

June 29, 1956

Dr. Bart J. Bok
Harvard College Observatory
Cambridge 38, Mass.

Dear Bart:

A. I cannot ignore the fact that your letter of June 20 to all members of the Panel speaks of my "praise" of the AUI report. It calls attention to my second paragraph of June 14, using the words that "you express yourself so favorably," and "the praise contained in this paragraph."

It is true that my paragraph surprised me a little when it appeared on the mimeographed copy. It was dictated as an afterthought when I realized that I had failed to indicate to Seeger that the report of the AUI should be accepted as completing their obligations under the two grants. They have spent the money and I see no reason to invite continuation of their expensive "study" procedures. To make sure of formal acceptance and completion of their work I listed all of the positive accomplishments, and I did not include any statement as to the technical shortcomings of the situation in which we find ourselves. I do not wish to rob you and Emberson of our collective thanks for the large amount of dedicated effort you two have put into this voluminous report. Nevertheless, it is important for the NSF and our Panel to recognize that the task of getting ready for a national facility is by no means completed.

B. There are some very fundamental questions which are not touched on in the report, nor has our Panel faced them and provided a written answer or recommendation. The principal one is the matter of the gulf between radio astronomy and optical astronomy, which we have helped to widen. My comments on this point are included in the copy of my letter to Goldberg which accompanies this letter. In essence, it is my conviction that the NSF must keep all of astronomy tied together, with guidance on facilities and funds for astronomical research in the hands of a single board, not several boards.

C. I also believe that at the operating level our Panel is gravely amiss if it does not provide for a very close living and working and regenerative relationship between the young and active optical astronomers and those who use radio detection methods. My concern on this point was expressed in the June 14 letter to our Panel in terms of a rather desperate proposal for the installation of some good optical equipment at Greenbank. This proposal is deplored and vetoed by Greenstein, Minkowski, yourself, and John Hall. I am therefore sure that this proposal was wrong, but the problem of inducing electronics experts to really know and live and love astronomy, as distinguished from electronic gadgets, has not been wiped out by the correctness of your position.

When our Panel two years ago removed the onus from Berkner and the AUI of a political decision as to regional location by stating that the search for sites should be within 300 miles of Washington, D. C. I am confident that none of us realized we were going to set up something comparable to Palomar in cost and complexity, and at the same time undertaking to specify, by its location, that it would be deprived of the continuous active working relationship of optical astronomers. It is one thing to set up an \$800,000 establishment, which I visualized at that meeting as adequate for some years, and quite another to spend millions. Since we have moved into the range of 4.5 to 5.0 millions of dollars it seems imperative to ask whether our Panel should now propose two actions: (a) Hold the options on the Greenbank land, and (b) Examine with the National Optical Observatory Panel the possibility of a joint installation, evidently in Arizona. The latter would bring the two groups into a close working and living relationship, and provide a growing basis for the men trained in physics and electronics to develop sound enthusiasms and critical judgment in astronomical problems.

I want to point out that the idea of transporting observatory equipment to and from our local installations has disappeared, and all we expect to move to the observing site and back again are some of the scientific and technical personnel. Phoenix, Arizona, is not more than several hours more distant than Elkins and Greenbank, West Virginia.

The basic point I raise is not related to land or technical advantages, it is related to motivation, stimulation, imagination, intellectual growth in a huge field of research, namely astronomy, which is not the common background of the physicists and engineers who become "radio astronomers." I commend most earnestly that you give careful thought to this point.

D. In accepting the NSF report we must not convey the impression that much of anything is ready to be acted upon. The site options were essential, but final decision on the site may take many months for the reasons above, and several others. The actual planning on a 140 foot dish is in a relatively sad state, due to the assortment of contradictory specifications among which a compromise was sought by "procurement office methods." Neither Berkner nor Emberson undertook to bring about the crucial engineering decisions which are necessary to produce an organic design. The tolerances on figure and angular precision were set, evidently on purpose, higher than anyone expected to achieve, and this result was reached. They cannot be achieved. The drive mechanism was allowed to be a separate problem from the rigidity of the mount, and the final MIT report brings out the fact, obvious from the start, that performance of the drive, and the design of the drive, is primarily determined by the rigidity of the mount, which is someone else's business. Incidentally, their final report also says that a closed servo loop must be used, but fails to point out, as far as I have noticed, that this must be a system of slow response. With this system the pointing deflection under variable winds depends primarily on the rigidity of the mount, just as with a synchronous motor drive on a polar mount (which can have a programmed correction through a differential to take care of gravity distortions; this is about all the closed servo loop of long period can accomplish). There are other technical features such as how many smaller dishes the Facility should have and with what articulation,

also the unexpected addition of a 250 foot dish as part of their avowed program for expansion.

I simply point out that the AUI feasibility report provides nothing but a beginning toward a basis for action, it does not provide a basis for action now. No quotations or estimates of course are available, since the basic choice of design has not been made, except by Berkner, who says the 140 foot dish is to be a prototype for the 600 foot equipment. This point of view has to date essentially defeated your hope and mine that the facility would promptly provide a useful dish of intermediate dimensions in the range 150 feet. In fact, while the AUI has been working toward the design of a 140 foot steerable dish by their office and contract procedures, we here at the DTM have been working on the technical job of dish and mount designs, and we are satisfied that a 150 foot dish with tolerances ample for 10 cm wavelength ($1/8$ wavelength deviation or less) and perhaps for 6 cm wavelength, on a relatively rigid polar axis mounting, with synchronous motor gear drive, is a straightforward design and construction task for a pointing accuracy considerably better than 30 seconds of arc. No limits on materials or fabrication processes are in evidence, and with modest attention firm quotations should be readily obtainable. Despite my hounding everyone on this point, the request you and I put through the AUI Steering Committee in March 1955 for such a simple and direct equipment, for use while the whole subject develops, has made no progress that I can see in the hands of AUI.

I believe it will take at least one year, and probably two years, before the engineering decisions will have been made to a point where funds can be allocated and contracts let. This is because the AUI still retains all of the contradictory specification requirements, and especially the one which requires the intermediate dish to be a prototype for their future huge-scale planning.

While we are at it let's face it, the AUI study has been an exceedingly expensive venture, and it has not produced a satisfactory basis for action now, because it has been carried out by the part-time efforts of Berkner and Emberson and occasional votes by a Steering Committee. Using clerical procedures and a checkbook the AUI has purchased for us some exceedingly expensive studies by consulting engineers and architects, and these studies have been so warped by the aim for a 600 foot dish that they have produced only a series of contradictory suggestions instead of a design, in the size range we asked for around 150 feet. Yet our DTM studies have confirmed the possibility of a straightforward design and cost structure for a 150 foot dish on a rigid equatorial mount with a simple synchronous drive. I see no reason for the position taken by you and several others that we lose a great source of strength and help if we do not utilize the AUI.

E. My principal criticism of the AUI activities, however, and of our Panel giving support to the present situation is that no personnel are really in sight for the responsible creation and use of this facility. Everyone who is pressing for it has a convenient retreat. The AUI is doing it for others and at the direction of others, so a failure due to wrong technical decisions or due to broad errors of judgment cannot be laid at their door. This is dangerous. They have not one man who wants actually to work in radio astronomy, or who will join this project and see it through thick and thin to success. The Panel well knows that this has been my criticism of the AUI activities from the start. The AUI system on this job is all a matter of action by proxy for the research men who are not there.

If you will ask yourself, as I have, for whom this facility is being built, you will find that it is to date intended for the part-time use of men who have other commitments and relatively large support elsewhere. Most of them are zero, one, or two years out from their PhD training. No optical astronomer aside from yourself has undertaken a responsible commitment in this project. You are going to Australia and that puts a definite time limit of about six months on your capacity for being responsible to the NSF or others here. Hagen, whose background is electronics, was considered for the leading post, but he elected to leave radio astronomy in order to be responsible for the earth satellite; he has accepted the commitment of being a hundred per cent not available to radio astronomy until the satellite adventure is completed. He is now out of the NRL radio astronomy group. Under these circumstances it will be a thoroughly irresponsible action if our Panel or the NSF undertakes to accept him as a candidate for primary responsibility in this national facility. I believe that the director should be a man of recognized high competence in astronomy, not in electronics.

Who is it that needs this facility so urgently? Harvard has Heeschen and Matthews and several students. These young men have just acquired a 60 foot equipment, which is quite a lot for them for a while yet. NRL has McClain, Lilley, Roman and several others; they have a 50 foot and a new 84 foot equipment not even yet set up. Michigan has Haddock and one advanced engineering student; they are erecting a 28 foot and a 60 foot equipment. Cornell has Marshall Cohen and several equipments. We here have five or six men working in radio astronomy, and several modest equipments; but you may be sure that the NSF Greenbank installation as guided by the AUI is not being planned by or for our Carnegie group. Ohio State has Kraus and several students, but they are busy with their large helix installation and are building a large tilting reflector for which we supplied funds. They are not much interested in the steerable parabolas nor in the AUI plans. Cal Tech has over half a million dollars and two 90 foot dishes under construction, plus others. Stanford has Bracewell and one or two students; they have funds approaching \$200,000 from the Air Force for an installation yet to be built. The rest of your list of institutions and individuals who are "climbing on the band wagon" or, in your various talks, are "active" in radio astronomy, I would class as "hopefuls" or "sympathizers." Among those who hope some day to do something are Rensselaer, Case, Yale, Illinois and Penn, and among those who sympathize with the idea of having radio astronomy happen some place and can give it an occasional technical or administrative boost are Berkner, Menzel, Townes, Dicke, Weisner, Goldberg, Gordon, Seyffert and perhaps others. Where among these are the sound research men who need this new five million dollar facility which we have urged? Shall we now decide we must import them from Manchester or Sydney? Our men in the universities are all building big equipments on funds supplied by ONR, OOR, NSF or the Air Force. Can we name even one first-rate man who is prepared to accept personal responsibility to make this added "National Facility" a wise and fruitful venture for the NSF? Our Panel is responsible on these points, I believe. Who says we have a sound basis for prompt action?

F. The above paragraphs are committed to cold print in order to be sure that we face our obligations. It becomes painfully evident that the NSF, at our bidding, is taking the step of underwriting "facilities" instead of men or ideas. Not only this, but

at our urging they are ready to undertake large-scale support of a highly specialized single facet of a broad subject. Radio astronomy is not a subject; astronomy is a subject. The optical identification of the radio objects is absolutely a sine qua non; no man can think about the radio sources unless he has some knowledge as to their state of physical aggregation, which can range from many cubic light years of tenuous and turbulent gas to highly compressed shock waves as in the Crab Nebula (perhaps), or the gas at the surface of a star like the sun with its enormous pressure gradients. It is true that to encourage broad progress in scientific fields attention must be given to highly specific pin point areas, but one hardly sets up a great facility to handle single instrumental tasks of this kind when no research men are ready to step in and carry full responsibility for its creation and its success.

G. I would call a meeting of our Panel if I could sense that anything fruitful would come of it. I feel, however, that several members of the Panel including yourself are flatly committed to the AUI plan. Hagen's letter criticizing my invitation to Irving Stewart shows how he wants to prevent any other action. One or two members find it difficult to take part at all, and I am left as the primary challenger who is asked to bring order into this situation. I do not accept the idea that the AUI can do that; an NSF board for the nurture of astronomy and radio astronomy can do it, but more slowly than you and Hagen and Berkner now think.

I have asked the NSF, if they choose, to bring together some optical astronomers the night before their July 11 meeting, and it is my hope that members of our Panel will come to that session, if it is set up by the NSF, on the assumption that they share my concern over the broad and fundamental aspects of the decisions which are to be examined July 11.

This began as a personal letter to you Bart, but I have decided to let the entire Panel face with you and me the basic responsibilities we have accepted and which we shall put somehow on the record July 11. My estimate of the situation is that not much is ready for action, nor can much more be done toward a radio astronomy facility until and unless a first-class astronomer and one or two dedicated scientific and technical colleagues are ready to accept a real personal responsibility to the NSF and to the country for this activity. A corporate Board set up at the request of the NSF to nurture all of astronomy for the NSF might be able to find these men and gradually create a true National Facility for optical and radio astronomy, placed in one or several locations, but operated as a unified activity.

Sincerely yours,

M. A. Tuve, Chairman,
Advisory Panel on Radio Astronomy, NSF

Copies: All Panel members, Alan Waterman, R. J. Seeger, L. Goldberg, and I. S. Bowen