October 12, 1956

Dr. Phillip Nolan
Farrand Optical Co., Inc.
Bronx Blvd. & East 238th Street
New York 70, New York

Dear Dr. Nolan:

Dr. Heeschen and I wish to thank you and your colleagues for the time and hospitality given us last week on our visit to Farrand. I was greatly impressed by the 12-inch inductosyn and other devices that were demonstrated and I have since been reading the manual you loaned us.

When we left, we had agreed to give you a detailed statement of the components or systems on which we would want a price, to be incorporated in a general cost study we are making of the various altazimuth and equatorial radio telescope designs. These cost estimates will enter importantly into the considerations leading to the decision of what design or designs will be sent out for formal bids. Hence, we are seeking lump sum figures rather than CPFF development estimates, such as might have been necessary on the twelve-inch inductosyn several years ago. Thus, we hope to have reasonably firm prices, although it is recognized that during the formal bidding Farrand would have the right to revise these figures, either in dealing directly with us or with some companies that agreed to submit a joint bid on the entire telescope.

It appears that we need cost estimates on three systems, which might be sub-parts of a more comprehensive drive and control system. In each case it would be helpful to have a description of the system as well as the cost estimate, e.g. in the first case below, to list the number of inductosyns, oscillators, amplifiers, single speed synchros, drives for indicator dials, etc. that are involved:

Case I. A system to measure the angular position of a shaft, relative to some arbitrary reference mark, the shaft position to be displayed at some remote location (several hundred feet away) with an accuracy approaching 1" of arc. Assume that the shaft may be turned in either direction; that if the shaft is turned at a fast slewing rate, such as 20^{0} per minute of time, continuous high precision is not required, but the indicator must not drop out

of synchronization; that if the shaft is turned at a slow rate, such as 1° in two minutes, the indicator should follow continuously and with a lag of not more than 1-2" of arc.

Case II. A command system that might be used, for example, on the declination or polar axis of an equatorial telescope, wherein the desired position is set-in on dials, either manually or automatically and continuously as with a sidereal clock. The output of your appropriate amplifiers would then be used to control the electric or hydraulic motors that would turn a shaft. You need not include such power motors in your system. (Thus in Fig. 2 of your manual, the small motor shown might be replaced by a power amplifier and much larger motor and these power elements should not be included in your estimate). The actual position of the driven shaft should then be compared with the command position and the error displayed with a precision of 1-2" of arc. The angular velocity considerations described for Case I would also apply to Case II.

Case III. A coordinate conversion system, specifically to receive command positions of hourangle and declination (both might vary continuously to compensate for atmospheric refraction, gear errors, or other systematic factors in addition to the input from a sidereal clock, as in changing from one stellar object to another); to convert the hourangle and declination into azimuth and altitude (or zenith distance); to amplify these outputs to control servo power motors, as described in Case II; and to compare the actual positions of the azimuth and altitude shafts with the command positions, or as an alternative to compare the actual hour angle and declination with the command values. Again the angular velocity and accuracy considerations described in Case I would apply.

From our discussions I believe you are aware that some astronomers do not have much confidence in any system that involves electronics. Hence, one way to do the error comparison discussed in Case II and III would be to use completely independent position indicators (and coordinate conversion, for Case III) to permit a direct visual comparison of the "command" dials and "indicator" dials. On the other hand, we recognize that this requires the duplication of several costly components. Hence, we should consider whatever you consider to be the best of the several alternatives described to us, provided that the system would clearly indicate if there were a serious failure.

Mr. J. O. Silvey, of the MIT Servomechanisms Laboratory, who visited you on a previous occasion concerning our radio telescope problems, is coordinating our efforts to get prices on all the various components or sub systems that might go into the drive and control system for an altazimuth or equatorial telescope. For example, he is getting us prices on the power units that would be controlled by your systems in Cases II and III. If you have any questions concerning the cut-off point of your estimates, I will be glad to try to help, but as I would probably have to first talk with Mr. Silvey, I suggest that you take up any such matters with him.

Sincerely yours,

Richard M. Emberson
Assistant to the President

cc: Heeschen ✓
Silvey
Karelitz