Phil

National Radio Astronomy Observatory
Tucson, Arizona

August 18, 1987

MEMORANDUM

TO: Addressee

FROM: John Payne JP

SUBJECT: 12 M Optics

Background of 12 M Optics

At the outset of the 12 m project various decisions were made regarding the optics of the new telescope. (12-M Memos 19 & 33). In summary these were:

1) The optics had to accommodate an unmodified 36' receiver. This dictated a subtended full angle of 4.2° by the subreflector when viewed from the receiver.

2) The receivers had to be accessible from behind the backup structure.

3) Four receivers had to be mounted on the structure at once and any receiver had to be quickly selectable.

In addition we chose to make the optics simple -- only plane mirrors were allowed. All these decisions were made in order to make the transition from the 36' to the 12 m as trouble free as possible and to absolutely minimize the manpower needed.

At that time it was recognized that we could incorporate into the optics (at the vertex of the telescope) various optical devices that would be common to all our receivers. In particular, continuum astronomers were interested in incorporating into the new telescope a device that Bobby Ulich and I developed for the old 36'. This device (the fast beam switcher) had improved the performance of the old 3 mm system by a factor of 2. With a view to building a universal beam switcher we purchased a new subreflector and hired Buddy Martin to work on a detailed analysis of the proposed system. As work progressed on this system it became obvious that an adoption of this arrangement would result in a severe loss of flexibility. In particular we would lose the advantage of the very slack tolerances on feed position in our receivers. In fact, we had taken such liberties with this aspect of the optics that our receivers would all have to be rebuilt. In spite of this Buddy and I persevered and last summer we successfully tested the prototype system at a wavelength of 3 mm. We used an elipsoidal mirror above the 3 mm receiver to match its optics to the beam emerging from the beam switcher. If we kept the present receivers we would probably need a separate elipsoidal mirror for each receiver. They cost 5K each.

In parallel with this effort I built a fast beam switcher for the 1 mm receiver, as some members of the scientific staff felt that fast switching would permit continuum observations at 1 mm in poor atmospheric conditions. Tests with this new beam switcher showed that the main contribution to atmospheric induced fluctuations was a slowly changing temperature difference between the beams which was largely unaffected by switching speed.

At the same time the fast beam switcher was being developed, it seemed likely that some, if not all, of the new receivers coming on line had less excess noise than the old receivers so at least some of the impetus for developing the fast beam switcher had slackened.

In summary the following seem to be true:

1) Fast beam switching can only help performance, but it seems likely that it will not help as much as was expected in the past.

2) A fully engineered fast beam switcher would be expensive both in money and manpower.

3) The existing optics will accommodate a fast beam-switcher directly over the receiver at 1 mm, but not at 3 mm.

4) A fast beam switcher as we envision it will not handle array receivers.

5) A fast beam switcher centrally located will greatly reduce the flexibility we enjoy with the present optics.

6) A corner cube would be difficult to incorporate into the same optics that accommodates a fast beam switcher.

Additions to Existing Optics

If we abandon the idea of a centrally located fast beam switcher, is there any way that we can simply achieve the other things we would like from a centrally located optics package? Additional devices that have been mentioned are as follows:

1) A single sideband filter with the image terminated in a cold load.

2) A calibration system with both an ambient temperature load and a cold load.

3) A corner cube.

These devices would be available at the vertex of the telescope and would be common to all receivers. 1) is a big job that I'm not even sure we can do. I think we should forget it, at least for now. Here are some suggestions for slowly modifying what we have now. No sweeping changes are involved, and provided things fit in the space available, I see no reason why it shouldn't work.

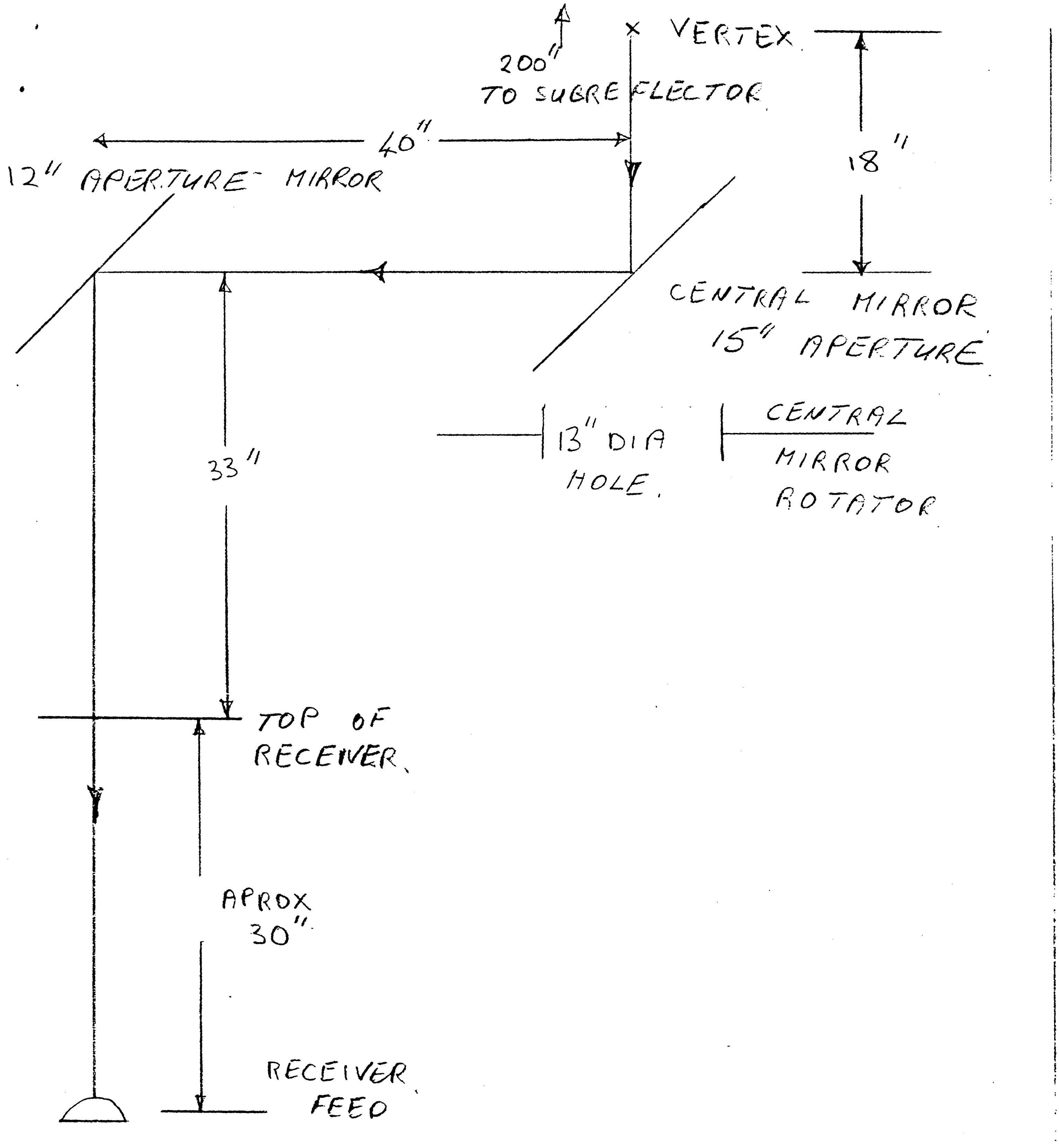
1) This summer we replace the central mirror itself (not the driving assembly) with a simple rectangular mirror bolted to a rectangular plate. This plate will bolt on the existing rotator. We make two identical plates -- one is installed on the telescope and we keep the other for building the second stage. We drill the telescope plate to accommodate the chopper assembly shown in fig. 2. This chopper assembly is an ambient temperature vane that covers the entire central mirror. I have ordered the components to build it -- it should switch in about 400mS. The chopper assembly can be added later in the year and all the individual receiver bay choppers removed.

2) During the next few months we build up the device shown in fig. 3. The corner cube has 3 mirrors with the bottom section moving and the chopper has been replaced with a switchable offset parabola made of honeycomb material. The cold load will be at 70K and will be cooled by a closed cycle refrigerator. A fast chopper in front of the cold load may be used for atmospheric extinction measurements or for tuning the receivers. The whole assembly rotates with the selection mirror.

Dennis and I will check to see if the system will fit. Does anyone have any comments or suggestions?

✓

c: Darrel, Dennis, Phil, James, Bob, Jeff, Jack and Antonio



ONE OF 4 RECEIVER BAYS.

SCALE $\frac{1}{10}$.

FIG 1 - EXISTING SYSTEM.

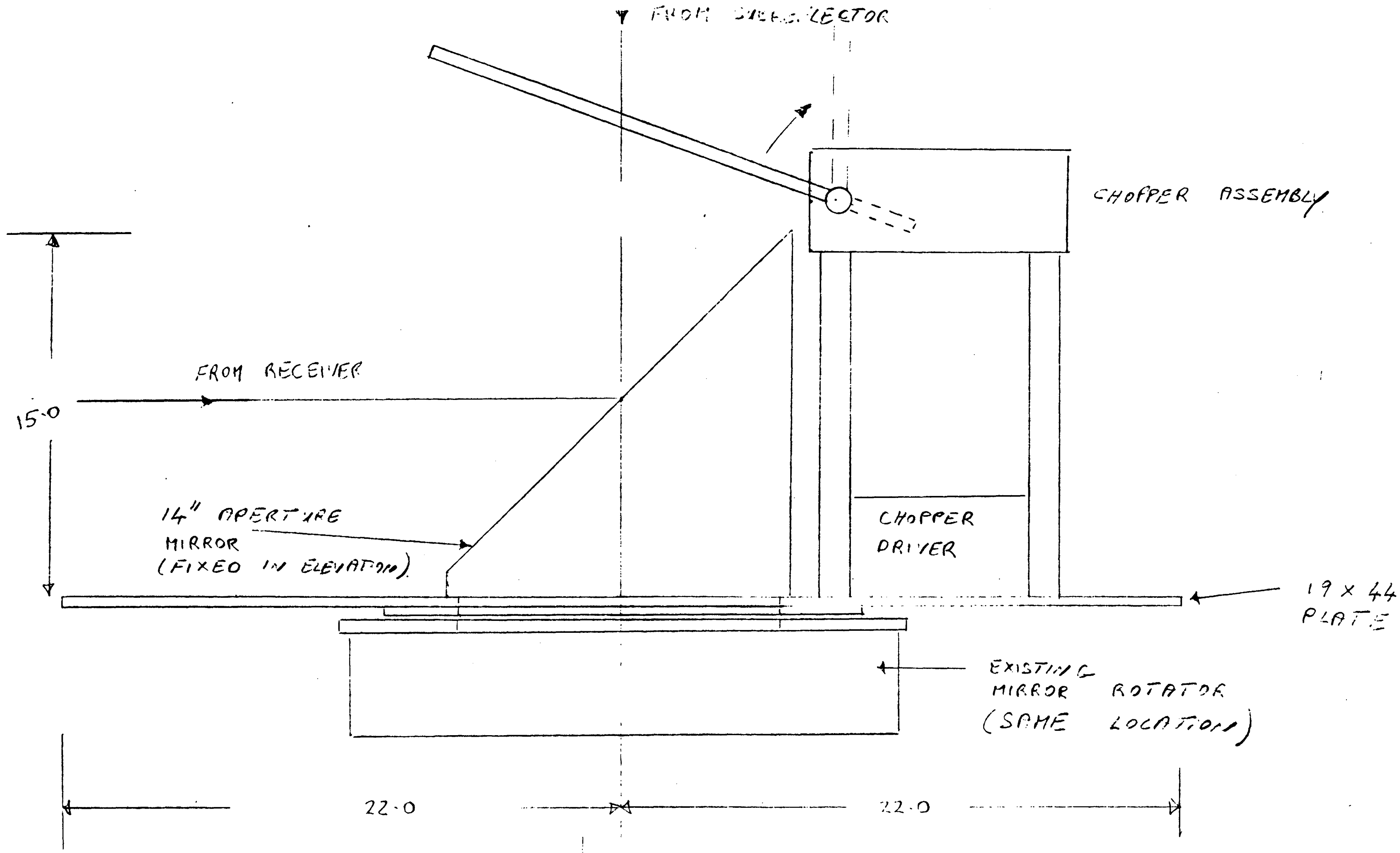
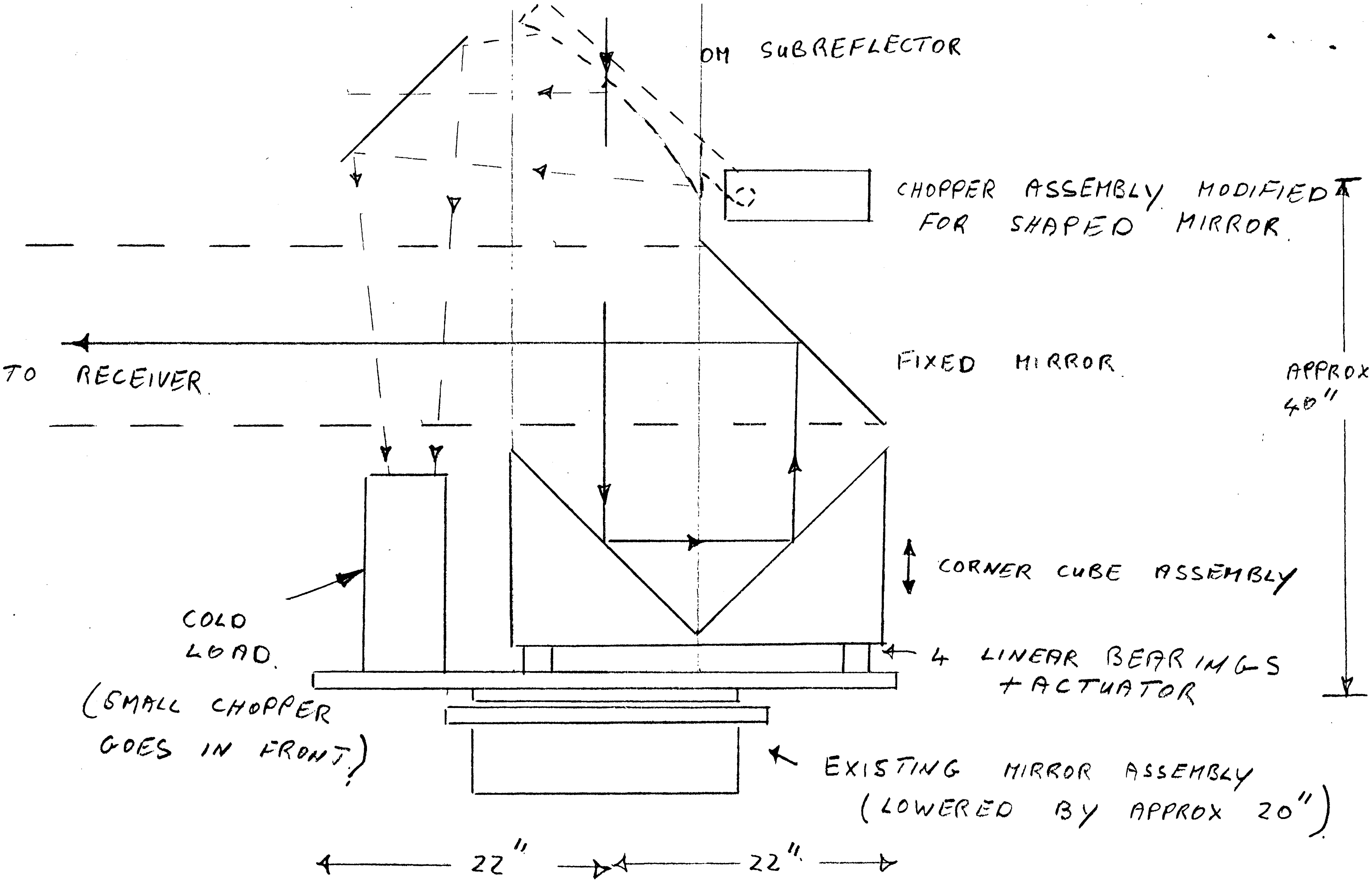


FIG 2 PROPOSED INTERMEDIATE ARRANGEMENT

SCALE $\frac{1}{4}$



SCALE 1/10

FIG 3 POSSIBLE FINAL ARRANGEMENT.