta, \phi)$$

where g_0 represents the unblocked aperture pattern, g_{CB} is the central blockage due to subreflector/flange of the feed, g_{PS} is the contribution of the plane wave shadows, g_{SS} is the contribution due to spherical waves, and A_{PS} is the weighting factor that includes the effect of the struts tilt.

Input Variables:

In terms of the following data cards:

- (1) DIAM, R1, R2, RC, EPSI, W
- (2) ROT, PHIAN, R11, RC1, W1, W2
- (3) NCN, NPSH, NSPSH, IT, NSTRT
- (4) ANG (I), I = 1, 2, ..., NSTRT
- (5) COFCN (I), I = 1, 2, ..., NCN
- (6) COEFF (I), I = 1, 2, ..., NPSH
- (7) COFSP (I), I = 1, 2, ..., NSPSH

The design parameters (self explained in the program comment statements) are printed as data to be read by the program. The main dish diameter is given in wavelength λ , and all other dimensions are given to the program as a ratio of the dish radius.

Output:

The existing output is a printout of the input data for checking, the aperture efficiency, the aperture blocked efficiency, the loss due to blockage in percentage and in dB. Also a printout of g_0 and g_t in steps of 0.05 degree along the first 10 degrees off the main axis of radiation. The program does punch these data points on cards to be used later with the plotter for graphical display whenever necessary.

\$JOB WATEIV ABOUL ATTA (APERTURE BLOCKAGE)
 C---THIS PROGRAM CALCULATES THE BLOCKAGE OF SIMPLE CASSEGRAIN ANTENNA,
 C---DUE TO THE SUBREFLECTOR AND A TRI-STRUT SUPPORT STRUCTURE.
 C---IT DOES ALSO CALCULATE THE BLOCKAGE DUE TO A FRONT-FED PARABOLOID
 C---WITH AN EXPERIMENTAL FEED "SHAFAI" WITH ITS RIGID VERTICAL CYLIN-
 C---DRICAL SUPPORT AND A TRI-WIRE ASSISTING SUPPORT TO BE USED AT "CRC".
 C---DIAM = DIAMETER OF THE DISH IN WAVE LENGTH.
 C---R1 = THE START OF THE SPHERICAL SHADOW (RATIO OF D/2).
 C---R2 = RADIUS OF THE SUBREFLECTOR OR THE FLANGE OF THE FEED (RATIO).
 C---RC = RADIUS OF CURVATURE (BEND) OF THE FEED SUPPORT (RATIO OF D/2).
 C--- IT IS ALSO USED AS THE RADIAL DISTANCE OF THE STRUT IN THE
 C--- FOCAL PLANE OF A CASSEGRAIN ANTENNA SYSTEM.
 C---EPSI = ANGLE OF FLOODING FROM THE FOCUS TO THE EDGE OF THE REFLECTOR.
 C---W = RATIO OF THE STRUT RADIUS TO THAT OF THE MAIN DISH.
 C---NCN = NO. OF TERMS IN THE POLYNOMIAL REPRESENTATION OF THE CENTRAL
 C--- SHADOW.
 C---NPSH = NO. OF TERMS IN THE POLYNOMIAL REPRESENTATION OF THE PLANE
 C--- SHADOW.
 C---NSPSH = NO. OF TERMS IN THE POLYNOMIAL REPRESENTATION OF THE SPHERI-
 C--- CAL SHADOW.
 C---ANG(I) = IS THE ANGLE BETWEEN THE I.TH. STRUT AND MAIN POLARIZATION.
 C---TILT = INCLINATION OF THE SUPPORT WITH THE HORIZONTAL.
 C---ANG(1) = ANGLE OF THE 1.ST. SUPPORT WITH THE MAIN POLARIZATION.
 C---ANG(2) = ANGLE OF THE 2.ED. SUPPORT WITH THE MAIN POLARIZATION.
 C---ANG(3) = ANGLE OF THE 3.ED. SUPPORT WITH THE MAIN POLARIZATION.
 C---ROT = THE ANGLE OF THE PLANE OF INTEREST RELATIVE TO THAT OF THE
 C--- MAIN POLARIZATION PLANE.
 C---IT = AN INTEGER OF VALUE 1 FOR CASSEGRAIN ANTENNA AND 0 OTHERWISE.
 C---PHIAN = ANGLE OF THE MAIN FEED STRUCTURE RELATIVE TO THE E-PLANE.
 C---THE APERTURE FIELD DISTRIBUTION IN THE CENTERAL AREA.
 C---COFCN(I)'S ARE THE COEFFICIENTS OF THE POLYNOMIAL REPRESENTATION OF
 C---COEFF(I)'S ARE THE COEFFICIENTS OF THE POLYNOMIAL REPRESENTATION OF
 C---THE APERTURE FIELD DISTRIBUTION IN THE PLANE SHADOW AREA.
 C---COFSP(I)'S ARE THE COEFFICIENTS OF THE POLYNOMIAL REPRESENTATION OF
 C---THE APERTURE FIELD DISTRIBUTION IN THE SPHERICAL SHADOW AREA.
 C---IN GENERAL WE HAVE COFCN(I)=COEFF(I)=COFSP(I).
 C---R11 = THE START OF THE SPHERICAL SHADOW OF THE TRI-WIRE SUPPORT OF
 C--- SHAFAI'S FRONT-FED PARABOLOID.
 C---RC1 = TO BE TAKEN AS HALF THE FLANGE'S RADIUS (RATIO OF D/2) IN THE
 C--- CASE OF SHAFAI'S FRONT-FED PARABOLOID.
 C---W1 = RATIO OF THE WIRE RADIUS TO THAT OF THE MAIN DISH IN THE CASE
 C--- OF THE TRI-WIRE SUPPORT OF SHAFAI'S FRONT-FED PARABOLOID.
 C---W2 = HALF THE WIDTH OF THE PLANE-SHADOW IN SHAFAI'S CASE.
 C---NSTRT = THE NO. OF THE EQUALLY SPACED STRUTS USED FOR SUPPORT.
 COMMON /A(3,20),PHI(20),COEFF(15),COFSP(15),CUCFN(15),EPSI,R1
 ,R2,U,V,W,KOT,IT,MN,MM,ALT4(10),AGT4(20),ASST(20),RC
 ,TWIRE(20),FCTR(3),FRE,FRH
 REAL CN(20),DISH(20),CNRD,ANG(19),FRDP(20)
 READ39,DIAM,R1,R2,RC,EPSI,W
 READ39,ROT,PHIAN,R11,RC1,W1,W2
 READ37,NCN,NPSH,NSPSH,IT,NSTRT
 READ39,(ANG(I),I=1,NSTRT)
 READ38,(CUCFN(I),I=1,NCN)
 READ38,(COEFF(I),I=1,NPSH)
 READ38,(COFSP(I),I=1,NSPSH)
 PRINT14
 IF (IT.EQ.1) PRINT15
 IF (IT.EQ.0) PRINT17
 PRINT16
 PRINT18
 PRINT19
 PRINT35
 DO 0 I=1,NPSH
 WRITE(6,36)I,COEFF(I)
 WRITE(6,40)ROT

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21 WRITE(6,27)EPSI
22 WRITE(6,22)DIAM
23 WRITE(6,23)R1
24 WRITE(6,24)R2
25 WRITE(6,25)RC
26 WRITE(6,26)W
27 IF (IT.EQ.0) WRITE(6,43)R11
28 IF (IT.EQ.0) WRITE(6,44)RC1
29 IF (IT.EQ.0) WRITE(6,42)W1
30 IF (IT.EQ.0) WRITE(6,41)W2
31 PRINT20
32 PRINT21
33 NSTEP =20
34 MRNG =201
35 PI =4.*ATAN(1.0)
36 SCALE =1.0/NSTEP
37 DO4F =TAN(0.5*EPSI*PI/180.)
38 ALFA =ATAN(0.5*(1.-(R1*DO4F)**2)/((R1-RC)*DO4F))
39 TILT =ALFA*180./PI
40 IF (IT.EQ.0) TILT=30.
41 IF (IT.EQ.0) ALFA=PI*TILT/180.
42 U00 =PI*DIAM
43 CR =PI*SCALE/180.
44 CALL GTLT(NCN)
45 Y =PI*(ROT-PHIAN)/180.
46 CS =COS(Y)
47 SN =SIN(Y)
48 IF (R1.LT.1.0) CALL ARRSH
49 DO 1 I=1,MRNG
50 J =I-1
51 UU =UU*SIN(CR*j)
52 UX =UU*R2
53 U =UU*CS
54 V =UU*SN
55 CALL CRSYM(UX,NCN,CNRD)
56 CN(I) =2.*PI*CNRD
57 TUT(I) =CN(I)
58 IF (IT.EQ.1) GO TO 1
C---THE FOLLOWING TWO STATEMENTS READJUST THE PLANE-SHADOW WIDTH FOR
C---THE MAIN MOUNTING SUPPORT OF SHAFAI'S FRONT-FED PRABULOID.
59 CHNGW =W
60 W =W2
61 CALL PSHRD(NPSH,RAD)
62 W =CHNGW
63 PL(I) =RAD
64 RAD =(0.00.)
65 IF (R1.LT.1.0) CALL SPHRD(NPSH,RAD)
66 SH(I) =RAD
67 TOT(I) =CN(I)+PL(I)+SH(I)
68 1 CONTINUE
69 CHNG2 =R2
70 R2 =1.
71 CALL GTLT(NCN)
72 DO 2 I=1,MRNG
73 J =I-1
74 UU =UU*SIN(CR*j)
75 CALL CRSYM(UU,NPSH,CNRD)
76 DISH(I) =2.*PI*CNRD
77 IF (IT.EQ.1) GO TO 2
78 RAD =DISH(I)-TOT(I)
79 X =CABS(RAD)
80 2 CONTINUE
81 R2 =CHNG2
82 IF (IT.EQ.1) GO TO 3
C---THE FOLLOWING SIX STATEMENTS INPUT THE DIMENSIONS OF THE TRI-WIRE
C---SUPPORT OF SHAFAI'S FRONT FED PRABOLOID.

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83 CHNGW      =W
84 CHNGY      =R1
85 CHNGC      =RC
86 W          =WL
87 RC         =RC1
88 R1         =R11
89 IF (R1.LT.1.0) CALL ARRSH
90 DO 4       K=1,NSTRT
91 Y          =PI*(ROT-ANG(K))/180.
92 CS         =COS(Y)
93 SN         =SIN(Y)
94 DO 4       I=1,MRNG
95 J          =I-1
96 UU        =UU*SIN(CR*j)
97 U          =UU*CS
98 V          =UU*SN
99 UX        =UU*R2
100 CALL     PS4RD(NPSH,RAD)
101 PLW(K,I) =RAD
102 RAD       =(0.,0.)
103 IF (R1.LT.1.0) CALL SPHRD(NSPSH,RAD)
104 SHW(K,I) =RAD
105 DO 6       I=1,MRNG
106 TWIRE(I) =(0.,0.)
107 DO 5       J=1,NSTRT
108 TWIRE(I) =TWIRE(I)+PLW(J,I)*SHW(J,I)
109 CONTINUE
110 YY        =PI*DIAM*w*COS(ALFA)
111 CALL     IFRC(YY,FRE,FRH)
112 DO 7       I=1,NSTRT
113 YYY       =PI*ANG(I)/180.
114 FCTR(I)  =-(FRE*COS(YYY)**2+FRH*SIN(YYY)**2)
115 DO 9       I=1,201
116 TWIRE(I) =(0.,0.)
117 DO 8       J=1,NSTRT
118 TWIRE(I) =TWIRE(I)+SHW(J,I)+FCTR(J)*PLW(J,I)
119 TOT(I)    =TOT(I)+TWIRE(I)
120 RAD       =DISH(I)-TOT(I)
121 X          =CABS(RAD)**2
122 DISH(I)   =DISH(I)**2
123 FRDP(I)   =X
124 CONTINUE
125 BLKDB     =10.* ALOG10(DISH(1)/FRDP(1))
126 PLSS      =100.* (DISH(1)-FRDP(1))/DISH(1)
127 FORMAT('1p // / / / T5p ANGLE RAD. PATTERN RAD. PATTERN' ANGLE RAD.
128 , PATTERN RAD. PATTERN')
129 FORMAT('1p T5, ' UNBLOCKED BLOCKED UNBLOCKED
130 , BLOCKED ')
131 FORMAT('1p T5, F5.2,1X,E12.5,1X,E12.5,4X,F5.2,1X,E12.5,1X,E12.5')
132 FORMAT('1p // / / / / / / T25, * * * * * * * * * * * * * * * * * * * * * * ')
133 FORMAT('1p T25, ' CASSEGRAIN ANTENNA SYSTEM')
134 FORMAT('1p T25, ' FRONT-FED PARABULOID')
135 FORMAT('1p T25, ' INPUT DATA')
136 FORMAT('1p T25, ' -----)
137 FORMAT('1p T25, ' OUTPUT DATA')
138 FORMAT('1p T25, ' -----)
139 FORMAT('1p T25, ' DIAM =',F7.2,' LAMDA')
140 FORMAT('1p T25, ' R1 =',F7.4,' D/2 RATIO')
141 FORMAT('1p T25, ' R2 =',F7.4,' D/2 RATIO')
142 FORMAT('1p T25, ' RC =',F7.4,' D/2 RATIO')
143 FORMAT('1p T25, ' W =',F7.4,' D/2 RATIO')
144 FORMAT('1p T25, ' EPSI =',F7.2,' DEGREES')
145 FORMAT('1p T25, ' LOSS DUE TO BLOCKAGE =',F5.2, DBS)

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146
147      FORMAT( "   T25,0 LOSS DUE TO BLOCKAGE= ", F5.2, " % " )
148      CALL      UNBLK(NPSH,XX)
149      YY      =FRDP(1)/DISH(1)
150      YY      =YY*XX
151      WRITE(6,32) XX
152      WRITE(6,33) YY
153      ANTNG    =10.* ALOG10(((PI*DIAM)**2)*XX/100.)
154      WRITE(6,34) ANTNG
155      WRITE(6,29) PLOSS
156      WRITE(6,28) BLKDB
157      PRINT10
158      PRINT11
159      PRINT12
160      DO 30    I=1,50
161      X       =2*(I-1)*SCALE
162      Y       =(2*I-1)*SCALE
163      J       =2*I-1
164      K       =J+1
165      30      WRITE(6,13) X,DISH(J),FRDP(J),Y,DISH(K),FRDP(K)
166      PRINT10
167      PRINT11
168      PRINT12
169      DO 31    I=51,100
170      X       =2*(I-1)*SCALE
171      Y       =(2*I-1)*SCALE
172      J       =2*I-1
173      K       =J+1
174      31      WRITE(6,13) X,DISH(J),FRDP(J),Y,DISH(K),FRDP(K)
175      FORMAT( "   T25,0 APERTURE EFFICIENCY = ", F5.2, " % " )
176      FORMAT( "   T25,0 BLOCKED EFFICIENCY = ", F5.2, " % " )
177      FORMAT( "   T25,0 APERTURE GAIN IN DBS= ", F5.2, " DBS" )
178      FORMAT( "   T25,0 POLYNOMIAL COEFFICIENTS ARE: " )
179      FORMAT( "   T25,0 COEFFICIENT(1,1)= ", E14.7 )
180      FORMAT( 5I16 )
181      FORMAT( 5E16.7 )
182      FORMAT( 6F13.7 )
183      FORMAT( "   T25,0 ROT     = ", F7.2, " DEGREES" )
184      FORMAT( "   T25,0 W2      = ", F9.7, " D/2 RATIO" )
185      FORMAT( "   T25,0 W1      = ", F9.7, " D/2 RATIO" )
186      FORMAT( "   T25,0 R11     = ", F9.7, " D/2 RATIO" )
187      FORMAT( "   T25,0 RC1     = ", F9.7, " D/2 RATIO" )
188      RETURN
189      END
190
191      SUBROUTINE GTLT(NCN)
192      COMMON      A(3,20),PHI(20),COEFF(15),COFSP(15),COFCN(15),EPSI,PKI
193      ,R2,U,V,W,ROT,PIT,MM,MMM,ALT4(10),AGT4(20),ASST(20),RC
194      ,DOUBLE PRECISION POLY
195      N      =NCN-1
196      X      =X/2
197      XSQ    =X*X/2
198      ALT4(1) =0.5
199      DO 1    I=1,9
200      1    ALT4(I+1)=-4.*ALT4(I)/(I**2)
201      DO 3    J=1,10
202      3    POLY   =XSQ*COFCN(N+1)/(N+J)
203      IF (N.EQ.0) GO TO 3
204      DO 2    I=1,N
205      2    POLY   =XSQ*(POLY+COFCN(N+1-I)/(N+J-I))
206      ALT4(J) =ALT4(J)*POLY
207      L      =N+1
208      K      =1
209      DO 4    I=1,L
4    AGT4(I) =.5*K*(XSQ**I)/I
      K      =-K
      DO 7    J=1,L

```

```

210
211      M      =N+2-J
212      K      =1
213      DO 5   I=1,M
214      ASST(I) =K*COFCN(J+I-1)
215      K      =K*(J+I-1)/I
216      POLY   =ASST(M)
217      IF (M.EQ.1) GO TO 7
218      K      =M-1
219      DO 6   I=1,K
220      POLY   =POLY*XSQ+ASST(M-I)
221      AGT4(J) =AGT4(J)*POLY
222      RETURN
223      END

SUBROUTINE CRSYM(UX,M,RAD)
COMMON B(3,20),PHI(20),COEFF(15),COFSP(15),COFCN(15),EPSI,RI
      ,R2,U,V,W,ROT,IT,MM,MMM,ALT4(10),AGT4(20),ASST(20),RC
      ,REAL*8, POLY(4),LAMDA(20),A(4,7) / -.78539810, 79788456,-2.35019449,
      ,79788456,-4.1663970-2,-7.70-7,1.2499612D-1,1.56D-6,-3.9540-3,-5.0
      ,274D-3,5.65D-5,1.659667D-2,2.62573D-3,-9.512D-5,-6.37879D-3,1.7105
      ,D-4,-5.4125D-4,1.37237D-3,7.4348D-4,-2.49511D-3,-2.9333D-4,-7.2805
      ,D-4,7.9824D-4,1.13053D-3,1.3558D-4,1.4476D-4,-2.9166D-4,-2.0033D-4
      ,
226      UXSQ   =UX**2
227      IF (UX.LT.4.0) GO TO 4
228      VR     =3./UX
229      DO 1   I=1,4
230      POLY(I) =A(I,6)+A(I,7)*VR
231      DO 1   J=1,5
232      POLY(I) =POLY(I)*VR+A(I,6-J)
233      CS1    =POLY(1)+UX
234      CS3    =POLY(3)+UX
235      LAMDA(1) =2.*POLY(4)*COS(CS3)/(UX*SQRT(UX))
236      LAMDA(2) =8.*((LAMDA(1)-POLY(2)*COS(CS1))/SQRT(UX))/UXSQ
237      DO 2   I=3,M
238      LAMDA(I) =4*I*(I-1)*(LAMDA(I-1)-LAMDA(I-2))/UXSQ
239      RAD    =0.
240      DO 3   I=1,M
241      RAD    =RAD+AGT4(I)*LAMDA(I)
242      GO TO 6
243      VR     =.6625*UXSQ
244      RAD    =ALT4(10)*VR+ALT4(9)
245      DO 5   I=1,8
246      RAD    =RAD*VR+ALT4(9-I)
247      RETURN
248      END

SUBROUTINE PSHRD(M,RAD)
DIMENSION Y(20)
COMPLEX X(20),XPIY,RAD
COMPLEX*16 POLY,DRAD,DCMPLX
COMMON A(3,20),PHI(20),COEFF(15),COFSP(15),COFCN(15),EPSI,RI
      ,R2,U,V,W,ROT,IT,MM,MMM,ALT4(10),AGT4(20),ASST(20),RC
      ,
249      DO 1   I=1,M
250      J      =I-1
251      Y(I)  =2.*REAL(XPIY(J,U,W))
252      X(I)  =XPIY(J,U,RI)
253      X(I)  =X(I)-XPIY(J,U,R2)
254      DRAD  =(0.D0,0.D0)
255      DO 3   I=1,M
256      POLY   =(0.D0,0.D0)
257      DO 2   K=1,I
258      POLY   =X(K)*Y(I+1-K)+(K-1)*POLY/(I+1-K)
259      DRAD  =DRAD+POLY*COEFF(I)
260      RAD    =DRAD
261      RETURN
262
263
264
265
266

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267      END

268      SUBROUTINE  ARRSH
269      COMMON      A(3,20), PHI(20), COEFF(15), COFSP(15), COFCN(15), EPSI, R1,
270                  , R2, U, V, W, ROT, IT, MM, MMM, ALT4(10), AGT4(20), ASST(20), RC
271      REAL        X, Y
272      A(1,1)      = 1.
273      A(2,1)      = SQRT(R1**2 - W**2)
274      A(3,1)      = 0.
275      A(1,2)      = SQRT(1. - W**2)
276      A(2,2)      = A(2,1)
277      A(3,2)      = W
278      CALL        PRMSH(R1, RC, W, EPSI, IT, 1, X, Y)
279      M           = 1. + (Y - W) / W
280      DELTA       = (1. - R1) / M
281      DO 1        I = 1, M
282      RV          = R1 + DELTA * I
283      CALL        PRMSH(R1, RC, W, EPSI, IT, RV, X, Y)
284      A(1, I+2)   = SQRT(1. - Y**2)
285      A(2, I+2)   = X
286      A(3, I+2)   = Y
287      A(1, M+2)   = A(2, M+2)
288      MM          = M + 2
289      MMM         = M + 1
290      RETURN
291      END

291      SUBROUTINE  SPHRD(NN, RAD)
292      COMMON      A(3,20), PHI(20), COEFF(15), COFSP(15), COFCN(15), EPSI, R1,
293                  , R2, U, V, W, ROT, IT, MM, MMM, ALT4(10), AGT4(20), ASST(20), RC
294      COMPLEX     EFF(20), INT(20,20), XPIY, RAD
295      COMPLEX*16   SUM, DRAD
296      INTEGER      COMB
297      DRAD         = (0.0D0, 0.0D0)
298      DO 4        I = 1, NN
299      SUM          = (0.0D0, 0.0D0)
300      COMB         = 1
301      DO 3        K = 1, I
302      INT(I,K)    = (0., 0.)
303      IMK          = I - K
304      KM1          = K - 1
305      DO 1        J = 1, MM
306      EFF(J)      = XPIY(IMK, U, A(1, J))
307      EFF(J)      = EFF(J) - XPIY(IMK, U, A(2, J))
308      PHI(J)      = REAL(XPIY(KM1, V, A(3, J)))
309      DO 2        J = 1, MM
310      INT(I, K)   = INT(I, K) + (EFF(J+1) + EFF(J)) * (PHI(J+1) - PHI(J))
311      SUM          = SUM + COMB * INT(I, K)
312      COMB         = COMB * (I - K) / K
313      DRAD         = DRAD + SUM * COFSP(I)
314      RAD          = DRAD
315      RETURN
316      END

316      SUBROUTINE  PRMSH(R1, R2, W, EPSI, IT, RV, X, Y)
317      REAL        X, Y, TN, MO, M1, M2
318      PI          = 4. * ATAN(1.)
319      TN          = TAN(EPSI * PI / 360.)
320      M2          = TAN(2. * ATAN(RV * TN))
321      MO          = TAN(2. * ATAN(R1 * TN))
322      IF (IT.EQ.1) GO TO 1
323      ALFA        = (R1 - R2) / R2
324      BETA        = R1 / (R2 * MO)
325      BSQM1       = BETA**2 - 1.
326      ALFSQ       = ALFA**2
327      XXX         = ALFSQ + BSQM1

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328      M1      =(ALFA*BETA-SQRT(XXX))/BSQM1
329      GO TO 2
330      1      M1      =(R1-R2)*MO/R1
331      2      GAMA    =(W*(1.-M1/M2))/(R1*(1.-M1/M0))
332      Y      =GAMA*RV
333      X      =SQRT(1.-GAMA**2)*RV
334      RETURN
335      END

336      SUBROUTINE IFRC(XS,RES,RHS)
337      C      SUBROUTINE TO CALCULATE THE INDUCED FIELD RATIOS.
338      C      X=2.0*3.14159265*COS(ALPHA)/WAVELENGTH
339      C      IMPLICIT REAL*8 (A-H,O-Z)
340      DIMENSION FJ(200),FY(200),FJP(200),FYP(200)
341      REAL XS
342      COMPLEX RES,RHS
343      COMPLEX*16 CSUM,CSUM1,DCMPLX,RE,RH,FTR,E,FTRH
344      X=XS
345      IF(X>80.0)100,100,150
346      150     RE=DCMPLX(-1.000,0.0D0)
347      RH=RE
348      RES=RE
349      RHS=RH
350      RETURN
351      100     NMAX=(2.2-X/100.)*X+12.0
352      50      NMAXL=NMAX-1
353      51      NMAXH=NMAX+1
354      C      CALCULATE BESSLE FUNCTIONS
355      FJ(NMAXH)=BES(X,NMAX)
356      FJ(NMAX)=BES(X,NMAXL)
357      DO 10 I=1,NMAXL
358      II=NMAX-I
359      10      FJ(II)=2.0*II*FJ(II+1)/X-FJ(II+2)
360      C      CALCULATE NEUMANN FUNCTIONS.
361      CALL BES0(X,FJ0,FY(1))
362      CALL BES1(X,FJ1,FY(2))
363      DO 15 I=3,NMAXH
364      II=I-1
365      IJ=I-2
366      15      FY(I)=2.0*IJ*FY(I)/X-FY(IJ)
367      C      CALCULATE THE DERIVATIVES OF BESSLE AND NEUMANN FUNCTIONS.
368      FJP(1)=-FJ(2)
369      FYP(1)=-FY(2)
370      DO 20 I=2,NMAXH
371      20      FJP(I)=FJ(I-1)-(I-1)*FJ(I)/X
372      FYP(I)=FY(I-1)-(I-1)*FY(I)/X
373      CSUM=DCMPLX(0.0D0,0.0D0)
374      CSUM1=CSUM
375      C      CALCULATE THE COEFFICIENTS.
376      DO 25 I=1,NMAXH
377      CSUM=CSUM+FJ(I)/DCMPLX(FJ(I),-FY(I))
378      CSUM1=CSUM1+FJP(I)/DCMPLX(FJP(I),-FYP(I))
379      FTR=E=FJ(1)/DCMPLX(FJ(1),-FY(1))
380      FTRH=FJP(1)/DCMPLX(FJP(1),-FYP(1))
381      RE=(2.0*(CSUM-FTR)+FTR)/X
382      RHS=(2.0*(CSUM1-FTRH)+FTRH)/X
383      RES=RE
384      RHS=RH
385      RETURN
386      END

387      SUBROUTINE BESC(X,FJ0,FY0)
388      C      CALCULATE THE BESSLE FUNCTION AND NEUMANN FUNCTION OF ORDER ZERO
389      C      IMPLICIT REAL*8 (A-H,O-Z)
390      PI = 3.141592653589793

```

384
 385 IF (X=4.0D0) 10,10,20
 386 XX = X/4.0D0
 387 X2 = XX*XX
 388 FJ0 = ((((((-0.0005014415D0*X2 + 0.0076771853D0)*X2 -
 1.0709253492D0)*X2 + 0.4443584263D0)*X2 - 1.7777560599D0)*X2 +
 2.3999973021D0)*X2 - 3.9999998721D0)*X2 + 1.0D0
 FY = (((((0.0000891322D0*X2 - 0.0013508487D0)*X2 +
 1.0148999271D0)*X2 - 0.1214187561D0)*X2 + 0.6694321484D0)*X2 -
 2.2331102234D0)*X2 + 3.6911388793D0)*X2 - 1.6911374142D0)*X2 -
 3.0.5772156649D0
 T = DL0G(X/2.0D0)
 FYC = (2.0D0/PI)*(FJ0*T - FY)
 GO TO 30
 20 XX = 4.0D0/X
 X2 = XX*XX
 A = 2.0D0/DSQRT(X)
 B = A*XX
 APO = A*(((((-0.0000037043D0*X2 + 0.0000173565D0)*X2 -
 1.0.0000487613D0)*X2 + 0.00017343D0)*X2 - 0.001753062D0)*X2 +
 2.0.3989422793D0)
 BQ0 = B*((((0.0000032312D0*X2 - 0.0000142078D0)*X2 +
 1.0.0000342468D0)*X2 - 0.0000869741D0)*X2 + 0.0004564324D0)*X2 -
 2.0.0124669441D0
 C = X - 0.25D0*PI
 CS = DCOS(C)
 SN = DSIN(C)
 FJC = APO*CS - BQ0*SN
 FYC = APO*SN + BQ0*CS
 30 RETURN
 END

405 SUBROUTINE BESI(X,FJ1,FY1)
 C CALCULATE THE BESSSEL FUNCTION AND NEUMANN FUNCTION OF ORDER ONE

406 IMPLICIT REAL*8(A-H,O-Z)
 407 PI = 3.141592653589793
 408 IF (X=4.0D0) 10,10,20
 10 XX=X/4.0D0
 X2=XX*XX
 FJ1 = XX*(((((-0.001289769D0*X2 + 0.0022069155D0)*X2 -
 1.0.0236616773D0)*X2 + 0.1777582922D0)*X2 - 0.8888839649D0)*X2 +
 2.0.656660544D0)*X2 + 3.99999971D0)*X2 + 1.9999999998D0)
 FY = ((1.0D0/X)*(((((-0.0010266368D0*X2 + 0.0169921876D0)*X2 -
 1.0.1691081720D0)*X2 + 1.1418033012D0)*X2 - 4.9105291148D0)*X2 +
 2.11.6207891416D0)*X2 - 10.7645472724D0)*X2 - 0.6177253972D0)*X2 +
 3.0.000000004D0)
 T = DL0G(X/2.0D0)
 FY1 = (2.0D0/PI)*(FJ1*T - FY)
 GO TO 30
 20 XX = 4.0D0/X
 X2 = XX*XX
 A = 2.0D0/DSQRT(X)
 B = A*XX
 API = A*((((0.0000042414D0*X2 - 0.000020092D0)*X2 +
 1.0.0000580759D0)*X2 - 0.000223203D0)*X2 + 0.0029218256D0)*X2 +
 2.0.3989422819D0)
 BQ1 = B*(((((-0.0000036594D0*X2 + 0.00001622D0)*X2 -
 1.0.0000398708D0)*X2 + 0.0001064741D0)*X2 - 0.00063904D0)*X2 +
 2.0.0374008364D0)
 C = X - 0.75D0*PI
 CS = DCOS(C)
 SN = DSIN(C)
 FJ1 = API*CS - BQ1*SN
 FY1 = API*SN + BQ1*CS
 30 RETURN
 END

```

429      FUNCTION BES*8(X,N)
430      C      CALCULATE THE BESSSEL FUNCTION OF ORDER N AND ARGUEMENT X
431      C      USING SERIES APPROXIMATION.
432      IMPLICIT REAL*8 (A-H,O-Z)
433      CP=-X*X*0.25D0
434      SUM1=1.0D0
435      SUM=SUM1
436      NM=M*M*1.0+20
437      35     DO 10 I=1,NM
438      XI=I
439      SUM1=SUM1*CP/((XN+XI)*XI)
440      10     SUM=SUM+SUM1
441      CP=X*X*0.5D0
442      DO 20 I=1,N
443      XI=I
444      SUM=SUM*CP/XI
445      BES=SUM
446      RETURN
447      END

448      SUBROUTINE UNBLK(N,EFF0)
449      COMMON   A(3,20),PHI(20),COEFF(15),COFSP(15),COFCN(15),EPSI,RI
450      ,R2,U,V,W,ROT,PIT,MM,MMM,ALT4(10),AGT4(20),ASST(20),RC
451      ,REAL*8   AUX(15),SQPOL(30),Z30*0.0D0,X,Y,XSQ
452      X      =0.
453      DO 1    I=1,N
454      AUX(I) =COEFF(I)
455      X      =X+COEFF(I)/I
456      XSQ    =X**2
457      DO 2    J=1,N
458      K      =N+J-1
459      DO 2    I=J,K
460      SQPOL(I) =SQPOL(I)+COEFF(J)*AUX(I-J+1)
461      Y      =0.
462      M      =2*N-1
463      DO 3    I=1,M
464      Y      =Y+SQPOL(I)/I
465      EFF0   =1C0.*XSQ/Y
466      RETURN
467      END

468      COMPLEX FUNCTION XPIY(M,A,S)
469      REAL*8   X,Y,Z,AS,VR,POLY1,POLY2,XX,YY,CS,SN,DCOS,DSIN
470      COMPLEX*16 DCMPLX
471      XPIY   =(0.0D0)
472      IF (S.EQ.0.) GO TO 2
473      Y      =S**((Z*M+1))
474      X      =Y/(2*M+1)
475      XPIY   =DCMPLX(X,0.0D0)
476      IF (A.EQ.0.) GO TO 2
477      AS     =A*S
478      Z      =AS**2
479      IF (Z.GT.10.) GO TO 100
480      N      =2*M
481      XX    =Y*((1.0/(N+1)-(1.0/(N+3)-(1.0/(N+5)-(1.0/(N+7)-(1.0/(N+9)-Z/(1.
482      ,     80*M+990))*Z*.1785715E-1)*Z*.3333333E-1)*Z*.8333333E-1)*
483      ,     Z**5)
484      YY    =.5*Y*AS*((1.0/(M+1)-(1.0/(M+2)-(1.0/(M+3)-(1.0/(M+4)-(1.0/(M+5)
485      ,     )-Z/(110*M+660))*Z*.1388888E-1)*Z*.2380952E-1)*Z*.05)*Z**6
486      XPIY   =DCMPLX(XX,YY)
487      GO TO 2
488      100    CS     =DCOS(AS)
489      SN     =DSIN(AS)

```

486 X =SN/A
487 Y ={1.-CS)/A
488 XP IY =DCMPLX(X,Y)
489 IF (M.EQ.0) GO TO 2
490 ASCS =AS*CS
491 ASSN =AS*SN
492 SQ =S**2
493 SS =1./S
494 DO 200 I =1,M
495 J =2*I
496 SS =SS*SQ
497 CSJ =CS*J
498 SNJ =SN*J
499 200 X =SQ*(SS*(CSJ+ASSN)-J*(J-1)*X)/Z
500 Y =SQ*(SS*(SNJ-ASCS)-J*(J-1)*Y)/Z
501 XP IY =DCMPLX(X,Y)
502 2 RETURN
503 END

SENTRY

APPENDIX BCOMPUTER PROGRAM FOR APERTURE FIELD DISTRIBUTIONPurpose:

This program calculates the aperture field distribution for front-fed paraboloid using the experimental field (described by Shafai DSS 01SU-36100-5-0313) and approximates the distribution in a form of an even polynomial.

Language:

WATFIV/FORTRAN IV

Author:

O. Aboul-Atta, Department of Electrical Engineering,
University of Manitoba.

Description:

The aperture field distribution has been calculated according to:

$$F(r') = (N/\rho') \left[G_{\text{eff}}(\theta) \right]^{1/2}$$

where G_{eff} is the average (relative) power pattern in both the E- and H- planes to be estimated from the experimental measurements. The program search for the optimum angle of flooding the main dish and interpolates the numerical field distribution (normalized to a dish radius of one) in the form

$$F(t) = \sum_1^N \text{COEFF } (I) t^{2(I-I)}, \quad t = 2r'/D$$

Input Variables:

In terms of the following four data cards:

- (1) U, V, W, X, Y, Z
- (2) F, G, H, L, XXX
- (3) U, V, W, X, Y, Z
- (4) F, G, H, L, XXX

The necessary information about the experimental feed's measurements in the E-plane and then the H-plane are fed to the program. The different parameters has been explained in the comment statements (see program listing).

Output:

Two display of print-out. The first is for the searching the optimum angle of illumination and its by-products (antenna gain factor, percentage of spill). The second display is for comparison of the numerical field distribution with a polynomial interpolation of 11 coefficient.

\$JOB NAMEIV ABDUL ATTA (APERTURE FIELD DISTRIBUTION)
 THIS PROGRAM CALCULATES THE OPTIMUM ANGLE OF FLUDDING A FRONT-FED
 PARABOLOID FROM THE EXPERIMENTAL DATA OF THE FLANGED FEED DESCRIBED
 IN THE REPORT. ALSO IT DUES INTERPOLATE THE APERTURE FIELD DISTRIBUTION
 IN A FORM OF AN EVEN POLYNOMIAL. THE VARIABLE OF THE POLYNOMIAL
 IS THE RATIO OF THE RADIAL DISTANCE TO THE OUTER RADIUS OF THE
 MAIN DISH.
 U=THE ANGLE AT WHICH THE PEAK FEED RADIATION PATTERN OCCURS.
 V=THE TRANSITIONAL ANGLE AFTER WHICH THE PATTERN IS CONSIDERED
 EXPONENTIALLY DECAYING.
 W=THE CENTRAL DROP IN THE FEED PATTERN IN DBS.
 X=THE MID WAY DROP IN DBS(HALF WAY BETWEEN THE CENTER AND THE PEAK)
 Y=THE DROP OF THE PATTERN AT THE TRANSITIONAL POINT IN DBS.
 Z=THE LOGARITHMIC SLOPE(DB/DEGREE) OF THE FEED PATTERN AT THE TRANS-
 ITIONAL POINT.
 F=THE OPERATING FREQUENCY.
 G=THE INNER DIAMETER OF THE GUIDE.
 H=THE FIRST FLANGE RETARDATION IN INS.
 L=AN INTEGER TO BE WRITTEN AS 9 FOR E-PLANE MEASUREMENTS AND 8 FOR
 H-PLANE MEASUREMENTS.
 XXX=THE SECOND FLANGE RETARDATION OF THE EXPERIMENTAL FEED.
 1 FJRMAT(1,1,8,X,1,DHJ,OPTIMUM ANGLE =,P1X,P5.2)
 2 FJRMAT(1,1,8,X,1,DHGF,MULT. =,P1E12.5)
 3 FJRMAT(1,1,8,X,1,ANGLE =,P1X,P120.0,T27.0,P--UBS0,T35.0,GF=UBS0,T43
 ,P1ANT GAIN =,T53.0%,SPILL =,P1)
 4 FJRMAT(1,1,8,X,1,T18.0,F7.5,T27.0,F6.0,T35.0,F6.0,T43.0,F7.5,T53.0,F7.5)
 5 FJRMAT(1,1,8,X,1,FREQUENCY =,P1F7.3,0,0X,0,GHZ)
 6 FJRMAT(1,1,8,X,1,INNER DIAMETER =,P1F7.3,0,0X,0,INS)
 7 FJRMAT(1,1,8,X,1,FLANGE RETARDATION =,P1F7.3,0,0X,0,INS)
 8 FJRMAT(1,1,8,X,1,UEFLY =,P1E12.0,0X,0,CUEFLU =,P1E12.0)
 9 FJRMAT(1,1,8,X,1,UEFLD =,P1E12.5,0X,0,UMX =,P1F6.3)
 10 FJRMAT(1,1,8,X,1,T11.0,-----,T18.0,-----,T27.0,-----,T35.0,-----,T43
 ,P1T53.0,-----)
 11 FJRMAT(1,1,8,X,1,ZED FLANGE RETARD =,P1F7.3,0,0X,0,INS)
 12 DIMENSION AFUST(1,1),XAARR(1,1),YARR(1,1),P(501),PP(301),AGF(301),
 ,SPILL(301),IR(1),IC(1),P(1),IC(1),IC(1)
 DOUBLE PRECISION RH(1),CUEFF(1),SUM
 I<=4
 N=2
 I<=J
 NV=N*180+1
 HALFPI=1.570795
 READ,U,V,W,X,Y,Z
 READ,F,G,H,L,XXX
 CALL GENFRP(U,V,W,X,Y,Z,N,NN,P)
 READ,U,V,W,X,Y,Z
 READ,F,G,H,L,XXX
 CALL GENFRP(U,V,W,X,Y,Z,N,NN,PP)
 RATIO =P(1)/PP(1)
 PP(1) =2.*SQRT(P(1))
 P(1) =4.*P(1)
 PPMX =PP(1)
 CONST =HALFPI/(N*180)
 DJ 13 I=2,NN
 P(I) =P(I)+RATIO*PP(I)+2.*SQRT(RATIO*P(I)*PP(I))
 PP(I) =SQRT(P(I))*COS(CONST*(I-1))**Z.
 IF (PPMX.GT.PP(I)) GO TO 13
 PPMX =PP(1)
 IMX =I
 COUNTINJE
 DJ 14 I=1,NN
 PP(I) =P3(1)/PPMX
 CALL ANTGF(P,AGF,FGF,UPTANG,NN,SPILL)
 WRITE(0,1)OPTANG
 WRITE(0,2)FGF
 PRINT3

```

43 PRINT40
44 DU 10 I=1,46
45 J=(I-1)*2
46 K=J+N+1
47 XX=10.*ALOG10(P(K))
48 YY=10.*ALOG10(FGF*P(K))
49 15 WKITE(6,4)J,P(<),XX,YY,AGF(K),SPILL(K)
50 16 FJRMAT(1,1)JX,AVERAGE TO E&H MEASUREMENTS)
51 WKITE(6,5)F
52 WKITE(6,6)S
53 WKITE(6,7)H
54 WRITE(0,1)XXX
55 PRINT10
56 I=1,4
57 IF (II.LT.12) GO TO 12
58 AFUST(I)=PD(1)
59 EPSI=67.5
60 NORM=2*N
61 AB=0.1*TAN(EPSI*CONST*N)
62 DU 17 I=1,100
63 THETAN=NORM*ATAN(AB*I)*90./HALFPI
64 J=THELAN+1
65 AAA=THETAN+1-J
66 BBB=1-AAA
67 17 AFDST(I+1)=PP(J)*BBB+PP(J+1)*AAA
68 TMX=TAN(CONST*(IMX-1))/TAN(CONST*N+EPSI)
69 J=L,J+TMX-3
70 YY=J.
71 DU 18 I=1,J
72 XX=AFDST(I+1)-AFUST(I)
73 IF (XX.LT.YY) GO TO 19
74 18 YY=XX
75 K=I
76 J=J+6
77 YY=J.
78 DU 20 I=J,100
79 XX=AFDST(I+1)-AFUST(I)
80 IF (XX.LT.YY) =I
81 YY=XX
82 L=-42
83 M=(L+4)/2
84 BENT1=J.1*(K-L)
85 BENT2=J.01*(L-L)
86 XARR(1)=J.001*( (K-L)**2)
87 XARR(2)=TMX**2
88 XARR(3)=J.001*( (L-L)**2)
89 XARR(4)=J.001*( (M-L)**2)
90 XARR(5)=1.
91 RH(1)=(AFDST(K)-AFDST(1))/XARR(1)
92 RH(2)=(AFDST(1)-AFDST(2))/XARR(2)
93 RH(3)=(AFDST(L)-AFDST(1))/XARR(3)
94 RH(4)=(AFDST(M)-AFDST(1))/XARR(4)
95 RH(5)=AFDST(101)-AFDST(1)
96 RH(6)=2500.*(AFDST(K+1)-AFDST(K-1))/(K-1)
97 RH(7)=J.
98 RH(8)=2500.*(AFDST(L+1)-AFDST(L-1))/(L-1)
99 RH(9)=2500.*(AFDST(M+1)-AFDST(M-1))/(M-1)
100 RH(10)=2500.*(AFDST(101)-AFDST(100))
101 DU 21 I=1,5
102 E(I,1)=1.
103 E(I+5,1)=1.
104 DU 24 J=2,4
105 E(I,J)=XARR(1)*E(I,J-1)
106 E(I+5,J)=J*E(I,J)
107 CALL MINVRS(E,10,10,DET,IER,IR,IC)
108 DU 22 I=1,10

```

```

199      K = [ + 1
200      CUEFF(K) = 0.
201      DO 22 J=1, 10
202      CUEFF(K) = CUEFF(K)+E(I,J)*RH(J)
203      CUEFF(1) = AFDIST(1)
204      SUM = 4*FDST(1)-CUEFF(1)-CUEFF(2)-CUEFF(3)-CUEFF(4)-CUEFF(5)-
205      -CUEFF(6)-CUEFF(7)-CUEFF(8)-CUEFF(9)-CUEFF(10)-CUEFF(11)
206      CUEFF(11) = CUEFF(11)+SUM
207      CUEFF(12) = CUEFF(12)+SUM
208      FJJKMAT(1) = 2*UX * COMPARISON OF THE POLYNOMIAL APPROXIMATION*
209      FJJKMAT(2) = 2*UX * WITH THE AVERAGE E&H-MEASUREMENTS OF THE*
210      FJJKMAT(3) = 2*UX * APERTURE FIELD DISTRIBUTION*
211      FJJKMAT(4) = 2*UX * RATIO * 3X * A.F.D. MEASURED * 3X * A.F.D. INTERPLUT*
212      FJJKMAT(5) = 2*UX * 2H --- 3X * 14H --- 3X * 15H ---
213      FJJKMAT(6) = 2*UX * F4.2 * 5X * E12.5 * 5X * E12.5
214      FJJKMAT(7) = 2*UX * CUEFLU = * E12.2 * 3X * CUEFLU6 = * E12.5
215      FJJKMAT(8) = 2*UX * CUEFLU1 = * E12.5 * 3X * CUEFLU7 = * E12.5
216      FJJKMAT(9) = 2*UX * CUEFLU2 = * E12.2 * 3X * CUEFLU8 = * E12.2
217      FJJKMAT(10) = 2*UX * CUEFLU3 = * E12.5 * 3X * CUEFLU9 = * E12.5
218      FJJKMAT(11) = 2*UX * **** * **** * **** * **** * **** * **** * **** * **** * *
219      FJJKMAT(12) = 2*UX * INFLEX1 = * F6.3 * 9X * INFLEX2 = * F6.3
220      PRINT23
221      PRINT24
222      PRINT25
223      PRINT26
224      PRINT27
225      DJ 36 I=1, 50
226      T = 0.51*(I-1)
227      X = T**2
228      SUM = CUEFF(10)+CUEFF(11)*X
229      DU 37 J=1, 9
230      SUM = CUEFF(10-J)+SUM*X
231      YAKR(I) = SUM
232      WRITE(6, 28) T*AFDIST(I), YAKR(I)
233      WRITE(6, 29) AFDIST(I), CLEFF(7)
234      WRITE(6, 30) CLEFF(2), CUEFF(8)
235      WRITE(6, 31) CLEFF(3), CUEFF(9)
236      WRITE(6, 32) CLEFF(4), CUEFF(10)
237      WRITE(6, 33) CUEFF(5), CUEFF(11)
238      WRITE(6, 34) CUEFF(6), TMX
239      WRITE(5, 34) BENT1, BENT2
240      PRINT33
241      PRINT29
242      PRINT27
243      DJ 38 I=2, 101
244      T = 0.51*(I-1)
245      X = T**2
246      SUM = CUEFF(10)+CUEFF(11)*X
247      DU 37 J=1, 9
248      SUM = CUEFF(10-J)+SUM*X
249      YAKR(I) = SUM
250      WRITE(6, 28) T*AFDIST(I), YARR(I)
251      PRINT( CUEFF(I), I=1, 11)
252      RETURN
253      END

254      SUBROUTINE GENFKP(THMX, THTR, DBC, DBM, DBT, SLOPE, N, NN, A)
255      DIMENSJN A(NN)
256      HALFPI=1.570795
257      K1=0.5*ALOGIC(DBC/DBM)/ALOGIC(2.)
258      K2=SLOPE*(THTR-THMX)/DBT
259      M=N*THMX
260      X=HALFPI/(N*THMX)
261      Y=-0.5*DBC
262      A(1)=10.*Y
263      RB=4.*((DBC-15.*DBM/9.)/(THMX**2))

```

```

173 RA=0.8C/(THMX**4) - RB*(THMX**2)
174 S1=N**2
175 S2=N*THMX
176 DJ_1 I=1,M
177 V=(S2-[ ]*(S2+I))/S1
178 U=-[V**2]*(RA+RB*V)*U.1
179 A(I+1)=IJ.U
180 J=M+1
181 M=N*THTR
182 X=1./[N*(THTR-THMX)]
183 Y=-U.1*UBT
184 Z=THMX/[THTR-THMX]
185 DJ_2 I=J,M
186 A(I+1)=IJ.U+(Y+(X*I-Z)**K2)
187 J=M+1
188 M=N*180
189 X=-U.1*SLOPE/N
190 Z=N*THTR
191 DJ_3 I=J,M
192 A(I+1)=IJ.U+(Y+(I-Z)*X)
193 RETURN
194 END

195 SUBROUTINE ANTUF(FRP,AGF,FGF,UPTANG,NN,SPILL)
196 DIMENSION FRP(NN),AGF(NN),SPILL(NN)
197 C1=U.0
198 C2=U.0
199 T1=U.0
200 T2=U.0
201 ST1=U.0
202 ST2=U.0
203 TT1=U.0
204 TT2=U.0
205 SP1=U.0
206 SP2=U.0
207 N=(NN-1)/180
208 CR=1.745329E-2/N
209 JJ=NN-2
210 DJ_1 I=JJ
211 T1=T1+FRP(I+1)*SIN(CR*I)
212 FGF=Z.0./[CR*T1]
213 AGF(I)=U.0
214 SPILL(1)=100.0
215 TT1=U.0
216 T1=U.0
217 JU=N*90
218 DJ_2 I=1,JU
219 ST2=SQRT(FGF*FRP(I+1)*TAN(U.5*CR*I))
220 SP2=FGF*FRP(I+1)*SIN(CR*I)
221 TT2=TT1+U.25*CR*(SP2+SP1)
222 AGF(I+1)=(Z.0.*UTAN(U.5*CR*I)*T2)**Z.0
223 SPILL(I+1)=IJ.U.U*(I-TT2)
224 C2=(SIN(U.5*CR*I)**2.0)*SQRT(FGF*FRP(I+1))
225 IF (C2.LT.T2.AND.C1.GE.T1) UPTANG=I-(T2-C2)/(C1-C2-T1+T2)
226 ST1=ST2
227 T1=TT2
228 SP1=SP2
229 TT1=TT2
230 C1=C2
231 OPTANG=UPTANG/N
232 RETURN
233 END

```

SENTRY

APPENDIX C

COMPUTER PROGRAM FOR THE APERTURE AMPLITUDE DISTRIBUTION
AND THE SPILLOVER LOSS OF THE DUAL REFLECTOR SYSTEMS

Purpose:

This program calculates the aperture field distribution and spillover loss of a standard cassegrain system or a system consisting of shaped subreflector with paraboloid main-reflector.

Language:

WATFIV/FORTRAN IV

Author:

R. K. Chugh, University of Manitoba, Department of Electrical Engineering, Winnipeg, Manitoba.

Description:

The conservation of energy principle is expressed differentially as

$$I_1(\theta_1) \sin\theta_1 d\theta_1 = I_2(y_2) y_2 dy_2$$

The quantity $I_1(\theta_1)$ is the power density of the primary illumination. The quantity $I_2(y_2)$ is the power density flow normal to the aperture of the main-reflector. The relation between y_2 and θ_1 is obtained by using the given equations for the two reflectors or the least square coefficients for the given data points. The calculated data for power density $I_2(y_2)$ for different aperture points y_2 is used to evaluate the coefficients $E(J)$ given by

$$AF(y_{n2}) = \sum_{J=1}^{NC} E(J) (y_{n2})^{2(J-1)}$$

where $y_{\text{sp}2} = y_2'/y_{2 \text{ max}}' = 2 y_2'/D$ with AF and D being the aperture amplitude and main-reflector diameter, respectively.

The spillover loss is calculated by using the following types of functions for the primary illumination:

$$I_1(\theta_1) = \begin{cases} a (\cos \theta_1)^b & 0 \leq \theta_1 \leq \theta_m \\ A e^{-B\theta_1} & \theta_m \leq \theta_1 \leq \pi \end{cases}$$

The above expressions are used to calculate the total radiated power of the feed. The program computes the maximum incident angle and thus the spillover loss.

Input Variables for the Standard Cassegrain System:

The input variables for the paraboloid - hyperboloid system are the following: KK, parameter 2 for hyperboloid subreflector; eccentricity ECC; distance between two foci DBTF; subreflector diameter DS; Focal Length FL; main-reflector diameter DM; distance of phase center from origin DP; distance of subreflector vertex from origin DSV; feed power pattern parameters a, b, and θ_m (in degrees); and number of coefficients NC.

Input Variables for the Shaped-subreflector with Paraboloid main-reflector:

The list of parameters for the shaped subreflector paraboloid system is as follows: KK, parameter 1 for shaped subreflector; number of data points for shaped surface NP; shaped coordinates XS and YS; subreflector diameters DS; and the other parameters FL, DM, DP, DSV, a, b, θ_m and NC have the same description as for the standard cassegrain system.

Output:

The printed output consists of the spillover loss in dB, the coefficients E (J), and the total absolute error for the aperture field distribution curve fitting.

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C-----PURPOSE

C----- TO CALCULATE THE APERTURE AMPLITUDE DISTRIBUTION OF A
 STANDARD CASSEGRAIN SYSTEM OR A SYSTEM CONSISTING OF A
 SHAPED SUBREFLECTOR WITH PARABOLOID MAIN-REFLECTOR.

C-----PARAMETERS

C-----KK INTEGER COEFFICIENT 1 FOR SHAPED SUBREFLECTOR AND
 Z FOR HYPERBOLOID SUBREFLECTOR.

C-----NP NUMBER OF DATA POINTS FOR SHAPED SUBREFLECTOR.

C-----XS X COORDINATE OF SHAPED SUBREFLECTOR FROM VERTEX.

C-----YS Y COORDINATE OF SHAPED SUBREFLECTOR.

C-----DS SUBREFLECTOR DIAMETER.

C-----ECC ECCENTRICITY OF HYPERBOLOID SUBREFLECTOR.

C-----DBTF DISTANCE BETWEEN TWO FOCI OF SUBREFLECTOR.

C-----FL FOCAL LENGTH OF MAIN-REFLECTOR.

C-----DM MAIN-REFLECTOR DIAMETER.

C-----DP DISTANCE OF PHASE CENTER FROM ORIGIN.

C-----DSV DISTANCE OF SUBREFLECTOR VERTEX FROM ORIGIN.

C-----CPF CONSTANT PART OF POWER FEED PATTERN.

C-----PF POWER TERM OF COS(TH) FOR THE FEED.

C-----FEED IS DESCRIBED IN THE FORM OF CPF*(COS(TH))**FP.

C-----THM MAXIMUM ANGLE THETA IN DEGREES FOR WHICH THE POWER

C-----FEED PATTERN FITTING IS VALID.

C-----NC NUMBER OF COEFFICIENTS FOR LEAST SQUARE FITTING FOR

C-----APERTURE FIELD.

IMPLICIT REAL*8 (A-H,P,U-Z)
 DIMENSION XS(500),YS(500),C(20),TH(500),D(20),YA(500),E(20),
 LAF(500)

XS(X)=DSQRT(DBTF*DBTF/(4.000*ECC*ECC)+Y*Y/(ECC*ECC-1.000))-DBTF/
 1(2.0*ECC)

DXSR(Y)=Y/(1.000*ECC-1.000)*(XS(X)+DBTF/(2.0*ECC))

READ*,KK

GD TU (20*10),KK

READ*,NP

READ*,(XS(I),I=1,NP)

READ*,(YS(I),I=1,NP)

READ*,DS

PRINT19

GD TU 10

READ*,ECC,DBTF,DS

PRINT22

READ*,FL,DP,DP,DSV,CPF,FP,THM

READ*,NC

C-----

10 FORMAT(4I4)

19 FORMAT(' ',5X,'SHAPED SUBREFLECTOR WITH PARABOLOID MAIN-REFL
 ECTOR')

22 FORMAT(' ',5X,'STANDARD CASSEGRAINIAN SYSTEM')//)

30 FORMAT(8F10.0)

34 FORMAT(' ',10X,'FOCAL LENGTH OF MAIN-REFLECTOR')

=',F10.6)

32 FORMAT(' ',10X,'DISTANCE OF PHASE CENTRE')

=',F10.6)

33 FORMAT(' ',10X,'DISTANCE OF SUBREFLECTOR VERTEX')

=',F10.6)

34 FORMAT(' ',10X,'FEED POWER PATTERN')

=',F10.6,

10 COS(TH)***,F10.6)

=',F10.6)

35 FORMAT(' ',10X,'MAIN-REFLECTOR DIAMETER')

=',F10.6)

37 FORMAT(' ',10X,'SUBREFLECTOR DIAMETER')

=',F10.6)

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205 FORMAT( ' ', // ' ', 'DX', 'RAYS FOR INCIDENCE ANGLE GREATER THAN ',  

240 'IFLUX', 'ARE GOING IN THE BACK LOBE DIRECTION')  

240 FORMAT( ' ', // ' ', 'DX', 'LEAST SQUARE CURVE FITTING FOR APERTURE FIELD  

240 'LED AS A FUNCTION OF APERTURE POINT')  

200 FORMAT( ' ', 'FLUX', '14', 'ORDER COEFFICIENT = ', 'F15.6')  

470 FORMAT( ' ', 'FLUX', 'ERROR IN LEAST SQUARE FIT = ', 'F15.6')  

470 FORMAT( ' ', 'FLUX', 'SPILL OVER LOSS = ', 'F15.6', ' DB')  

200 FORMAT( ' ', )  

PRINT 7,US  

PRINT 31,FL  

PRINT 33,DM  

PRINT 32,DP  

PRINT 33,DSV  

PRINT 34,CPE,FP  

NP=20  

NUD=14  

GU TJ (20243),KK  

20 CALL LSTSG( Z,YS,XS,DV,US,NP,C,NPL,ERR,DU )  

GU TJ 24  

23 YSTEP=US/4.0D2  

DU ZD I=1,2,0  

YS(I)=I*YSTEP  

29 XS(I)=XSR(YS(I))  

24 XM=DM/Z.  

4=DM*DM/(16.0*FL)  

DY=DS/4.0D2  

NP=200  

DU I=1,NU  

IJ=1  

YUNE=Y$1  

GU TJ (40442),KK  

42 XUNE=XSR(YUNE)  

DXUNE=DXSK(YUNE)  

GU TJ 70  

40 XUNE=C(1)  

XX=Z.  

DU 8 J=2,NPC  

XX=XX*YUNE*YUNE  

80 XUNE=XUNE+C(J)*XX  

DXUNE=C(2)*Z.*YUNE  

XX=YUNE  

JJ=2  

DU 5 J=3,NPC  

JJ=JJ+2  

XX=XX*YUNE*YUNE  

70 DXUNE=DXUNE+JJ*C(J)*XX  

TH(I)=DATAN(YUNE/(XUNE+DSV-DP))  

TTHT=DATAN(TH(I)/Z.)  

TB=(DXUNE+TTHT)/(1.0-UXUNE*TTHT)  

TB=(Z.*TB)/(1.0-TB+TB)  

POINT=YUNE+(XUNE+DSV)*TB  

YTWO=Z.*FL*(DSQRT(1.0+POINT*TB/FL)-1.0)/TB  

DYTWO=Z.*FL/YTWO  

TTHT=(1.0-DYTWO*TBT)/(DYTWO+TBT)  

TTHT=(Z.*TTHFT)/(1.0-TTHFT*TTHFT)  

XTWO=YTWO*YTWO/(4.*FL)

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YTWOUP=YTWOU+(H-XTWO)*TTHF
YA(I)=YTWOUP
IF(YA(I)-RM)100+100+105
100
CONTINUE
NPS=NP
J=108
NPS=IJ-1
PRINT100,TH(NPS)
JK=3.14159265358979/1.8002
FP=FP+1.0D0
THMD=THM*JK
PB=FP*DUTANT(THMD)
COSNT=DCOS(THMD)**FP
CEXP=DEXP(PB*THMD)
PA=CPF*CEXP*COSNT
THF=(1.0D0-COSNT*DCOS(THMD))/FP1+PA/(PB*CEXP)
SKP=(1.0D0-DCOS(TH(NPS))**FP1)/FP1
SPL=1.0D0*DLCG20(SRP/TPF)
PRINT172,SPL
CALL LSTSQ(3,TH,YA,D000,NPS,D,NCD,EERR20)
OTH=TH(NPS)/2.0D0
BD=3.14159265358979/(2.0*TH(NPS))
DU120 I=1,200
TH(I)=OTH*I
YTP=D(I)
DYTP=0.0
DU120 J=2,NCD
JJ=J-1
ANGLE=BD*TH(I)*JJ
SINA=DSIN(ANGLE)
USA=DCOS(ANGLE)
YTP=YTP+D(J)*SINA
DYTP=DYTP+BD*JJ*D(J)*CUSA
YA(I)=YTP
AFN=CPF*DCOS(TH(I))**FP
AF(I)=AFN*DSIN(TH(I))/(YTP*DYTP)
AF(I)=DSQRT(AF(I))
120
CONTINUE
CFN=0.0D0
DU120 J=1,200
FF(AF(J),GT,CFN)CFN=AF(J)
CONTINUE
DU130 I=1,200
YA(I)=2.0*YA(I)/DN
AF(I)=AF(I)/CFN
PRINT140
CALL LSTSQ(2,YA,AF,D000,D00,E,NCD,EERR30)
DU130 I=1,NC
I=I-1
PRINT100,I,I
PRINT170,EERR3
PRINT180
STOP
END
SUBROUTINE LSTSQ(MM,X,Y,MD,N,C,M,EERR,IE)
IMPLICIT REAL*8 (A-H,O-Z)

```

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C-----PURPOSE

```

C----- TO CALCULATE LEAST SQUARE FITTING COEFFICIENTS FOR A
C----- GIVEN DATA OF X AND Y.
C----- DIMENSION X(MD),Y(MD),C(2U),YA(404),A(2U,2U),B(2U),F(2U,4U4)
20  DO 20 J=1,N
21  F(I,J)=1.
22  DO 22 I=2,M
23  DO 23 J=1,N
24  II=I-1
25  F(I,J)=F(II,J)*X(J)
26  DO 26 I=3
27  DO 27 J=1,N
28  XX=X(J)*X(J)
29  DO 29 I=2,M
30  II=I-1
31  F(I,J)=F(II,J)*XX
32  DO 32 I=3
33  DO 33 J=1,N
34  II=I-1
35  BB=3.14159265358979/(2.0*X(N))
36  F(I,J)=DSIN(II*BB*X(J))
37  DO 37 I=3
38  NN=(M-1)/2
39  DO 39 I=1,NN
40  NC=I+1
41  NS=NC+NN
42  DO 42 J=1,N
43  F(NC,J)=DCOS(I*X(J))
44  F(NS,J)=DSIN(I*X(J))
45  CONTINUE
46  DO 46 I=3
47  IF(I-2)20,20,27
48  DO 48 J=1,N
49  F(I,J)=DCOS(X(J))
50  DO 50 I=3
51  II=I-1
52  IJ=I-2
53  DO 53 J=1,N
54  F(I,J)=((2.*IJ+1)*F(2,J)+F(II,J)-(J*F(IJ,J))/II
55  CONTINUE
56  DO 56 I=3,M
57  DO 57 K=1,I
58  A(K,I)=0.
59  DO 59 I=2,N
60  A(K,I)=A(K,I)+F(I,J)*F(K,J)
61  A(I,K)=A(K,I)
62  DO 62 K=1,M
63  B(K)=0.
64  DO 64 J=1,N
65  B(K)=B(K)+Y(J)*F(K,J)
66  CALL MINV(A,M,Z0,B,DET,L)
67  DO 67 I=1,M
68  B(I)=B(I)

```

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```

    DO 41 J=1,N
    SUM=J.
    DO 42 I=1,M
    SUM=SUM+C(I)*F(I,J)
    DIFF=Y(J)-SUM
    YA(J)=SUM
    EKK=J.
    DO 43 J=1,N
    EKK=EKK+DABS(Y(J)-YA(J))
    IF (I.EQ.1) GO TO 150
    ERM=0.001*N
    IF (EKK-ERM).LT.1300120
    IF (M-EK).LT.120+1300120
    M=M+1
    GO TO 10
    CONTINUE
    RETURN
    END

```

SUBROUTINE MINV(A,N,M,B,DET,M)

```

-----PURPOSE-----
-----TO SOLVE SYSTEM OF SIMULTANEOUS EQUATIONS.
IMPLICIT REAL*8 (A-H,U-Z)
DIMENSION A(NM,NM),B(NM),IPVUT(100),INDEX(100,2),PIVUT(200)
EQUIVALENCE (IKUNW,JKUNW),(ICUL,JCOL)
DET=1.00
DO 17 J=1,N
IPVUT(J)=0
DO 155 I=1,N
T=0.
DO 9 J=1,N
IF (IPVUT(J)-1)13,9,23
13 DO 23 K=1,N
IF (IPVUT(K)-1)43,23,81
43 IF (ABS(T)-DABS(A(I,K)))85,23,23
83 IRUNW=J
ICUL=K
T=A(J,K)
CONTINUE
9  CONTINUE
IF VUT(ICUL)=IPVUT(ICUL)+1
IF (IRUNW-ICUL)73,109,73
73 DET=-DET
DO 12 L=1,N
T=A(IRUNW,L)
A(IRUNW,L)=A(ICUL,L)
12 A(ICUL,L)=T
IF (M)109,109,33
109 DO 2 L=1,M
T=B(IRUNW)
3 (IRUNW)=B(ICUL)
3 (ICUL)=T
INDEX(1,2)=ICUL
PIVUT(1)=A(ICUL,ICUL)
A(ICUL,ICUL)=1.
DO 209 L=1,N

```

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```
205 A(1COL,L)=A(1COL,L)/PIVUT(I)
IF(M)347,347,55
347 JU 52 L=L,M
32 3(1COL)=B(1COL)/PIVUT(I)
JU 139 LI=L,N
IF(LI-1COL)<1,139,21
21 T=A(LI,1COL)
A(LI,1COL)=0.
JU 89 L=L,N
39 A(LI,L)=A(LI,L)-A(1COL,L)*T
IF(M)455,455,48
48 JU 68 L=L,M
55 B(LI)=B(LI)-B(1COL)*T
CONTINUE
57 JU 3 I=I,N
L=N-1+1
IF(INDEX(L,2)=INDEX(L,2))19,3,49
19 JR0W=INDEX(L,2)
JC0L=INDEX(L,2)
JU 549 K=L,N
T=A(K,JC0L)
A(K,JC0L)=T
49 CONTINUE
3 CONTINUE
81 RETURN
END
```

PLOT PROGRAM

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PLOTTING JOB FOR CRCs

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DIMENSION X(203),Y(203),Z(203),IBUF(7000)
DIMENSION IBX(4),IBY(2)
DATA IBX/1 ANGLE 0 DEG KEEPS/
DATA IBY/0 GAI NODD/
READ ACF
DO 9 I=1,202
9 READ ACF X(I),Y(I)
FORMAT(2E17.7)
FORMAT(F9.4)
FACT=X(1)
PRINT Z(X(I),I=1,202)
PRINT Z(Y(I),I=1,202)
FORMAT(0.0E+7.7)
DO 10 I=1,202
X(I)=10.0* ALOG10(X(I))/FACT
Y(I)=10.0* ALOG10(Y(I))/FACT
IF(X(I).LT.-40.0)X(I)=-40.0
IF(Y(I).LT.-40.0)Y(I)=-40.0
Z(I)=(I-1.0)*0.05
10 PRINT Z(I),X(I),Y(I)
FORMAT(1.0,3E20.7)
X(202)=-40.0
Y(202)=-40.0
X(203)=5.0
Y(203)=5.0
Z(202)=0.0
Z(203)=1.0
CALL PLJTS(IBUF,7000)
CALL PLUT(1.0,-15.0,25)
CALL PLOT(5.0,1.0,25)
CALL FACTUK(0.7)
CALL AXIS(1.0,IBX-10,10,0.0,1.0)
CALL AXIS(1.0,IBY,8,8,90.0,-40.0,0)
CALL GRID(1.0,1.0,1.0,1.0,8)
CALL SYMBOL(0.5,0.5,0.14E7H,FACT = 0.0,0.7)
CALL NUMBER(999.0,0.5,0.14E0,0,2)
CALL SYMBOL(999.0,0.5,0.14E3H,DB=0.0,3)
CALL SYMBOL(0.1,0.1,0.14E1,0,0,-1)
CALL SYMBOL(0.5,0.0,0.14E2H,UNPERTURBED,0,12)
CALL SYMBOL(0.5,0.0,0.14E2,0,0,-1)
CALL SYMBOL(0.5,0.0,0.14E1CH,PERTURBED,0,10)
CALL LINE(Z,X,201,0,8,1)
CALL LINE(Z,Y,201,0,8,2)
CALL PLOT(12.0,0.0,999)
STOP
END

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