Interoffice

National Radio Astronomy Observatory

Green Bank, West Virginia

March 21, 1980

To: Addressee

ENGINEERING MEMO No. 135

From: John Ralston

Subject: 140-ft. Cassegrain Receiver, New Feed and Revisions

(A) Drawings
   a. General

(B) Installation Procedure, Equipment and Components

   (1) New Feed Leg Hoist
   (2) New Spoiler
   (3) Structural Support for new Feeds Atop Cassegrain House
   (4) New Radome De-icing System
   (5) Structural Revision to Ceiling Panels, Access Ladder to Attic
   (6) Wall and Floor Supports for Rack
   (7) New Receiver Rack Installation
   (8) Installation of Refurbished Ceiling Panels and Ladder
   (9) Polarimeter

(C) Work by Other

   (1) Heaters and lights in attic
   (2) Cryogenics
   (3) Power and signal cables (if required)

Attached is a brief rundown of the above format, a copy of C. J. Brockway's memorandum dated 1/10/79, and preliminary schedule of work days related to the above listed jobs.

Attachments

DRAFT
3/21/80

INSTALLATION PROCEDURE FOR NEW CASSEGRAIN RECEIVER AND FEEDS FOR 140-FT TELESCOPE

Reference -- Memorandum from C. J. Brockway, 140-ft Cassegrain Receiver - 1/10/79.

A. DRAWINGS

Reference NRAO Dwgs.:

(1) 36D00245 - Focal Point Hoist Assemblies & Layout

(2) 36D00246 - Details of Focal Point Hoist Assembly

(3) 36D00153 - Cassegrain Bldg. - Marked-up for heating & lighting

(4) 36D00253 - Attic Access Layout - Details of ladder & ceiling panel revisions

(5) 36D00253 - Bracket & Support Details for "Maser-Rack" -- New "K", "Ku", "X" & "C".

(6) 36D00256 -
" 257 -
" 258 - New Spoiler
" 259 -

(7) 36D00247 - Cover Plate Details & Layout for New Cassegrain Feeds

*(8) 36D00173 - Ceiling Panels - Marked up for rack clearance

(9) 36D00249 -
" 250 - New Feed Support Leg Hoist
" 251 -

(10) 36D00248 - Transition & Support Details for New Feeds (X, C, Ku &K)

(11) Sketches - Air Blower Unit Relocation
"X" Band Feed Support Brackets
Radome De-Icer Alum. Duct
Plexi-Glass Nozzle
Flange Additions for new Feed Horns
Air Distribution Box for Radome De-icing
*"K" & "Ku" Support Angles

*(12) Preliminary Dwg. for weatherproof cover for "X" Band feed.

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* Not fabricated as of March 20, 1980

ATTACHMENT: (1) Preliminary Work Schedule
(2) Memorandum - C. J. Brockway - 140' Cassegrain Receiver.

General

Based on the general information and described in the above mentioned memorandum, we have proceeded to accomplish this task for the past year. We have designed, altered and changed the Cassegrain House on the 140-ft telescope to meet the requirements for installing the new receiver and its new feeds as designed by "Rick" Fisher.

We have only completed a small portion of the required field work which included removing the old "L"-Band, "C"-Band and "K"-Band with their associate supports and have installed new cover plates in these areas atop the Cassegrain House. We have also removed the old receiver with its waveguide, etc.

We have been in the planning and design stage since May, 1979 to support the new receiver and feeds.

As of this writing, we have made up preliminary scheduling for field installation of all engineering support on this project.

Other work to be included in scheduling down time is cryogenics, power and signal cable, heat and lighting, etc.

B. INSTALLATION PROCEDURE, EQUIPMENT AND COMPONENTS

(1) The very first component installed outside the Cassegrain house will be the feed support leg hoist which consists of an electrical hoise mounted at the base of northeast feed support leg and six sheaves spaced evenly along the leg with special bolted brackets. The top sheave is located so that it will not interfere with the subreflector operation and is used when telescope is in service or in stow position. It will be used mainly for changing feed in the future. The hoist will also be used to remove the old spoiler and to install the new spoiler and any other component too heavy or too large to handle by other means.

(2) A new spoiler will replace the old one since the azimuth location of the new feeds are in different areas from the old spoiler. Also the new spoiler is designed in four pieces allowing easier installation or removal.

(3) A new structural support is required for the new feeds and this support is bolted to the existing cover plates that were installed in May 1979. Accessories to the new support are jackscrews and angle brackets that hold the new feed in the support. For the larger feeds ("X" and "C"), an additional support will be installed for support since they protrude through the top of the Cassegrain house approximately three to five feet. A new weatherproof cover was designed to weatherproof around the new feeds atop Cassegrain house.

(4) A new radome de-icing system was designed using the old blower unit. A new air distribution box is located at the center of the Cassegrain house which allows duct branching to any of the proposed feeds.

(5) The installation of new components requires some inside work such as cutting rack clearance holes in the ceiling panels, cutting an access hole in another ceiling panel, and installing an access ladder to the attic area. This work is required before the receiver rack is installed which protrudes up through the ceiling into the attic.

(6) New wall beams are to be mounted on the wall where receiver rack is located. Since this receiver rack was constructed in two sections and protrudes through the ceiling into the attic, an extra wall beam will be installed above the ceiling panels to support the "Dewar" section of the rack. Also floor brackets will be installed for rigid support to the "drawer" section of the rack.

(7) The new receiver rack is installed in two pieces using the hoist to lift and hold the "Dewar" section which the "drawer" section of the rack

is manhandled into place. The top section is then lowered onto the bottom section and securely bolted together. The rack has jack-screws built into the base for final adjustment.

Note: During the rack installations the new "X"-Band feed has to be removed along with a section of the spoiler so the hoist line can hold the "Dewar" section of the rack. After the rack is secured, the feed horn is re-installed from the top of Cassegrain house. The feed had been aligned previously so the final section of waveguide can join the feed and receiver by "Brockway". The spoiler section can be reinstalled also and final sealing around the feed cover, etc. atop Cassegrain house.

(8) Now the ceiling panel sections can be reinstalled along with the access ladder to the attic.

(9) At some time during this scheduled shutdown the new Polarimeter, which has been designed and fabricated by the electronics division, can be installed on top of Cassegrain house. An area has been designated for this receiver, which protrudes the roof of the Cassegrain house into the attic section.

C. WORK BY OTHERS

(1) Installation of new electric heaters and lights.

(2) Cryogenics panel, etc.

(3) Power and signal cable, etc.

cc: B. Peery
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M. Balister
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NATIONAL RADIO ASTRONOMY OBSERVATORY

MEMORANDUM

January 10, 1979

To: Addressee

From: C. J. Brockway

Subj: 140-ft Cassegrain Receivers

General

By the end of 1979 it is hoped that there will be one channel of an upconverter-maser receiving system ready for the 140-ft Cassegrain. The frequency ranges available at that time will be 7.5-11.5 GHz (X band), 11.5-15.5 GHz (Ku band), and 18-26 GHz (K band). A 5-7 GHz (C band) upconverter is currently being built (AIL) and might also be ready for use by the end of 1979. Each frequency range will have a new broadband feed designed by Rick Fisher and built in the Green Bank shop. The delivery schedule for the feeds is:

Band	Date
Ku	Completed
X	June 1979
K	June 1979
C	January 1980

Changing frequency bands will involve removing one feed and replacing it with another, directly over the receiver. The receiver remains fixed in position for all frequencies. The only polarization available at first will be fixed linear.

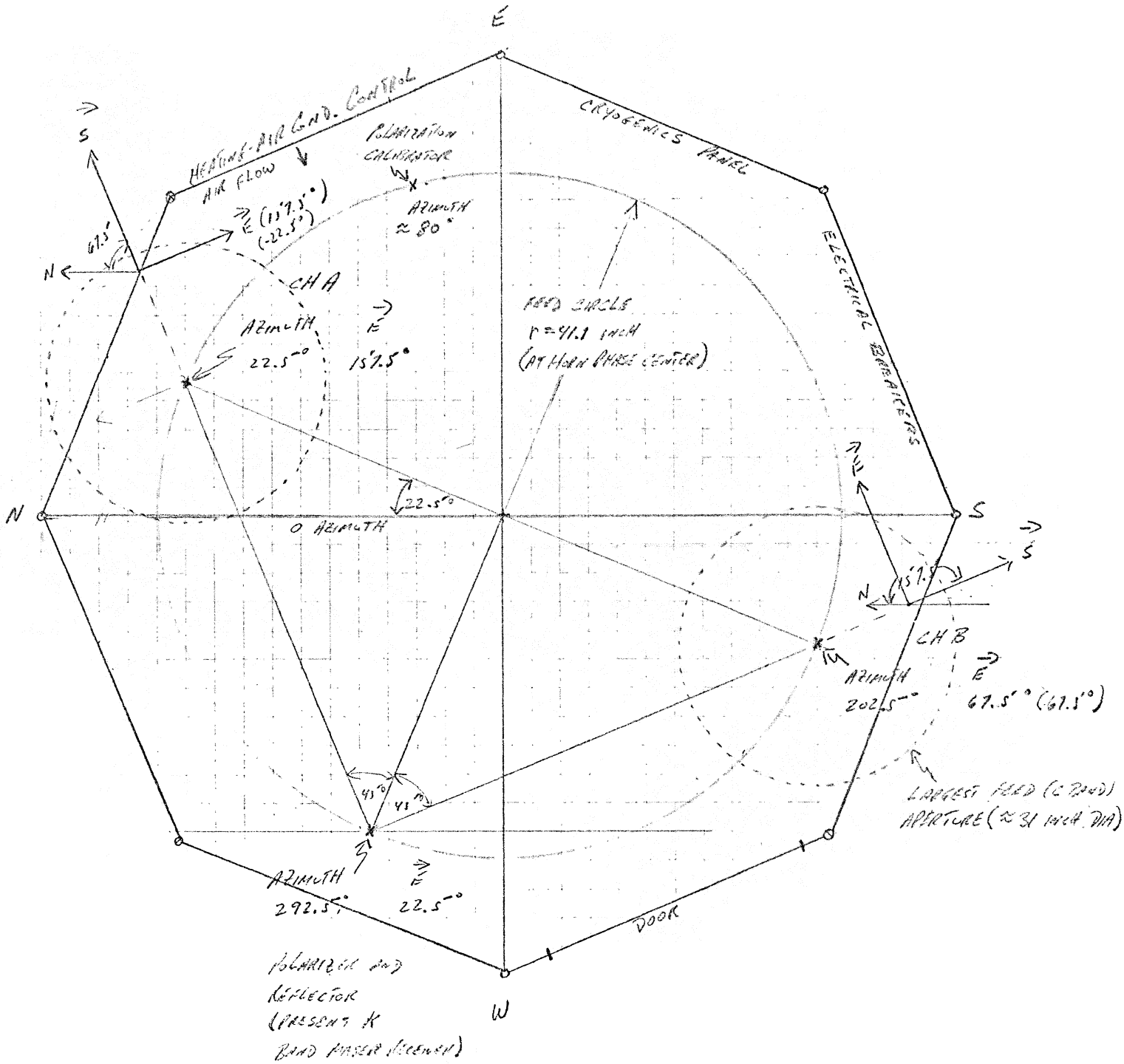
By mid-1981, a second receiver identical to the first should be ready for the telescope. In adding the second channel and using an IF polarimeter, it will be possible to receive circular polarization, to polarization switch, and to determine the Stokes parameters.

In designing the receiver, provision is being made to allow for the addition of one more upconverter to cover a yet undetermined frequency range. The intent is to wait and see how all the upconverters perform at their respective band edges and then select a frequency range with this and observer interest in mind. An additional feed may or may not be needed. Another possibility is that only the throat section of an existing feed may need to be changed for the new frequency.

Feed Geometry

Figure 1 shows the top of the vertex house as viewed from the prime focus. The present K band maser feed is located at 292.5 degrees azimuth. The deformable subreflector can only be made to properly change shape at 292.5 and 112.5 degrees azimuth at the present time, but further work will allow additional possible points of operation at 22.5 and 202.5 degrees azimuth.

When both receiver channels are in operation, it is intended to illuminate a passive beam splitter-reflector located at 292.5 degrees azimuth. Orthogonal linear polarization will be reflected to solid reflectors placed over the



140FT CASSEGRAIN
S-26 GHz RECEIVER
FEED LOCATION
12/78

Figure 1

receiver feeds at 22.5 and 202.5 degrees azimuth. Preliminary design of the feed system indicates that there may not be enough room for using this configuration below 7 GHz. In this case, a less desirable method is to illuminate the splitter only at either 22.5 or 202.5 degrees azimuth. One polarization is passed through the splitter into the feed, the orthogonal polarization being reflected to the second channel on the opposite side of the feed circle. In either or both cases, the splitter and reflectors can be oriented such that the receiver can always remain fixed in position directly under the feed circle at 22.5 and 202.5 degrees azimuth.

It should be noted that the phase centers for the new feeds are about 40 inches closer to the vertex than the original Cassegrain system, and there is the reflection path length of about 50 inches to consider as well. Rich Fisher has pointed out (memo of September 11, 1978) that the subreflector must then be moved towards the vertex by about one inch in order to correctly focus on a new feed; but then the subreflector shape is no longer right, causing an aperture efficiency loss of 3 to 4% at 22 GHz. This discrepancy should be considered if a new subreflector is eventually specified.

Although the feeds themselves have been fully specified, much work remains to be done on the beam splitting and reflecting afterwards. But the basic principles have been established and it looks like feed and receiver locations at 22.5 and 202.5 degrees azimuths are best.

Feed Mounting

Mounting of the feeds, and eventually the reflectors and splitter, will require quite extensive modifications to the vertex house and will not be an easy job for John Ralston. Present placement of structural members in the vertex house make it desirable to place the feeds at 0 and 180 degrees azimuth but the deformable subreflector characteristics do not allow this. Preliminary examination shows, however, that only one supporting member might be in the way for the proposed 22.5 and 202.5 degree azimuth locations.

Figure 2 is a rough drawing from notes showing the relative sizes of the feeds and their approximate vertical positioning in the vertex house. The idea is to have each feed apex terminate directly over the approximate center of the receiver. A short length of flexible waveguide will be used for each band since some motion between feed and receiver is inevitable. Figure 2 does not show the feed tilt; also the feeds will not all terminate in the same plane since the feed transitions and input coupler lengths will require slightly different distances between feed apex and receiver for each feed. But each feed will have the identical axial position and polarization.

Forced air across the feed radomes can be supplied by ductwork adjustable for each feed height above the roof. Since the feeds are constructed in sections, pressurization with dry air means either a sealant between sections or a second radome behind the aperture, or a combination of both.

The feed must be changed from the outside since the receiver rack is fixed in position directly underneath. There is also the problem of unused feed storage to consider. Dropping of the feeds into position by using a winch at the

prime focus cannot be done because the subreflector will be in position for many of the feed changes. Actually, there is no reason why the feeds cannot be stored on the ground with the larger feeds broken down into two or more pieces, winched or wrestled up into the vertex house and onto the telescope surface, then hoisted up to the roof and put together in sections. Changing frequency bands would not then be much more time consuming than changing prime focus front-end boxes.

At the present time there is a spoiler mounted on the roof of the vertex house to improve the baselines of prime focus systems. It would be quite difficult to change Cassegrain feeds with the spoiler in place. If the spoiler must stay, it has to be made easily removable. The plates might be readily mounted to the outside walls of the vertex house when not in use.

A rotating feed polarization calibrator is to be mounted at the vertex. It need not be on the feed circle but its location must be such that it does not interfere with the Cassegrain feed system. It appears that a location of about 80 degrees azimuth, on or slightly outside the feed circle is a good place. The calibrator should be placed as close as possible to the east pointing beam in the attic structure. This is the approximate location of the Ku band feed for the original Cassegrain system.

There will be times when the two channel receiver will be operating with the first channel on one frequency band and the second channel on another. The feed mounting design should allow any combination of feeds.

There is an admitted risk in doing the design and construction of the horn mounting before the entire feed system has been specified. On the other hand, there is much to say for an operating single channel receiver as soon as possible. It is reasonable to expect that the horn positioning and stability specifications for the original Cassegrain system (Cassegrain system for 140-ft Telescope, P. Napier, November 8, 1972) can serve as a guide for the same requirements of the new feeds.

Other Work

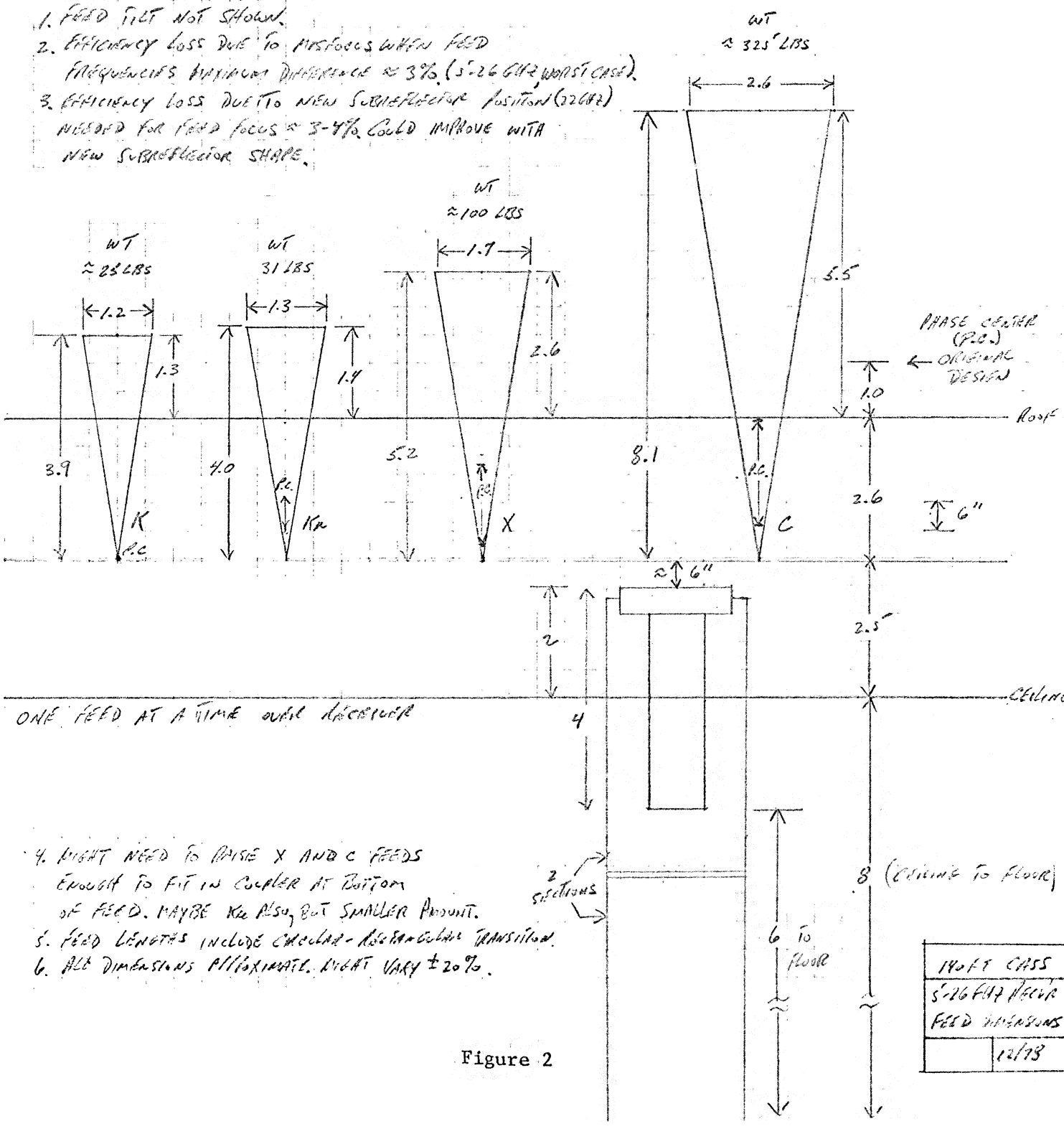
1. The original Cassegrain feeds must be removed (except for the K band). The original Cassegrain receiver has been taken out but the rack supporting structure remains and needs to be removed.

2. The cryogenic panel is now mounted on the same wall where the first receiver channel is to be placed. Once the old Cassegrain rack support is taken out there will be room for the cryogenics panel on the wall section between east and southeast and mid-way between the two receivers. Each will use a CTI 1020.

3. It is hoped that there is room through the polar shaft and cable trays for two more 30 conductor control cables between vertex and control room. It is planned to bring all cables into the vertex house through a side wall rather than up through the floor as at present.

FEED (GHz)	APERTURE DIA. (FT)	LENGTH (FT)	PHASE CENTER (FROM APERT.) (FT)	APPROX. WT. (LBS)
18-26 (K)	1.2	3.9	3.8-3.9	25
11.5-15.5 (Ku)	1.3	4.0	3.1-3.7	31 (MEASURED)
7.5-12 (X)	1.7	5.2	5.5-5.0	100
5-7.5 (C)	2.6	8.1	5.6-7.5	325

1. FEED TILT NOT SHOWN.
2. EFFICIENCY LOSS DUE TO MISFOCUS WHEN FEED FREQUENCIES MAXIMUM DIFFERENCE ≈ 3% (5-26 GHz WORST CASE).
3. EFFICIENCY LOSS DUE TO NEW SUBREFLECTOR POSITION (22GHz) NEEDED FOR FEED FOCUS ≈ 3-4%. COULD IMPROVE WITH NEW SUBREFLECTOR SHAPE.



4. MIGHT NEED TO RAISE X AND C FEEDS ENOUGH TO FIT IN COUPLER AT BOTTOM OF FEED. MAYBE Ku ALSO, BUT SMALLER AMOUNT.
5. FEED LENGTHS INCLUDE CIRCULAR-RECTANGULAR TRANSITION.
6. ALL DIMENSIONS APPROXIMATE. MIGHT VARY ±20%.

140 FT CASS
5-26 GHz NEAR FIELD FEED DIMENSIONS
12/78

Figure 2

Other Work (continued):

4. The upconverter-maser dewar will extend about two feet into the vertex house attic. The rack will have a total height of about ten feet. It will be made in two sections; the top part containing the dewar and weighing about 300 pounds can be winched into the attic, then the bottom section placed into position underneath. The two sections are then fastened together and rigidly secured to the vertex house side wall.

5. A lot of time will be spent working in the attic. A ladder or stair should be built for easier access and lighting and outlets should be installed.

6. At the present time, the attic is isolated from the remainder of the vertex house and is not temperature controlled. The air flow path for the heating-air conditioning system is through a filter in the main room ceiling, then to the return in the attic. There will be some electronic components in the part of the receiver rack projecting up into the attic but these components will be made to remain stable over the attic temperature range so that major modifications to the air conditioning system are not needed. But the access to the attic should be made to be easily closed off while observing. Strip heaters should be installed in the attic so that the receiver can be worked on in cold weather. The heaters can be thermostatically controlled while operative and turned on and off from the control room. Strip heaters should also be installed in the main part of the vertex house as a backup to the primary system.

7. Since the rotating feed polarization calibrator can be used for the calibration of prime focus receivers (and eventually for the Cassegrain receiver when both channels are operating), it would be desirable to install it before the Cassegrain feeds. The location of the calibrator in the attic is in front of the heating-air conditioning system return but it appears unlikely that there will be any problem with air flow blockage as the return area is quite large and there would be several inches clearance between the calibrator and return. The hole cut in the spoiler may have to be enlarged some and/or relocated slightly to the east. The raised portion of the roof in which the old Cassegrain feeds were mounted should probably be removed when the calibrator is installed. It would be advisable to direct air flow across the rotating feed aperture from the existing system; this would not be too involved since most of the needed ductwork is already in place.

Plans

The first receiver channel is being built and oriented in the vertex house to receive a polarization of 67.5 degrees. It will be located at an azimuth of 22.5 degrees. The present K band maser and feed will remain in position until the new receiver is operating on the telescope. Actually, the present receiver can remain in place for quite awhile as it will not interfere with either channel of the new receiver. It may eventually be taken out to make room for an equipment rack. Placement of the beam splitter-polarizer over the receiver will not be a problem since it does not extend below the roof except for possible mounting fixtures.

It is anticipated that the first channel of the new receiver will be used at C, X, Ku and K bands while the second channel is being built and the beam splitting reflecting design is being completed. The second channel and entire feed system should be completed at about the same time in 1981.

If it should turn out that the dimensions of the reflecting components are just too big to reasonably mount on the roof of the vertex base in the 5-7 GHz frequency range, it might be necessary to use a single feed at 22.5 degrees and more conventionally obtain orthogonal linear polarization with an orthomode junction in the attic. This would add about 10°K additional noise temperature to channel A and 20°K to channel B at 6 GHz. Since the expected system temperature is around 30°K, it is seen that this method can only be used as a last resort.

It is hoped that any difficulty with the largest (5-7.5 GHz, C band) feed system will not delay observing with the first channel at K, Ku and X bands towards the end of 1979; that is, a more involved feed support structure for the C band could be installed after observing time is logged at the higher frequency bands. Also, if the deformable subreflector does not yet work satisfactorily at 22.5 degrees azimuth at the end of 1979, perhaps the new receiver could be used at X and Ku bands and the K band maser now on the telescope could remain to be used at 292.5 degrees azimuth.

CJB/cjd

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(Preliminary)

140' TELESCOPE SCHEDULE FOR REVISING CASSEGRAIN SYSTEM

MARCH 7, 1980

SUNDAY	MONDAY	TUESDAY	WED.	THURSDAY	FRIDAY	SATURDAY
	X REMOVE OLD SPOILER. REMOVE BLOWER UNIT. RIG NEW SPOILER ON TELESCOPE IN SERVICE. MOVE TO STOW.	X INSTALL NEW SPOILER ON CASSEGRAIN HOUSE COMPLETE	X COMPLETE SPOILER. START TRANSITION FEED SUPPORT FOR "X"-Band. REMOVE CEILING PANELS (TO SHOP)	INSTALL "X"-Band FEED AND ALIGN. COMPLETE BOLTED CONNECTIONS AND SHEET METAL COVER.	START NEW AIR DIST. SYSTEM.	
	COMPLETE INSTALL AIR BLOWER UNIT. INSTALL NEW POLARIMETER.	REINSTALL CEILING PANELS FROM SHOP. INSTALL LADDER SUPPORT ANGLE FROM SHOP, INSTALL LADDER START RACK SUPPORTS, CASS. HOUSE	X CONTINUE RACK SUPPORTS ON WALL FLOOR REMOVE "X" BAND FEED AND SPOILER PANEL HOIST UP RACK TO	X HOIST UP DEWAR RACK. MATE RACK & LOCATE TEMPORARY IN BLD.	X MOUNT RACK. REINSTALL "X" BAND & SPOILER. SEAL PERMANENT.	
	LOST TIME DAY ON ANY PREVIOUS WORK IF SCHEDULE SLIPS	LOST TIME DAY SAME	LOST TIME DAY SAME			

X = DO NOT MOVE TELESCOPE

NOTE: WORK BY OTHERS COULD START ON THIRD DAY AND EACH DAY THRU SCHEDULE.