DISCUSSION ON MMA ANTENNA CONFIGURATION

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1. Basic design parameters

1.1 MMA antenna requirements

* aperture size	8 m
* surface rms error	25 um
* frequency range	30-366 GH
* pointing accuracy	1 arc sec.
* receiver size	0.75 x 0.75 x 1 m
* operation condition	day and night
temperature range	full range
wind range	depend site condition
* fast antenna switching	1.5 deg.

* solar observation
* minimum spacing between antennas
* transportable

1.2 Fundamental questions on antenna design

* optical arrangement
* back-up structure design (not considered at configuration study I)
* reflector support structure
* mounting configuration
* reciever condition
* thermal performance
* dynamic performance
* cost estimation

1.3 MMA design goals

* higher efficiency — smaller blockage
* passive, open back-up structure
* stable receiver condition
* higher natural frequency
* low cost

1.4 Parameter determination

* system focal ratio, f ~ 12

for coude system, this results a larger secondary mirror
(question: can it be larger ?)

* primary focal ratio, fp ~ 0.4
  this affects mostly secondary support.
* sagitta of primary mirror, S
  S = D / 16 fp, D = 8 m, for fp = 0.4 S = 1.25 m
  fp = 0.3 S = 1.66 m
* secondary mirror diameter, Ds = (fp + B/D) D / (f + fp)
  B is back focus distance
  since fp << f, Ds = B / f + D / m, m is magnification factor
  (note: this is zero field diameter)
  for f = 12 m, m = 30; when B = 8 m, Ds = 0.93 m
  B = 4 m, Ds = 0.6 m
  f = 14 B = 8 m, Ds = 0.83 m
  B = 4 m, Ds = 0.55 m
* hole diameter of primary mirror Dh = B (fp + B/D) / f
  (note: this is zero field diameter)
* aperture blockage, n = (Ds/D)**2

2. Configurations considered in this study

Five configurations have been selected here. They represent different styles and different design ideas. Main features of these configurations are listed here for study purpose.

2.1 Coude arrangement as proposed by Lamb and Payne (Fig. 1)

* long back focus distance, B = 6.8 m
* large secondary mirror diameter
* four reflecting mirrors above the fork structure
* truss type reflector support system being not possible, yoke box structure required
* elevation axis has to be lower in order to house yoke box and reflecting mirrors
* large opening under the yoke for passing wave beam
* side elevation drive required, stiffness around elevation axis reduced
* balance weight required
* stable receiver position provided
* wind loading will affect elevation drive and pointing
* small cable wrap at elevation axis

2.2 Slant axis concept by Lamb (Fig. 2)

* semi-Nasmyth focal arrangement
* back focus distance B = 4.5 m
* Two flat mirrors used to stablize focus, large incident angle (67.5 deg.)
  (question: any polarization effect? study required.)
* no elevation axis, instead a large slant bearing ring being used
* space is necessary from back-up structure to slant bearing center in order to have enough supporting radius

* both bearings have different force condition when pointing to different elevation angle, bearing preload is necessary
* moment of inertia is smaller than other cases
* balance weight can be added but is not essential
* structure has higher natural frequency
* slant drive moves two deg. in order to move antenna one deg. in elevation
* pointing accuracy is twice as slant encoder indicated
* larger acceleration required at slant drive when antenna switching fast to reference source
* stable receiver postion provided
* pointing correction model needed to estabish particularly
* wind load will not increase much drive power
* wind load will not effect pointing at elevation angle
* small cable wrap at slant axis

* not a conventional concept, design study required

2.3 Cassegrain arrangement as Berkeley 6 m antenna (Fig. 3)

* shortest back focus distance
* small secondary mirror
* all truss type reflector supporting structure is possible but will result limited receiver room
* for large receiver cabin, hub structure is necessary
* central bull gear type drive is possible, stiffness increased around elevation axis
* balance weight is necessary
* larger moment of inertia around elevation axis
* receiver force condition changes along with elevation angle
* cable wrap required at elevation axis
* wind load affect elevation drive and pointing

* conventional concept, ready to design

2.4 Nasymth arrangement (Fig. 4)

* short back focus distance
* small secondary mirror
* truss type reflector supporting structure is possible but central hub design is desired to leave space at receiver platform outside elevation bearings
* larger (0.45 m) elevation bearing hole required for passing the wave beam
* central bull gear type drive is possible
* balance weight required
* stable receiver platform but may cause shock when antenna fast switching to reference source
* two focal station provided
* small cable wrap required at elevation bearing
* Nasmyth platform bring center of gravitation up
* moment of inertia at azimuth axis increases

* wind load affects elevation drive and pointing

* not a conventional design, only used at telescope with enclosure

2.5 Coude with focal reducer

* the design is similiar to first concept, except

  * short back focus distance
  * small secondary mirror
  * two aspherical miirors are used to change focal length
    (deffraction performance needs study)

3. Comparison between configurations

In this configuration study, no detailed design dimension has been given for each concept. Therefore the comparison here is preliminary. Further design study is still necessary.

	Concept 1	Concept 2	Concept 3	Concept 4	Concept 5
OPTICAL SYSTEM	Coude system	semi-Nysmyth system	Cassegrain system	Nasmyth system	Cass- & focal reducer
DIAMETER OF SECONDARY MIRROR	large	medium	small	medium	small
REFLECTOR SUPPORT STRUCTURE	yoke box	ring truss	hub or truss	hub box	yoke box
ELEVATION DRIVE POSITION	side	slant ring	center	side or center	side
DISTANCE FROM TRUSS TO AXIS	large	medium	short or medium	medium	large
MOMENT OF INERTIA AT FIRST AXIS	large	small	medium	medium	large
WIND EFFECT TO DRIVE AND POINTING	yes	small	medium	medium	yes
NATURAL FREQUENCY	low	high	medium high	medium low	low
ADDITIONAL REQUIREMENTS	four mirrors	two mirrors and a ring bearing	elevation cable wrap	one mirror large bearing hole	four shaped and plane mirrors
RECEIVER CONDITION	stable	stable	non stable	stable	stable
SWEEPING VOLUME	medium	small or medium	medium	medium	medium
MOUNTING TYPE	fork	half sphere	truss or fork	fork	fork
MOMENT OF INERTIA AT AZIMUTH AXIS	medium	medium	medium	large	medium
ESTIMATED COST	high	low	low	low	high

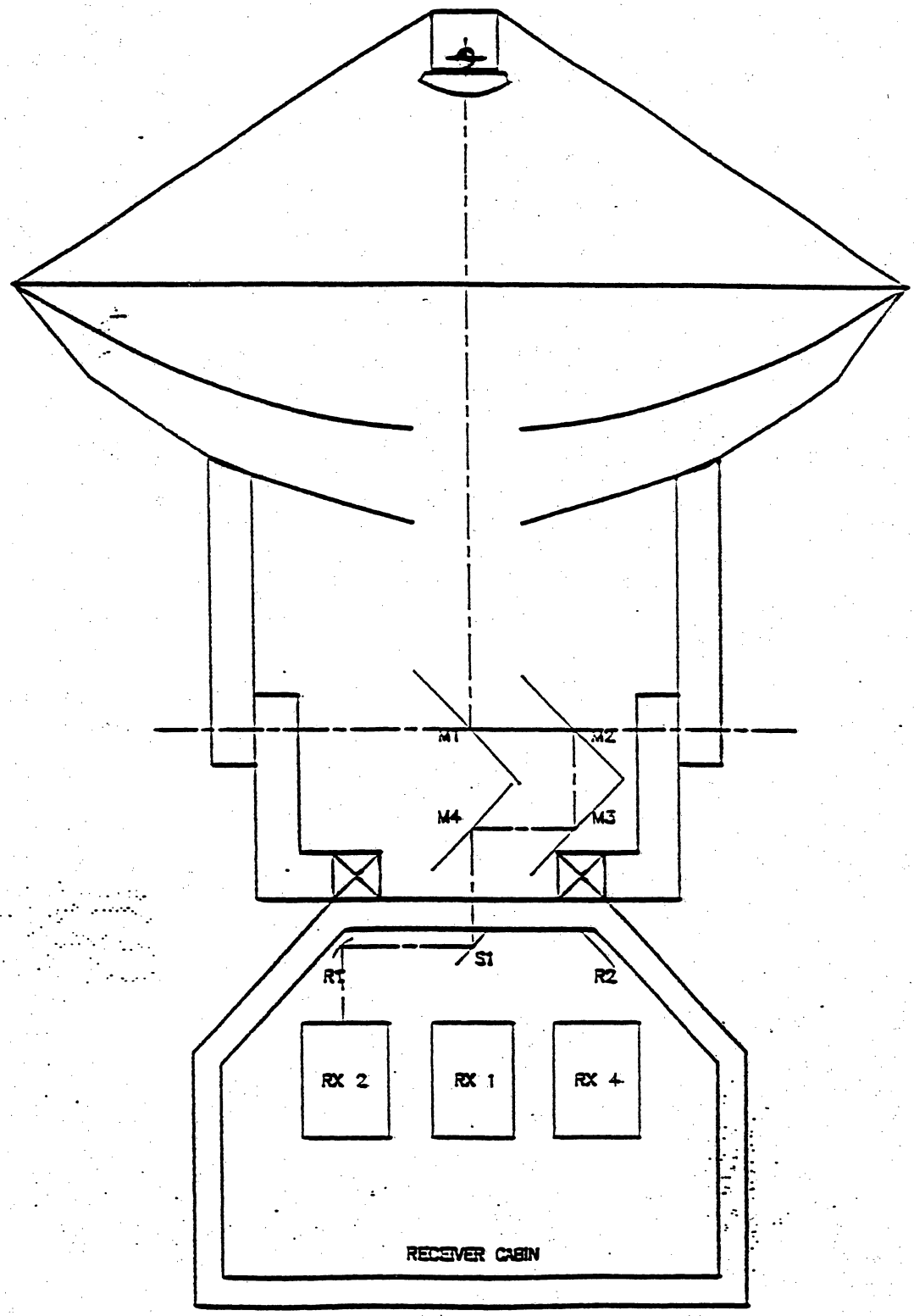

Fig. 1 Coude concept of MMA antenna

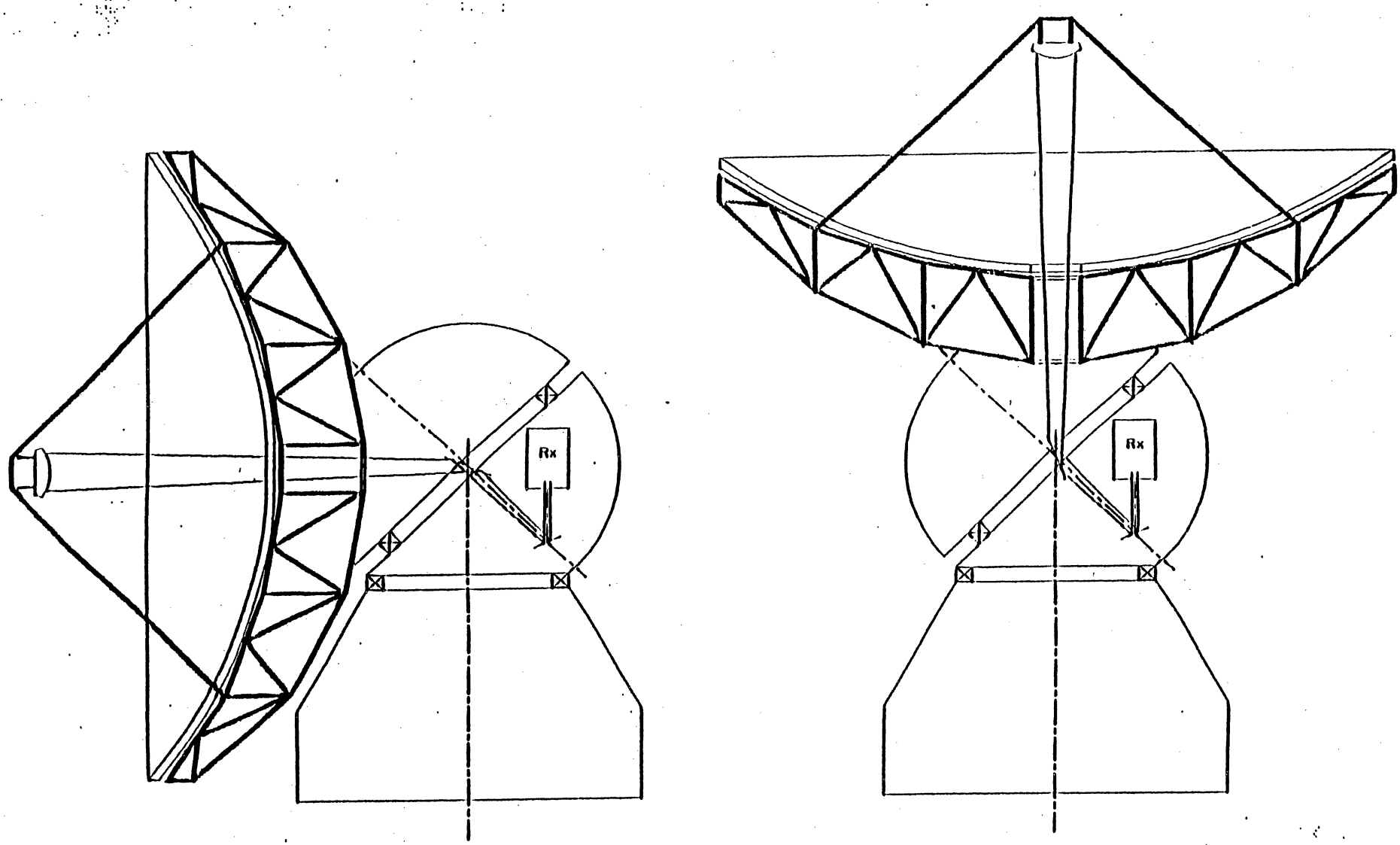

Fig. 2 Slant axis concept of MMA antenna

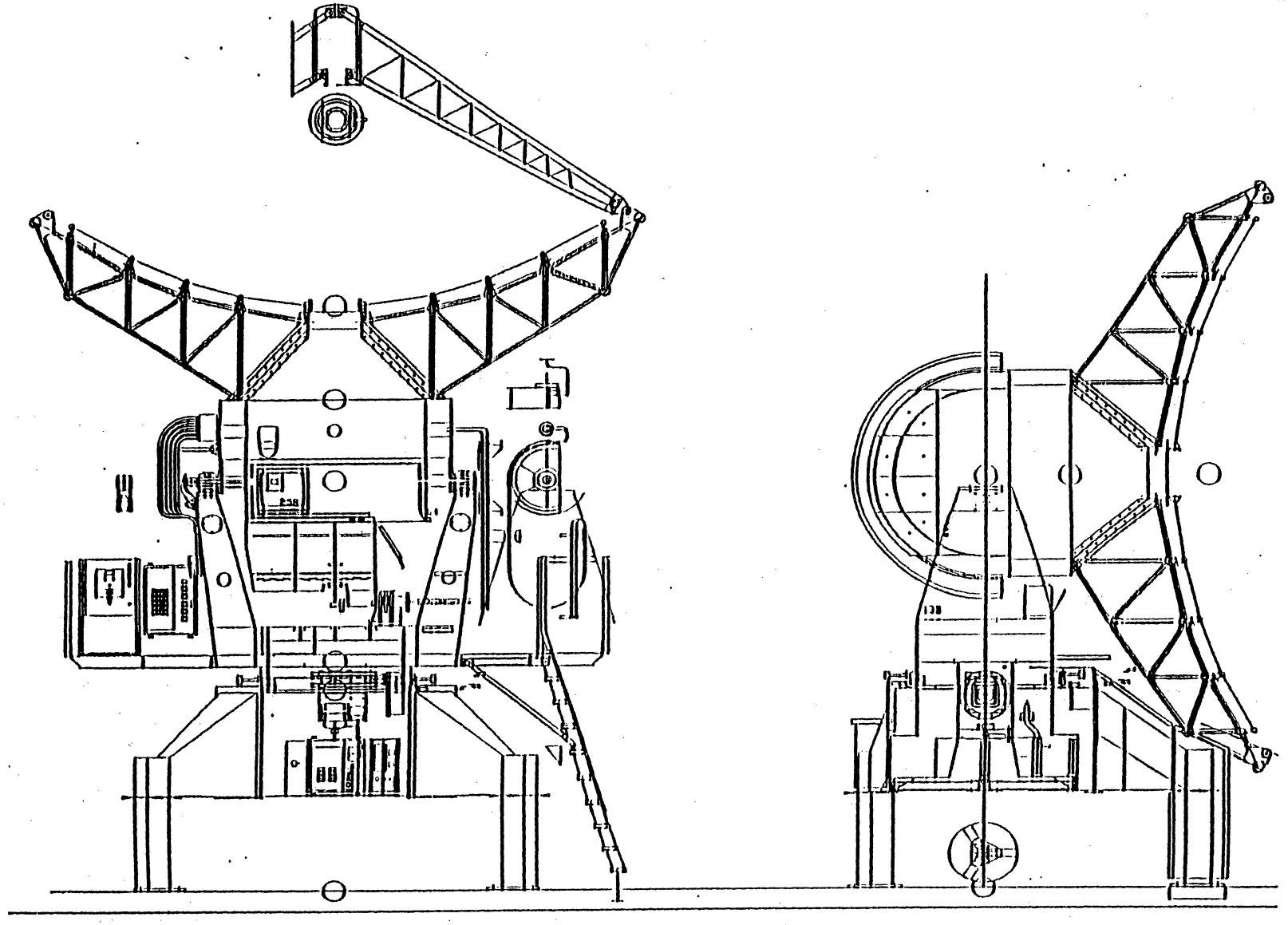

Fig. 3 Cassegrain concept design

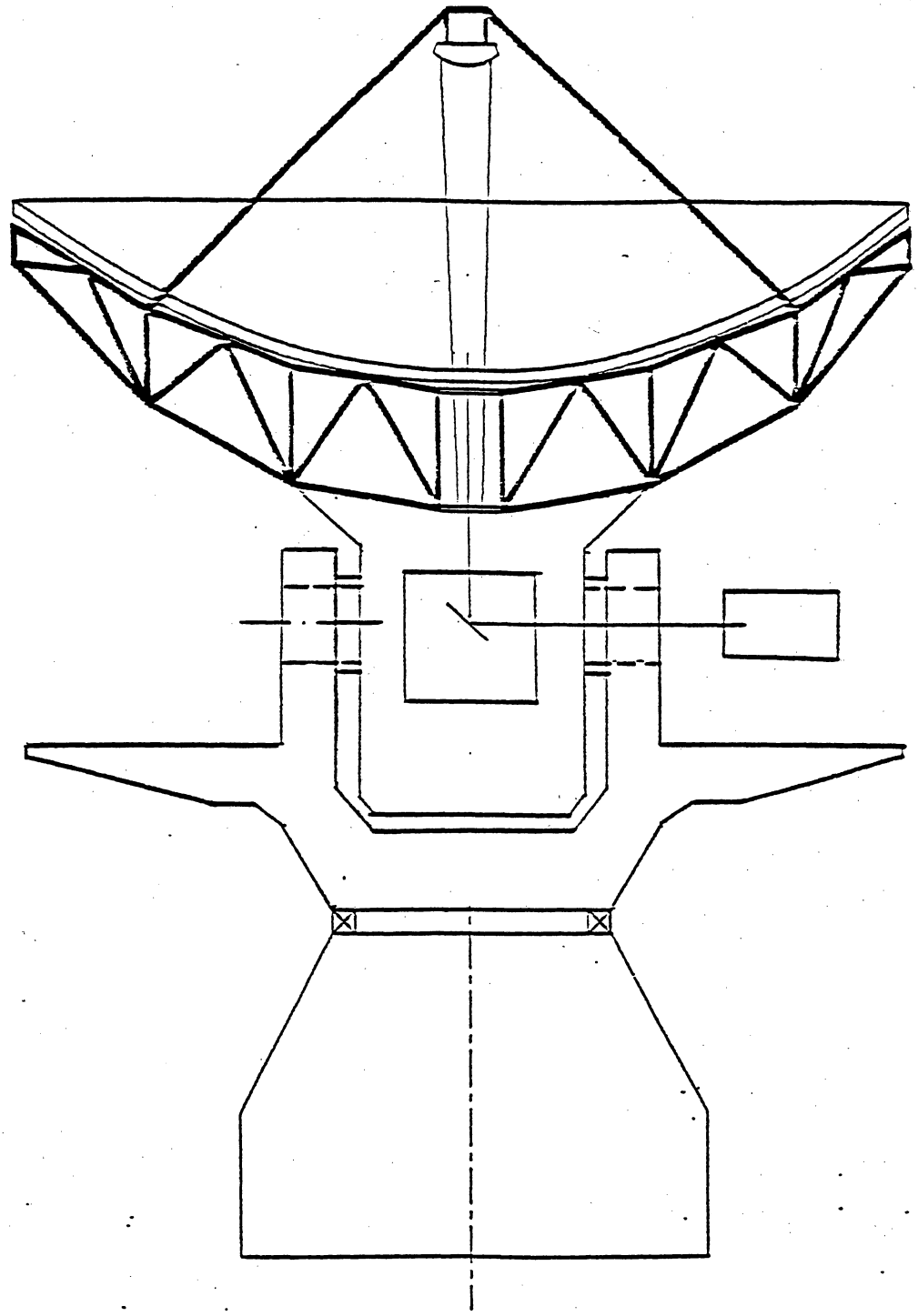

Fig. 4 Nasmyth concept design