THE RISE AND FALL OF THE QUEEN ELIZABETH II TELESCOPE

Proposal and Acceptance

Some time early in the 1960s Canadian astronomers began to feel the need for a larger telescope. The leading position that Canada had enjoyed a generation earlier, with the 72-inch telescope at the Dominion Astrophysical Observatory and the 74-inch at the David Dunlap Observatory of the University of Toronto, was being rapidly eroded. Accelerating astronomical research in other countries had provided larger and larger instruments, and Canada had slipped into tenth place among countries possessing large telescopes. Modern astronomy was turning increasingly to the spectrographic and photometric study of globular and galactic clusters, which were believed to hold the secret of stellar evolution, and to the observation of external galaxies, of their distances, ages and motions, which held the clues to the history of the universe. Canadian astronomers were excluded from these studies by the lack of a large-aperture telescope.

Canadian universities had expanded since the end of the war, both in numbers and in complexity, and many of them had started departments of astronomy. These worked under severe handicaps with inadequate observing facilities, and their brighter students were attracted to the United States where these were available. Only the University of Toronto had a major telescope, and this was proving inadequate for even its own students. There was a ten-fold increase in the number of students enrolled in astronomy, and a questionnaire circulated to universities, government laboratories and industrial firms suggested the need for 30 fully trained astronomers and 30 astronomy-trained physicists within the next five years. Further studies by Professor Donald MacRae showed that this accelerated need would continue, and that four or five new centres of graduate training in astronomy would have to be developed to keep abreast of the demand. Not all of these anticipated students would work in optical astronomy. Radio astronomy and theoretical astrophysics would occupy many of them, but a steadily increasing demand for observing time on a first-class telescope had to be anticipated.

A similar situation had been developing in American universities; to meet the need an "Association of Universities for Research in Astronomy" (AURA) had been established "to provide American astronomers and qualified graduate students with modern telescopic and instrumental equipment for astronomical research". Already two moderate sized, Cassegrain focus, telescopes, a 16-inch and a 36-inch, were in operation at the Kitt Peak National Observatory, in Arizona, and an 84-inch telescope of advanced design was undergoing final testing. Plans were well advanced for a 150-inch telescope, and its funding was assured. Much of this expanded interest in astronomy was directed toward photometry. We learned something about photometry in Chapter VII. By measuring a star's apparent brightness at a number of different colours it is possible to discover its physical properties – its absolute magnitude, temperature, radius and spectral classification, and to measure the interstellar absorption that its light suffers.

By the early 1960s photometry measured colours and brightness with photoelectric detectors, which were at least twenty times more sensitive than the photographic emulsions then used in spectroscopy. There were a number of consequences: photometric observations could be made much more quickly than spectrographic ones, at the rate of 20 to 50 an hour; the same stars could be studied with much smaller telescopes; fainter and more distant objects, beyond the limits of spectroscopy, could be observed, thus pushing back the limits of the observed universe.

Photometry had not been a major Canadian interest. It requires very clear skies without the contamination of city lights, and stable atmospheres. Neither the Dominion Astrophysical Observatory nor the David Dunlap Observatory at Toronto provided these. But there was a growing demand for photometric facilities. This was particularly true in university groups; the speed with which data could be accumulated made photometric studies ideal as thesis material.

Petrie, with advice from his astronomer friends at Kitt Peak, Mount Wilson and Palomar, started to consider the specifications for a large telescope early in 1962. At the same time Odgers began a search for a suitable site. In late October 1962 they discussed their plans at a meeting of the Canadian Committee for the IAU, which supported the idea with a formal resolution¹. Beals sent a copy of this resolution to the Deputy Minister, W.E. van Steenburgh, who replied²:

"There is no question about the need for a larger telescope in Canada, – the problem is . . . to present the need in such a way that it will receive 'agreement in principle' in the reasonably near future.

In the future, no costly scientific program will receive recognition and approval unless it is *completely* documented. This means a consideration of need, location, design costs and final costs. Such a document should be prepared in acceptable booklet form for provision of adequate copies for all levels of consideration. The 'Upper Mantle Project' presentation might serve as an illustration of what is needed."

Clearly planning had not progressed to the point that such a detailed study could be presented, but publicity could be given to the idea. Petrie³ published a paper in the Journal of the Royal Astronomical Society of Canada calling for "A Large Optical Telescope for Canada". He reviewed the history of astronomy in Canada, described some of the exciting and important fields of research open only through a large telescope, and speculated

on the telescope design. Professor Helen Hogg, of the University of Toronto, wrote about the need for a new telescope in her column "With The Stars" in the Toronto Star⁴ and Professor Wehlau of the University of Western Ontario supported the project with a paper in the Journal of the Royal Astronomical Society of Canada⁵.

Support for the telescope came from an unexpected source. In 1963 the government set up an Interdepartmental Committee to plan for the celebration of Canada's Centennial in 1967. Each Department, and ultimately each Branch, was asked to suggest projects. Beals made two proposals:

1. "a 150-inch optical telescope available to all universities and qualified students in Canada ... to be erected and operated by the Department of Mines and Technical Surveys".

2. "a geophysical, geological, oceanographic and topographical study of Hudson Bay and its environments."

The second of these suggestions led to a major retirement project for Beals, the editing of a two volume study on "Science, History and Hudson Bay". We are here interested in the first proposal. It appealed to van Steenburgh; he sent it to the Interdepartmental Committee with a strong recommendation, and he immediately took charge of the campaign for its acceptance by the government. I have described elsewhere van Steenburgh's enthusiasm for imaginative and worthwhile scientific projects, and his great ability to push them through. As Beals put it⁶:

"We are all hoping that Dr. van Steenburgh's almost uncanny feeling for the promotion of a scientific project will run true to form when the large telescope project comes to a showdown".

I think the astronomers in Victoria were a little surprised, perhaps even alarmed, at the speed with which things moved. Five days after receiving the proposal van Steenburgh was calling for "a well thought out brief on the proposal for a new telescope"⁷; again the pamphlet on the Upper Mantle Project was suggested as a model.

The brief reached Ottawa by November 15, 1963, and 150 copies had been printed within a month. Van Steenburgh also called for letters of support from astronomers and organizations: appropriate resolutions were passed by the Ottawa Centre of the Royal Astronomical Society of Canada⁸ and by the Council of the parent society⁹ and many astronomers, including Dr. I.S. Bowen, recently retired Director of the Mount Wilson and Palomar Observatories, wrote in support of the project.

Van Steenburgh was clear on one point: the telescope must be built in Canada. Millman had proposed that, considering the dearth of large telescopes in the southern hemisphere, Canada should join with other Commonwealth countries to support a telescope in the southern hemisphere instead of lobbying for a large telescope in Canada. Commenting on this van Steenburgh wrote¹⁰:

"Dr. Millman has expressed the same thing to me in the past. I told him at that time, and I wish to repeat myself again, that the chances of securing such an instrument for outside Canada would appear impossible.



Juan Geuer's conceptual drawing of the 150" telescope and dome. This drawing appeared on the cover of the initial brief for a Confederation telescope; the caption was modified when the telescope was renamed to honour the Queen.

It is going to be difficult enough to persuade the Government to construct a large telescope in Canada. To suggest such an instrument for a foreign country would compound the difficulties several hundreds of times."

The Interdepartmental Committee liked the proposal for the telescope, although it questioned how much of the Observatory could be completed in time for the Centennial. When it was suggested that a road, support buildings and some equipment transferred from Ottawa could be in place by 1967, the Committee accepted the telescope¹¹ as "The Confederation Telescope" and agreed to support it. A first draft of a Memorandum to Cabinet was prepared by February 25, 1964.

Van Steenburgh was glad of any support but he had no intention of leaving the matter there. In late March 1964, he and Beals appeared before the National Research Council to present the case for the new telescope. Beals reported to Petrie¹²:

"The meeting consisted of about 25 persons including Millman and Herzberg who were present for the discussion on the telescope. ... The reaction so far as I could judge was a good deal more favourable than I had anticipated. Millman and Herzberg both gave us strong support as did several of the physicists from whom I had expected opposition because of the competing accelerator project. Members of the NRC were inclined to insist that universities and other organizations (such as NRC!) should have a definite voice in policy and management and the Deputy Minister agreed with them.

It would probably be a good thing therefore to give some thought to the formal organization of what, regardless of its value, will almost certainly be a new Institute for advanced research in the Astronomical Sciences with a board of directors not unlike a miniature Research Council with representation across Canada. My own impression is that a good preliminary proposal along these lines could go a long way toward assuring the success of the project so I recommend it to your attention."

Leaving nothing to chance, Beals himself revised the Cabinet submission to accommodate the concerns of the NRC. These having been met, President Ballard wrote to C.M. Drury, Chairman of the Privy Council Committee on Scientific and Industrial Research, giving the Council's unqualified support for the project. The Departmental submission was sent forward late in June, was reviewed by the Committee Secretariat, and forwarded to Treasury Board for study.

The Committee could not meet to consider the submission until Treasury Board approval had been obtained. There was no way of knowing when this would occur, which complicated van Steenburgh's plans for Departmental representation at the meeting. Beals had retired at the end of June; I would replace him, but would need strong astronomical back-up. Petrie was committed to attending the meetings of the International Astronomical Union and planned to leave Canada in early August, returning in early October. When it seemed clear that the meeting would take place during Petrie's absence, van Steenburgh arranged with the Committee Secretary that we be given four days notice of the meeting, and instructed that Odgers should hold himself in readiness to come to Ottawa on short notice.

The meeting was held on September 21¹³. The Committee consisted of six Ministers chaired by C.M. Drury, the Minister of Industry. It was augmented by a distinguished group, including the President of NRC, the Chairman of the Defence Research Board, and the Deputy Ministers of the Departments of Finance and of Industry. Dr. F.A. Forward, of the recently established Scientific Secretariat was also there. Our Department was represented by its Minister, Mr. Benidickson, van Steenburgh, Odgers and myself.

The reception was most cordial. Benidickson introduced the proposal, van Steenburgh spoke briefly, and I was invited to make the principal defence. This was done, I think, very effectively, but it was a nervous time because Odgers had not yet shown up at the time of my presentation. He arrived, very much out of breath, almost an hour late. He had made an error of an hour in adjusting his watch to Ottawa time, had spent the past hour pacing up and down in front of the Parliament Buildings, until he had happened to glance up at the clock in the Peace Tower! He explained the situation so amusingly, pointing out his chagrin as an astronomer in not knowing what time it was, apologised so charmingly, that the Committee was in fine humour. His mistake was almost an asset in gaining the Committee's sympathy.

There were many questions, some administrative, which van Steenburgh or I answered, most technical, which Odgers fielded. At the end "the Committee agreed to recommend to the Cabinet that approval in principle be given to a Confederation telescope ... subject to a review by the Treasury Board, in consultation with the Department of Mines and Technical Surveys, of the most suitable time-phasing of the project."

After the meeting Odgers and I returned to the Observatory in a high state of euphoria. Odgers sent a telegram to Victoria, with the good news, I a cable to Dr. and Mrs. Petrie¹⁴ at their hotel in London. I ended the cable with "recommend Cordon Rouge as appropriate", referring of course to the splendid product of G. H. Mumm and Co. of Reims.

In our euphoria neither Odgers nor I thought to spread the glad tidings around the Observatory. In particular we neglected to tell Locke, who had worked hard for the telescope, especially after Beals' retirement had placed a non-astronomer in the Director's chair. It was an oversight which I much regretted, and which created the erroneous impression that the Ottawa astronomers were being excluded from the planning.

On September 23, 1964 Cabinet accepted the project. I cabled the Petries, now returning home on the Empress of England. They had not understood my reference to Cordon Rouge, but by the time my cable arrived telling of the final acceptance the message had been interpreted. They cabled back¹⁵: "Message received congratulations appropriate ceremony observed".

Her Majesty the Queen was to visit Canada on October 5-11. The Cabinet was in something of a quandary about a suitable gift to mark the occasion. Someone suggested, perhaps facetiously, that they might give her the telescope, which they had just approved. The suggestion appealed to the Ministers and it was agreed to.

An interesting idea, but how could the presentation of an observatory, still in the astronomer's minds, be symbolized? Odgers had shown some drawings of the proposed Kitt Peak Observatory at the meeting of the Privy Council Committee. Could these be made available? They could, and better still, so could a scale model of the telescope and dome. These were shipped by air freight from Tucson and arrived in time for the presentation. Her Majesty was obviously pleased, as the photograph on the following page will attest.

Not everyone was happy with the new name for the telescope. A Dr. Bennett, from Nanaimo British Columbia, wrote to the Prime Minister objecting to the name. The telescope should have been named after some pioneering astronomer, probably J.S. Plaskett. It fell to me to write the reply. Mr. Pearson signed a letter which contained the following paragraph¹⁶.



Her Majesty Queen Elizabeth II, Prince Phillip and Prime Minister Pearson admire the model telescope. National Archives of Canada, Photo C135459.

"I am sorry that you are disappointed in the name 'Queen Elizabeth II' telescope which we had felt was a particularly happy selection. It honours the gracious and courageous Queen of Canada and, at the same time, removes the telescope from the realm of partisan politics throughout the long period which will be required for its completion."

With hindsight we may regard this as a prime example of dramatic irony!

Even before the Government had announced its intention of dedicating the new telescope to the Queen, van Steenburgh wrote to Petrie¹⁷: 'I think it is time that we finalize the site – i.e. if you are ready to do so. I have not been anxious to give out specific information about location, but after the announcement is made my reasons for keeping quiet will have disappeared."

This was requiring the astronomers to make a site selection before they would have wished to; they had settled on the southern Okanagan Valley, and Mount Kobau was certainly the preferred site of the three under consideration but Petrie wanted another year, perhaps two, of testing¹⁸. However, he opted for Mount Kobau and an announcement to this effect was made by the Government on October 28. The announcement included a sentence which, while true, would come back to haunt us. "In the dry belt of the British Columbia Interior, the area is a northward extension of the Great American Desert." Before making the announcement on the location the Prime Minister required some reassurance on the choice, and I was bid to his office. Mount Kobau was not in a Liberal riding; could I assure him that there was no Liberal mountain that would be just as satisfactory? I could, and did, having phoned Victoria earlier in the day for moral support.

Before anything could be done it was necessary to comply with the Privy Council Committee's directive for a review, with Treasury Board, of the "most suitable time-phasing of the project". Departmental plans were spelled out in a memorandum¹⁹ which called for a six-year schedule, with completion in the fiscal year 1970-71, and a total cost of ten million dollars. This was accepted by Treasury Board²⁰, and funds and positions for the first year were approved. The memorandum made the point very firmly that "the minimum time for completion ... is determined almost entirely by the lengthy period required to manufacture the optical components of the telescope. ... For a six-year time schedule to be met, the order for the 150-inch mirror blank must be placed without delay." The point might also have been made that planning for the grinding and polishing of the mirror, involving the design and construction of the polishing machines and of the Optical Shop to house them, must also begin but this was not done. The need to order the mirror blank was accepted; the requisition was submitted almost immediately, tenders were received by early July 1965, and the contract was awarded to the Corning Glass Works at a contract price of \$1,148,000.

In December 1963, months before the telescope had been approved, it was announced that the instrument and electronics division of Canadian Arsenals Ltd., in Scarboro, would be closed. This division had been a source of much fine optical equipment for Canadian astronomers. Professor MacRae, of the University of Toronto, brought the closing to Beals' attention²¹, suggesting that some means be found of hiring the opticians. This was done, and Roy Dancey and John Miller were brought on staff by June 1965. They were able to contribute expert knowledge to all questions involving the polishing of the mirrors.

Scientists regard administration as, at best, a necessary evil, but in this case it was very important. The work would involve two departments, Mines and Technical Surveys and Public Works, and the Treasury Board, and the expenditure of large sums of money; the separation of senior management from the scientists by half a continent complicated the arrangements.

Within the Department the lines of communication were simple: in Victoria, Petrie and Odgers were responsible for all aspects of telescope planning, in Ottawa, the responsibilities rested with, in order of seniority, W.E. van Steenburgh, Deputy Minister, J.M. Harrison, Assistant Deputy Minister for Research, J.H. Hodgson, Director of the Observatories Branch, and J.L. Locke, Chief of the Stellar Physics Division. Because Petrie was almost completely occupied with the design of the new telescope, K.O. Wright assumed responsibility for most of the management of the Dominion Astrophysical Observatory.

The aim was always to let the astronomers make all technical decisions and to keep them fully informed of administrative decisions in Ottawa, but to intrude on their time as little as possible. There were some failures, but, by and large we did this; as I have reviewed the files from those exciting times I am quite impressed with what we did. I am equally impressed by the fact that the astronomers responded promptly, cheerfully and effectively to the administrative demands that were made on them.

While all technical decisions about the telescope and the associated observatory would be made by the Department of Mines and Technical Surveys, the actual work on the mountain top would be supervised by the Department of Public Works. This was the responsibility of the Chief Architect, J.A. Langford, and of the Regional Architect for British Columbia, R.J. Bickford. To provide effective cooperation between the two Departments, P.Z. Marcsan was appointed as a Liaison Architect.

A number of committees were set up to coordinate the work. As we shall see presently, the firm of A.B. Sanderson, of Victoria, was appointed as prime consultant. Sanderson arranged for monthly meetings of everyone involved in the project to discuss the progress of the work; this group was referred to as the Steering Committee. It usually met in Victoria and the meetings were frequently attended by representatives from Ottawa.

The idea that a committee of senior astronomers, government and university, should be established to advise the Department was in Beals's mind some time before his retirement and was certainly advanced by van Steenburgh's agreement to the NRC suggestion "that Universities and other organizations should have a definite voice in policy and management" of the proposed telescope. Discussions were held with university astronomers at Toronto, Western and Queen's. All agreed that such a committee would be valuable, that it should consist of approximately equal numbers of representatives from universities and government, but that the number of university representatives should not be sufficient to override the government, that it should be chaired by the Director of the Observatories Branch or his designate and that the Secretary should be appointed from the Observatory staff. A proposal for the establishment of a National Advisory Committee on Astronomy, so constituted, was approved by Treasury Board in early April 1965²². The first meeting of the committee was held on October 26, 1965.

The amount of planning that had to be done was clearly beyond the resources either of the Regional Architect, or of the small design group in Victoria. The Department of Public Works proposed²³ "that a competent firm be hired to carry out a study for the project in its entirety and ultimate form, so that the planning is carried out with the whole project in mind and includes all aspects, present and future, in the proposal. This study is to form a basis for the whole development." This call for a Prime Consultant was echoed by Petrie²⁴: "It is now our opinion that the appointment of a consultant, for the whole project, is the best way to make progress and this should be done as soon as possible."

Very well, but what would the responsibilities of the Prime Consultant be? The astronomers were clear about how the design of the telescope was to be carried out. It must proceed under their close supervision aided by experts from a variety of engineering disciplines and with the advice of their colleagues in the United States. The design would depend on the research for which the telescope was to be used and each step in the design must be examined for feasibility from an engineering point of view. Only when these studies had been completed would it be possible to draw up specifications to permit competitive bidding.

This approach was completely unacceptable to Treasury Board²⁵. All past experience "in the design and development of unique equipment" had taught them that "competitive tenders for the design and fabrication of such equipment" led to better cost control and lower prices. They advocated that "the scope of the prime consultant's work should be limited wherever possible to the establishment of the necessary specifications, and that the design of the telescope and its ancillaries should be accomplished through competitive tenders, preferably in a major package, i.e. telescope, mount, drive and controls."

This was unsatisfactory both to the astronomers and to the Department. In his reply to the Treasury Board²⁶, van Steenburgh pointed out that each large telescope produces unique problems and that no firm existed with specific competence. "We do not wish to set up our own engineering competence, as the Americans have done. Rather we wish to employ, through the prime consultant, the best specialized skills available. These people are in a variety of industries and in Universities, and we believe that most of the experts we need can be found in Canada. The consultants will, for the most part, need to work in Victoria so that they can be in constant consultation with the prime consultant and with the astronomers". Treasury Board remained unconvinced.

At the same time an English firm, Sir Howard Grubb Parsons and Company, was campaigning to obtain the contract to build the telescope. This firm had an unquestioned competence in the construction of large telescopes. It had supplied the 48-inch telescope at Victoria and was currently building the 98-inch Sir Isaac Newton telescope, to be erected in the United Kingdom. Their approach²⁷ urged exactly the arrangement which Treasury Board was proposing: "that competitive designs to a performance specification prepared by your Department, be requested, to include prices for

- (a) Grinding and polishing the mirror blank;
- (b) Design and manufacture of the complete package;
- (c) Supervision of erection, optical testing and commissioning.

I have not been able to find the original letter from Grubb Parsons, but to judge from the reaction of astronomers, it must have been pretty offensive²⁸, suggesting the incompetence of Canadian astronomers, and industry, and offering not more than 10% Canadian content in the finished product. But, since it accorded so closely with Treasury Board thinking it required careful consideration. There were many things against it: the limited Canadian content, the fact that the Grubb Parsons design would be an up-scale of the Sir Isaac Newton telescope, which was yet far from being successful, that the mirrors would be ground in England, with no provision for final figuring in the telescope dome. Most serious of all, the opportunity for developing a Canadian expertise in telescope design would be lost. A major submission to Treasury Board²⁹ restated the Departmental position on the design and construction of the telescope and, in particular the reasons why the Grubb Parsons proposal was unacceptable. The submission was supported by a resolution of the newly-formed. National Advisory Committee on Astronomy. It ended with a plea for the early appointment of the prime consultant and of an engineering design team, and for the early construction of the optical shop.

This seems to have ended the discussion except for one question: why have a *prime* consultant, rather than having the Department itself hire consultants as needed? The arrangement was opposed by at least one senior officer of Treasury Board³⁰. Time proved him right, but the idea of a prime consultant was accepted and the firm of A.B. Sanderson of Victoria, which had been acting in a limited way, was appointed on January 27, 1966. Sanderson retained the architectural firm of Wade, Stockdill, Armour and Partners, of Vancouver, to assist in the design of ancillary facilities on the mountain top, and, on the advice of the astronomers, the firm of Dilworth, Secord, Meagher and Associates of Toronto as engineers to work with them on the design of the telescope. Treasury Board set up a Monitoring Committee³¹, consisting of representatives of Treasury Board and the Departments of Mines and Technical Surveys and Public Works, to which Sanderson was to report monthly on the state of the work, on the money spent to date, and the projected costs.

The contract for Phase I covered the preliminary planning of all aspects of the telescope and the Observatory - the telescope itself, carried to the point of establishing the practicability of the design, the optical components that this design would entail and the best method of procuring them, the facilities and services required on the mountain top and the design and location of a headquarters building and an optical shop. All alternative methods of supply were to be investigated, costs were to be estimated, and the probable percentage of Canadian content to be determined. A critical path study of all the elements of the project, showing time schedules and phasing, was to be prepared, and the most effective method of monitoring and controlling costs and timing was to be suggested. The period of the study was to be one year; this was later extended to 15 months, bringing the closing date to March 31, 1967.

Two blows hit the project early in 1966. One, the retirement of van Steenburgh, had been anticipated. He was succeeded as Deputy Minister by C.M. Isbister. Isbister supported the project fully, but was never deeply involved in its management. Van Steenburgh was appointed Scientific Advisor to the Cabinet and in this capacity continued his involvement with the telescope. Harrison assumed the leading Departmental role, assisted by a newly-appointed Executive Assistant, Duncan Turnbull, formerly a senior officer with the Civil Service Commission.

The second blow was the sudden death of Petrie on April 8, 1966. K.O. Wright was appointed Acting Director of the Dominion Astrophysical Observatory, a position in which he was shortly confirmed by the Civil Service Commission. Odgers, who had been working closely with Petrie, assumed responsibility for the telescope design, and for overall planning of the entire project, and E.H. Richardson, G.A. Brealey and D.H. Andrews were assigned to the design team. This arrangement, both in Ottawa and in Victoria, continued throughout the life of the project.

Phase I

Planning the Mountain Top

Mount Kobau lies on the Thompson Plateau, a long, narrow, flat-topped ridge, at an elevation of approximately 6000 feet above sea level. The ridge extends in a north-south direction, and its top varies in width from about one to two miles. There are many knolls and small peaks on the plateau, the highest, Mount Kobau, having an elevation of 6,148 feet.

A first requirement was to secure the land. Since it was Crown Land, in the right of the Province of British Columbia, this was a formality. An area one mile wide and two miles long was set aside for the Observatory.

The planning for the development of Mount Kobau was the principal responsibility of the prime consultant and of the architects. This was a much more complex matter than simply arranging for the large telescope. We saw in Chapter V, in the Beals-Petrie correspondence, that these two leaders hoped that the new telescope would become the focus of a major observatory, to which most if not all of the astronomical work at the Dominion Observatory would be transferred. Petrie even envisaged the ultimate transfer of the two Victoria telescopes to the new site. This vision of a National Observatory, that would bring together in one institution positional astronomers, astrophysicists, solar astronomers and radio astronomers was perhaps as important to Beals as the large telescope itself. The idea was not stressed particularly in the presentations to the Government, but the correspondence makes it clear that a National Observatory was very much a part of their thinking. From the beginning it was part of ours, and it had to be an integral part of the planning of the mountain top, even though its implementation might be far in the future.

In late September 1965 a submission was prepared for consideration by the Advisory Committee describing a longrange astronomical research program for Mount Kobau. It called for the possible transfer of the two telescopes from Victoria, the construction of two photometric telescopes of 40-inch and 16-inch aperture, the construction of two solar telescopes, a spar and a solar tower, the transfer of the Mirror Transit telescope from Ottawa and the construction of a 60-inch astrometric telescope, and the transfer of the Super-Schmidt cameras from northern Alberta. The total cost, exclusive of the 150-inch telescope, was estimated at three and a half million dollars, of which approximately 60% could be found by re-directing existing budgets. The plan called for the establishment of an "Institute of Astronomy" as a Headquarters for the complex. The Committee approved the plan with minor variations, and urged that an approach be made to the University of British Columbia as a possible location for this Institute. The revised submission was then issued as a "Blue Book" embodying the Departmental plan - 233 -

for the development of Mount Kobau. Treasury Board accepted the submission, in principle, in May 1966³²; this did not of course commit it to funding the development.

During the summer one could drive to the mountain top by four-wheel vehicles travelling on existing ranch roads and cattle trails, but in winter it could be reached only on skis or snowshoes. A road to the top was a first consideration. Should it be the minimum road required for initial studies, or the road which would ultimately be required? The decision was for the latter; engineering studies were begun in June 1965, tenders were called in October, the contract was awarded to Peter Kiewit Sons of Canada, Ltd. Work proceeded throughout the winter. Construction was very difficult; snow conditions were the worst in 50 years, and the continuous grade presented unusual problems. Nevertheless the road was completed by the early summer of 1966, at a total cost of \$1,480,000, and was officially accepted by the Minister, the Honourable Jean-Luc Pepin, on July 27, 1966. It had a width of 22 feet with six foot shoulders, an average grade of 7.5%, a maximum grade of 7.95%. Paving was deferred to the completion of the project.

Dr. V. Dolmage was retained to make a geological examination of the site. He reported³³: "the topography and the geology of Mount Kobau as well as its recent geological history augur well for the permanent stability of the foundation of all the instruments and other structures of the observatory complex." Five holes were drilled at the proposed site of the large telescope. They encountered metamorphic rocks, quartzite and amphibolite schists, with considerable jointing. Dolmage suggested that grouting would be desirable.

Dolmage also investigated the available water supply. The conclusions were not encouraging. The only source of surface water was a small lake on Observatory property – Testalinden Lake – which obtained its water from the rain and snow falling on its relatively small drainage area. In 1937 the lake had been extended to provide water for irrigation in the valley below; the lake bottom was deepened to bedrock level and an earth-filled dam was constructed to raise the level of the lake. It was believed that this lake would provide adequate water in normal years but that it would be desirable to provide additional storage for dry years.

Drilling showed the rock under the dam to be badly fractured, resulting in considerable seepage. A small creek, fed by this seepage, begins some distance below the lake and it was suggested that this might be dammed to form a second reservoir.

Water rights, to the lake and to the creek, were held by local ranchers, who would have to be compensated if the water were diverted to Observatory use.

A second study of the water supply was made by E.C. Halstead of the Geological Survey of Canada³⁴. It agreed essentially with Dolmage's conclusions: the total precipitation was about 22 inches per year, almost all of which was lost by run-off and evaporation; if the run-off could be ponded it would provide an adequate supply of water of good quality.

The philosophy dictating the design of the mountain top is well stated in the report³⁵. "Major observatories are located upon the tops of remote mountains so that, among other reasons, they will be removed from the glare, haze, dust, and atmospheric disturbances associated with human habitation and industry. Accordingly, the arrangement and layout of the observatory should be designed so that, as far as possible, the services and facilities will not themselves create the very conditions it has been sought to provide by the remote location of the scientific instruments."

The top figure on the next page shows how it was proposed to meet the problem. The various telescopes would be located along the ridge, each having an unobstructed view as required and far enough apart so as not to influence the seeing conditions at neighbouring locations. The "Village" or operating centre for the mountain, the astronomer's residence and the Visitor's Centre, all heated buildings and therefore potential hazards to good seeing, would be far removed from the observing sites. The access road would enter at the lower left, pass a picnic area, and end in a parking lot outside the Observatory complex. This parking lot, itself a major source of thermal disturbance, would thus be removed as far as possible from the telescopes.

The lower figure shows the limited extent of the initial installation.

A major problem in protecting the environment on Mount Kobau was posed by the large numbers of visitors expected. Even before approval for the telescope had been announced we had been asked by our Minister about the number of visitors to be expected; Locke, basing his estimates on the numbers visiting other observatories, estimated the number at not less than 100,000 annually. The consultants, considering a large amount of data available on tourism in British Columbia, expected this number to be exceeded each month during the tourist season; they fixed on 130,000 visitors per month as an upper limit for planning.

The maintenance of the fragile ground cover on the mountain was a major consideration. If this were destroyed it might never recover, with the resulting problem of wind-blown dust causing a deterioration in the seeing. Visitors must always be confined to paved areas. To prevent them from stopping on the way up the mountain and wandering off the paved road, the shoulders of the road were kept narrow, with paved look-out points provided to overlook the more interesting views.

The visitors must also be kept out of the way of the astronomers. They would park outside the observatory fence, and proceed on foot to a reception and display building. The architects planned a quite elaborate and attractive building, worthy of a National Observatory, where visitors would learn about the design and construction of the telescope as well as some fundamental facts about astronomy. The building, as planned, would have three floors. Visitors would move from there to the large telescope in controlled numbers. In the dome there would be viewing galleries, from which they could see the telescope through non-radiating glass, and also an exterior gallery from which they could admire the countryside.

Climate³⁶ and Seeing³⁷

Initial estimates of the number of clear hours that might be expected on Mount Kobau were based to a considerable extent on the observations of George Seaman, a school principal from Bridesville, who during the years 1964-1966 made observations on cloud cover and on seeing conditions. Additional information was obtained from an all-sky camera operated at Omak Mountain, about 30 miles south of Mount Kobau, at an elevation of 5200 feet. For 1966 it showed 1100 hours of clear sky on 160 nights; many nights with light overcast, suitable for spectroscopic observations, were not included in this figure. At Victoria in the same year there were 731 hours actually observed, making 1966 the worst year for observing in the 50 year history of the Observatory – the 40 year average, 1919-1958, being 1172 hours on 194 nights. That 1966 was also an anomalous year in the Okanagan Valley was confirmed by solar observations recorded at Summerland, some 50 miles to the north of Mount Kobau, over a thirty year period; 1965 and 1966 were well below the thirty year average, and 1966 had the least sunshine over the past six years.

On the basis of this information and comparison with the detailed records from Victoria Odgers stated³⁶ that "one would expect to have from 1200 to 1400 hours observing on



Mount Kobau per year, but with the same wide range as at Victoria, so that the extreme values would be 1,000 to 1,500 hours."

The collection of additional climatological data was an important part of the feasibility study, to which the Micrometeorological Section of Transport Canada contributed. They assembled them from published and unpublished observations from ten neighbouring Canadian meteorological stations and from five weather stations south of the international border maintained by the United States Geological Survey. In September 1966 they erected a 100-foot tower, which carried wind and temperature sensors at a variety of heights; the aim was to establish the boundaries of the ground turbulence layer and so provide data for the optimum height for the large telescope.

While the danger of basing climatological conclusions on such limited data was recognized, the study concluded that the mean annual precipitation on the mountain lay in the range of 20 to 24 inches per year. The snow load was highly variable and much of the snow ablated rather than melted. The temperature extremes were from -40 to $\pm 100^{\circ}$ F but these extremes were to be expected only once in 50 years; a temperature of -20° was to be expected once in ten years.

Odgers and Petrie made the initial "seeing" survey of the Mount Kobau region between 1962 and 1964, using two small telescopes, an 8-inch Cassegrain reflector and a 3.5 inch Questar. They made continuous observations of a number of close double stars. On most nights binaries were resolved down to the theoretical telescope resolution. An objective calibration of this was supplied by observing in Victoria, with the 8-inch telescope set up outside the dome of the 48-inch, under a variety of conditions, and comparing the observations with those obtained at the coudé slit of the large telescope. Seeing at Mount Kobau was thus calibrated to the Victoria scale. Observations were also made of the moon and of the major planets; detailed and steady images were obtained to within 15° of the horizon. These methods were exactly those which had been used in selecting the sites for the highly successful Mount Wilson and Palomar telescopes.

The figure on this page shows their estimates of the diameter of the stellar disk on Mount Kobau as compared with that observed over the same period on the 48-inch telescope at Victoria. The former has a maximum at 1.3 seconds of arc, the latter at 3.5. The observations suggested that a disk value of 0.5" occurred frequently enough to be adopted as the resolution factor to be used in the design of the telescope.

Odgers reported³⁸

"It became clear very early in the survey that seeing conditions at the mountain sites in the British Columbia interior were very much better than Victoria and that much of the summer seeing was very good indeed. The same instruments were used at Kitt Peak and Mount Wilson in March and April 1965 without altering the impression that the seeing during the good observing periods of spring, summer and fall was equal to Mount Wilson and that there could also be periods of excellent seeing in winter. Hence, comparing seeing at Mount Kobau with Victoria, an 150-inch telescope at the former site has an efficiency greater by more than twenty compared with the Victoria 73-inch telescope. This factor is increased further by the use of more precise optical surfaces and an improved optical design, and present indications from the current state of the design indicate that this factor is more than forty."

During the years 1964-1966 Seaman made nightly estimates of seeing and sky transparency. During the winter months, because of the absence of a road, it was almost impossible for him to observe on Mount Kobau; he observed instead on two lower mountains that had easy access. His observations were believed to represent a lower limit for sky quality on Mount Kobau. Although the road to the summit of Mount Kobau was completed in 1966, permanent living quarters were not in place until mid-1967, after the completion of the Phase I report. Then, as we shall see, a thorough site-testing program was carried out, but it was too late to protect the site from the attacks of those who wished to denigrate it.

The Departmental plan called for the establishment of a solar observatory on Mount Kobau, and V. Gaizauskas conducted extensive site tests during the summers of 1966 and 1967. He used a 6-inch spar telescope and a ciné camera to monitor solar areas containing sun spots. Two sites on the mountain were selected for testing, and observing platforms were built at both locations by Mel Lytle, the Observatory carpenter. These raised the objective lens of the telescope six metres above the ground. As we have seen, 1966 was much below average in the hours of sunshine, which led to great frustration. Gaizauskas was heard to fulminate against those who would build an observatory on a mountain where the sun never shone, a phrase which later became something of a battle cry for those opposed to the Mount Kobau site for the large telescope. There were in fact many successive cloudfree days over the two years but the seeing was seldom of the highest quality. There was no point in having a new solar observatory with inferior seeing at the same longitude as the superb observatories in the southwestern United States. The search switched to the Ottawa area.

Design of the Telescope³⁹

Petrie, assisted by Odgers, had begun the initial planning of the telescope even before its future was assured. The basic concept had already been tentatively agreed on, in consultation



Estimates of the diameter of the stellar disk, left at Mount Kobau, right with the 48-inch telescope at Victoria.



Observing platform, telescope and ciné camera used by Gaizauskas to monitor daytime seeing on Mount Kobau.

with university astronomers⁴⁰. It would be a "Cassegrain" telescope, designed to provide optimum photometric observing at that focus, but with observing also at a prime focus and with powerful spectrographs utilizing a coudé focus.

To meet the photometric requirements the telescope would employ Ritchey-Chrétien optics. This design, then relatively new, employs primary and secondary mirrors of large departure from sphericity which, in combination, produce a field of about 45 minutes of arc at the Cassegrain focus free of coma and spherical aberration. Because of the aspherical primary mirror, the fields at the prime and coudé foci are badly distorted but these can be adjusted by correctors.

The prototype of this design was the 84-inch telescope at Kitt Peak, which had proved successful at the Cassegrain and coudé foci, but had not been designed for use at the prime focus. However a good deal of work had already been done on the design of the prime-focus correctors and it was generally accepted that these problems could be met.

Under the Ritchey-Chrétien system the surface of all the mirrors and lenses, primary, secondary and correctors, more than 30 in all, are extremely complex, and must be figured with the greatest accuracy. This is why the astronomers were so insistent that they must be figured in their own shop under their own supervision. By the time engineering consultants had been appointed the specifications for the telescope had been decided on⁴¹. The mirror would have a diameter of 154 inches with an aperture of f/2.8. There would be three secondary mirrors; one with aperture of f/30 to supply the coudé focus, and two, of apertures f/8, and f/15, for the Cassegrain focus. The f/15 system was intended to provide optimum photometric and photographic operation. Correctors would provide a field of 1° at the prime focus. A coudé spectrograph with a beam length of 60 feet was planned to allow for the possibility of 24-inch gratings becoming available in the future.

Once these decisions were made, Petrie and Odgers had turned their attention to the telescope design. Should the secondary mirrors and the prime focus correctors be provided in a universal fixed end or as detachable units, to be stored outside the telescope and to be installed as required? How should the telescope be mounted to provide a maximum viewing area? Two methods suggested themselves, a fork polar axis or a horseshoe yoke. What were the ramifications of selecting one or the other? How would the mirror, expected to weigh some 16 tons, be supported so that it would suffer no distortions as the telescope changed position? In studying these questions design sketches of specific parts had to be prepared.

To help in this work, Beals⁴² suggested that G.A. Brealey, who had been responsible for the mechanical design of the mirror transit, and who was "a minor genius with mechanical design", should become part of the design team. The need for this quickly became apparent; Petrie asked for Brealey's assistance, initially for a period of six months. He proved to be so valuable, not only in the initial design but as a liaison between the astronomers and the consulting engineers, that his transfer was made permanent.

The firm of mechanical engineers, Dilworth, Secord, Meagher and Associates, was appointed in January 1966. They established an office in Victoria, with E.E. Eggmann as chief engineer, and the astronomers and engineers worked in close and most satisfactory collaboration. At the same time a second design office was set up in Toronto, under the direction of J. Farrell, to study some of the purely mechanical problems involved in the design of such heavy yet precise equipment.

From the beginning the teams enjoyed the closest collaboration with other groups involved in the design of large telescopes: at the California Institute of Technology led by B. Rule and I.S. Bowen; at the Kitt Peak National Observatory led by W. Baustian and D. Crawford; at the European Southern Observatory, led by O. Heckmann and W. Strewinski. There was also close cooperation with astronomers at the Lick Observatory on Mount Hamilton, who operated a number of telescopes including a 120-inch reflector. Canadian astronomers and engineers visited the American observatories on many occasion and were invited to a number of large-telescope design symposia⁴³. Nor was the cooperation limited to technical personnel; almost everyone with any responsibility to the project, from the Deputy Minister down, profited from visits to the American observatories and discussions about their particular part of the planning.

The magnitude of the problems involved in the design and manufacture of the telescope are well described in the following quotation⁴⁴. "The telescope, which weighs many tons, must be directed in any viewing direction to an accuracy of ± 10 seconds of arc and must not allow a displacement of the optical components of more than one fiftieth of an inch. The optical surfaces of these components must be supported to within millionths of an inch."

A first problem, the solution of which influenced all other design, was the configuration of the prime focus end of the telescope. How were the various secondary mirrors, the cage for an observer and the several potentially large prime focus correctors to be installed and stored? One possibility was exchangeable components which would be installed directly into mountings on the telescope. This idea was discarded immediately because of the danger of accidents, both to equipment and personnel. Two possibilities remained, a cage that could be flipped in and out of position and from which the mirrors could be changed, or exchangeable ends. The moments acting on the telescope tube were three times higher with the former than with the latter solution; this would demand a 25% increase in the length of the fork tines needed to support the telescope tube and would increase the tube deflection by more than 200%. The use of exchangeable ends was adopted.

There would be three ends:

(1) A prime focus cage which would carry the observer, the plate holder and a number of small correctors. Provision would be made for carrying much larger and heavier correctors, the future development of which was anticipated;

(2) A "ring and spider" carrying the f/8 Ritchey-Chrétien secondary for the Cassegrain focus;

(3) A ring and spider carrying the f/15 secondary for the Cassegrain focus;

(4) A ring and spider carrying the f/30 secondary for the coudé focus.

In each case the ring would attach to the upper end of the telescope; the spider was a system of thin supports that would hold the mirror in position on the optic axis.

To interchange the ends, the telescope would be positioned horizontally and to the north. The exchange would be made by the night assistant, controlling an exchange machine on a hydraulic platform. It was estimated that one end could be removed and placed on a storage dolly on the observing floor, and a new end installed, in approximately fifteen minutes. This was very important; it would allow the telescope to be changed quickly from one mode to another to accommodate changes in the seeing quality.

The telescope tube would be open, an arrangement of trusses that would maintain the precise distance between the primary and secondary mirrors but provide a minimum weight to be carried by the supporting fork.

There are a number of ways in which a telescope can be supported with two freedoms of motion allowing it to be pointed in any direction. The easiest one for a large telescope is a "yoke" mount in which the telescope is carried in a large member which is held in the polar direction by supports at either end. Unfortunately, with this mounting the telescope is unable to scan some areas of the sky; these areas become larger as the polar axis becomes steeper, and the mount was therefore not acceptable for a telescope at the latitude of Mount Kobau.

Could a fork mounting be built? In this mounting a huge fork, lying in the direction of the polar axis, is cantilevered out from a supporting base and carries the telescope between its tines. The fork rotates around its axis to provide motion in right ascension, the telescope moves in the fork to provide motion in declination. There are two principal problems in the design: can the fork be made heavy enough to carry the telescope to any position without appreciable distortion; and can bearings be designed to permit the smooth rotation of the fork around its axis? Both these problems were investigated to a level that ensured they could be met.

A more difficult problem concerned the support of the primary mirror. The mirror was expected to weigh in excess of 16 tons; in operation, when it might occupy any position from horizontal to vertical in any azimuth, its reflecting surface must not deviate from the designed configuration by more than 1/20 of a wave length of light! How was this to be accomplished?

A novel and very effective method was developed. The mirror would be centred in the optic axis by a three-point defining device located in the central hole. Its weight would be supported by twenty-four pneumatically operated pistons, the pressure to each of which would be automatically adjusted as the inclination of the mirror changed.

The changing lateral forces on the mirror would be met by a counterweight levering system that could provide tensile or compressive forces at 32 points around the periphery of the mirror through pads, bonded by adhesive to the mirror edge. The radial force imposed by each lever support system would be proportional to the mirror's inclination to the gravity field and its position around the periphery, the force varying from maximum tension at the upper location, through zero at the horizontal diametral axes, to a maximum compression at the lowest support.

Because the mirror support system was so critical, its design was carried much further than that for other parts of the telescope or the dome. One radial support and one axial support prototype were fabricated and a series of performance tests were conducted to determine precisely the operating efficiency that could be expected from them. Experiments were also set up to test the feasibility of bonding pads to the periphery. Pad and fused silica materials similar to those proposed for the telescope were tested for a variety of adhesives, and for the effects of moisture, corrosive agents, thermal cycling, tensile strength and creep under load⁴⁵.

The proposed dome was 118 feet in outside diameter and would rotate on 34 steel-wheeled trucks at a slewing rate of 36° per minute. A viewing slit nineteen feet wide was planned and the dome would track automatically during observing in conjunction with the telescope. There would be inside and



Cross section of the proposed dome and telescope.

outside viewing galleries for both the public and the astronomers. The declination axis of the telescope would be located 80 feet above the ground to avoid the temperature stratifications and turbulence caused by ground effects. Beneath the observing floor would be a large, two level, coudé room, and, at a still lower level, a room for the aluminizing of the large mirror. An elevator would transport the mirror to the telescope.

The estimated weights of the various parts of the assembly were as follows:

Cantilever fork –	108 tons.
Felescope tube –	75 tons,
Mirror –	about 16 tons,
Dome –	950 tons, 118' diameter.

The costs, not including the Optical Shop, were estimated as follows:

Optical components –	\$ 1.3 million
Telescope –	4.5
Controls –	0.8
Dome –	2.7
Building & foundations –	3.3
-	\$12.6 million

The National Institute of Astronomy and its Optical Shop

As outlined in the "Blue Book" and approved by the Advisory Committee, the National Observatory would consist not only of a complex of instruments on Mount Kobau, but also of a headquarters building, equipped with all the facilities, including computing, necessary for the reduction of observations. Most government astronomers would work at this headquarters, and university astronomers would return there after their periods of observation, or at any time that they wished. The general feeling, based on experience in other observatories, was that the headquarters should not be on Mount Kobau, nor even at one of the nearby towns, but should be attached to a major university, as a National Institute of Astronomy. One of the facilities of this Institute would be the Optical Shop to be used to grind the mirrors and lenses of the 150-inch telescope. Planning for the Institute could wait; planning for the Optical Shop could not.

Late in 1965⁴⁶ Petrie and Odgers, following the recommendation of the Advisory Committee, approached the President of the University of British Columbia about the possibility of this Institute being established on the campus of the University of British Columbia. The approach was supported by V.J. Okulitch, Dean of Science, who was a member of the National Advisory Committee. The proposal was enthusiastically accepted and, on May 10, 1966⁴⁷, the Board of Governors of the University approved, in principle, the assignment of a five-acre site for the Institute Head-quarters and the Optical Shop, subject to its approval of the design. Planning for the shop proceeded on this basis.

Two polishing areas were planned, one to hold the 150-inch polishing machine, a second to hold the smaller machines. The two areas would be connected by a horizontal testing tunnel, but would normally be isolated from each other to prevent coarse grinding material in use in one area from contaminating the operations on the other. In addition to the polishing shops there would be a completely equipped machine shop.

A vertical test tower would be centred on the 150-inch polishing machine, rising about 75 feet above the table. It would consist of an inner instrument tower, surrounded by an outer tower to provide insulation and with working platforms and thermostated electric heaters every ten feet. During periods of testing, temperatures in the tower would be kept constant to $\pm 2^{\circ}$ F, and ventilation would be closed to prevent turbulence.

Access to the polishing shops would be through a change room, opening into the secondary shop. Personnel would change to and from their "clean" clothing on entering and leaving the polishing shop.

Since the large polishing machine would be needed only to produce the 150-inch mirror, consideration was given to the possibility of providing temporary facilities to house it, and limiting the final shop to one able to polish mirrors of smaller size. A possible temporary shop was found, an unused generating station of the BC Hydro, and the costs of the two possibilities were compared. The costs of the two-phase operation was greater by about a quarter of a million dollars; it was therefore recommended that the larger shop be built.

Consideration of the Phase I Report

The Phase I Report consisted of two volumes. The first, which dealt with the development of the mountain top and of the Institute, was written principally by the Sanderson staff, with a major input from the architectural consultants, Wade, Stockdill, Armour and Partners. Because the report considered the potential development of the mountain top as a focus for all government astronomy, there were submissions also from Ottawa astronomers about their specific requirements. The second volume, dealing with the design of the telescope and of the dome, was produced by the engineering consultants Dilworth, Secord, Meagher and Consultants, with the full cooperation of Odgers.

The report was submitted on March 31, 1967, in type-written form, in four large binders, two binders to a volume. It had been intended that the report would be printed, but in the interest of economy and prompt distribution this was not done. A number of Xeroxed copies were produced and these were distributed to all responsible government officials and to all members of the National Advisory Committee on Astronomy.

The most thorough examination of Volume I of the report was made by engineers and architects of the Department of Public Works Regional Office for British Columbia. Their report⁴⁸ consisted of 22 pages of specific criticisms and six more of summation and recommendations. They found the report repetitious, inconclusive and incomplete, with too much space devoted to the additional astronomical instruments which might later be deployed. They were particularly critical of the tourist facilities proposed: "it seems that the maximum has been aimed at ... as if a secondary feature is being allowed to obscure the real purpose of the project".

In fairness to Sanderson these latter two criticisms apply as much to the Department of Mines and Technical Surveys as to the prime consultant; it was important to us that our plans for a National Observatory should be taken into account in planning the mountain top. The tourist potential of the telescope had been one of the selling points in the approach to the Government. The Departmental astronomers didn't, of course, like this. As Wright said of this section⁴⁹: "The discussions of the village and the Visitor's Centre are extensive, elaborate and grandiose."

A criticism that might have been levelled at the report concerns its failure to expand the knowledge of the climate and the seeing on Mount Kobau by direct observation during the seven months that had elapsed since the completion of the road.

The Public Works team were much kinder to Volume II:

"The Sub-Consultants work on the telescope, mounting and immediate ancillary equipment seems to have been subjected to careful research and study and in any event the recommendations are strong and in most cases firm."

Dr. I.S. Bowen, former Director of the Mount Wilson and Palomar Observatories, and Mr. Bruce Rule, Director of the Central Engineering Services at the California Institute of Technology, were retained as consultants to decide on the merits of the preliminary telescope design. While each made some suggestions for improvements both were enthusiastic. To quote Rule⁵⁰:

"You have ample reasons to proceed with the final telescope design and construction phases with full confidence of the project success and in the work schedules planned and hopefully within the costs estimated." At the suggestion of Bowen and Rule, John Case, a Californian with broad experience in the design of domes, was retained to consider the part of Volume II dealing with the dome. His comments on the dome and building were somewhat critical but were all in the direction of money-saving simplifications⁵¹.

The Gathering Storm

From the beginning, astronomers at the University of Toronto had questioned the competence of the Victoria group to supervise the design and construction of a large telescope. Petrie found this somewhat annoying because, while they made vague criticisms, they would never offer concrete help in design problems⁵². When I visited them in May 1966, shortly after his death⁵³, their objections had become much stronger. They pointed out that the all three existing large telescopes had had severe problems, and thought that American designers, specifically Bowen and Rule, should be recruited to the design team.

During the visit they also attacked the concept of the Institute of Astronomy. They did not visualize having any need for the Institute; their staff and students would merely travel to Mount Kobau and return to the University. The Institute, as opposed to the Mount Kobau National Observatory, would serve no useful purpose for any university except that of British Columbia.

This was a remarkable change from the desire expressed by the Advisory Committee at its first meeting. The Observatory would be used by staff and students from many universities other than Toronto, few of which had the ancillary equipment necessary for the reduction of their observations. It seemed to me that there was a deeper reason for the Toronto change of attitude – that an Institute on the campus of the University of British Columbia would challenge Toronto's position as the senior graduate school of astronomy in Canada. In the struggles that followed I had no reason to change that appraisal.

The Toronto attack on the competence of the design team continued in subtle ways over the following months but was pretty well negated by an action of the design consultants Dilworth, Secord, Meagher and Associates. In late February 1967⁵⁴ they held an open seminar in their offices to disclose the status of the entire project, particularly of the telescope design. Representatives from government and universities as well as from potential industrial bidders on the telescope construction were invited. Senior people from the telescope design team, and from the various groups considering the design of the mountain top, discussed their work. All had come armed with good illustrations and with in-depth data that could provide answers to the most penetrating questions. It was apparent that the design team was competent, that the project was essentially on schedule and that the wishes of the universities had all been accommodated.

From this time on the Toronto attack was levelled, not at the competence of the design team, but at the site. Many astronomers were in Toronto early in March 1967, attending a meeting of the National Committee for the IAU. Toronto astronomers scheduled a discussion at the conclusion of the meetings to consider the suitability of Mount Kobau. I had some warning of this and had arranged for Beals to be present.

Professor Sidney van den Bergh was the principal speaker. He had his material well prepared, and he delivered it in so dramatic a fashion that I was reminded of Marc Anthony's oration over the corpse of Julius Caesar; graduate students played the role of the Roman mob.

He first attacked the site, suggesting that the number of usable hours would be 800 rather than the 1200 estimated by Odgers. Next he questioned the validity of seeing estimates based on the resolution of double stars by a small telescope. Bad seeing on a small telescope implied bad seeing on a large one, but good seeing on a small telescope did not ensure good seeing on a large one. The fact that Odgers had carefully correlated his measurements on Mount Kobau with the seeing on the 48-inch telescope at Victoria was not mentioned. Image motion techniques were now the preferred way of evaluating seeing and he would accept nothing less.

Whether or not one agreed with this didn't matter. The whole point of the discussion was, that no matter what values one adopted either for the number of observing hours or for the quality of seeing, Mount Kobau was much inferior to sites in Chile, where the six-year average of clear hours was 2600, of which 2200 were photometric, and where the median value of the seeing disk was 0.7°. Some rapid blackboard calculations demonstrated, to the converted, that even accepting Odgers' values, a 24 to 36 inch telescope in Chile would produce the same photometric results as a 150-inch telescope on Mount Kobau, and that a 50-inch telescope would produce equivalent photographic results. Even for spectroscopy a Chilean site would far outstrip Mount Kobau. Considering that future research would be involved with increasingly faint objects, a telescope on Mount Kobau would become less and less significant with the passing years. The conclusion? The telescope must be built in Chile!

Another factor to consider was the number of viewing hours. Assuming that a research astronomer would require 200 hours per year, the Mount Kobau telescope would provide facilities for five astronomers, whereas for a site in Chile the equivalent number would be thirteen. More importantly, an astronomer assigned time on a telescope in Chile could count on 12 or 13 clear nights in any fortnight. Such conditions were important for university professors and students who cannot leave their classrooms for months at a time. Anything less was quite unsuitable for a "national" observatory.

Finally, accepting the unsuitability of Mount Kobau for photometric observations, there was no point in the sophisticated optics which were proposed. A simple parabolic mirror, more within the capacity of inexperienced opticians, would suffice.

Beals presented the case for Mount Kobau. The excellent conditions available in Chile had been known to Canadian astronomers during the early days of planning but they had been assured by responsible officials that the government would not consider funding a telescope outside Canada. No one had suggested that Mount Kobau was not the best site in Canada. There was no question that it was inferior to sites in Chile, but an 150-inch telescope on Mount Kobau would give a performance at least 20 times better than that at Victoria. Over the years Victoria had published some 300 important papers, had established itself as a world centre in spectroscopic astronomy and, he might have added, produced two Fellows of the Royal Society of London; surely an output twenty times that was not to be lightly discarded. The argument that the Mount Kobau site would not be useful to university astronomers was specious; many astronomers from western universities, some of them photometrists, were already working with the Victoria telescopes and were looking forward to observing on Mount Kobau.

He also discussed the problems of building and maintaining a large telescope in a distant, scientifically unsophisticated and politically unstable country.

Finally he turned to the subject that was on all our minds: if the attack on the Queen Elizabeth telescope were to become public the result must certainly be that we would lose a telescope in Canada rather than gain one in Chile. "Would anyone", he questioned, "rather have no telescope than one on Mount Kobau" and called for a show of hands. Van den Bergh's hand, and those of the graduate students, shot up; hands of some other eastern astronomers were raised rather slowly and doubtfully.

With the publication of the Phase I Study at the end of March 1967 the Toronto attack expanded, and the absence of additional climatological or site-testing data did nothing to oppose it. Representations began to be made to senior officials in Ottawa as is attested by a letter which passed between the Department of Industry and the Treasury Board in late June⁵⁵:

"In the course of our enquiries, a serious question affecting the feasibility of the entire project came to light, viz. it is understood that a study of atmospheric conditions at Mt. Kobau performed by a University of Toronto Group concluded that due to prevailing temperature instability, accurate observations would only be possible for a very small percentage of the time. Unless it can be positively established that this condition is the exception rather than the rule, then the advisability of proceeding with this project is open to serious doubt."

At about this time a complicating factor appeared. The Carnegie Institution which, with the California Institute of Technology, supported the Mount Wilson and Palomar Observatories, had for some time been planning to build a major observatory in Chile, to be known as CARSO (for Carnegie Southern Observatory). The principal telescope would be a 200-inch reflector, more-or-less a duplicate of the Palomar telescope; it would be augmented by a 60-inch reflector and a 72-inch Schmidt with a 48-inch corrector. During one of Odgers' visits to Pasadena informal and confidential discussion had been held about the possibility of Canada joining in the funding, design, construction and use of this proposed observatory. Some time later I.S. Bowen, director of the California observatories, met Harrison at a scientific meeting and again, and again in confidence, broached the possibility. He stressed that the discussion was exploratory since the CARSO proposal was under consideration by an agency of the United States Government. Harrison "expressed interest, but not much enthusiasm.... The proposal came at the worst possible time in the relation to the Mount Kobau project ... and it would not be possible to give an affirmative answer until the matter had been discussed with Treasury Board and probably with the Science Council⁵⁶."

A meeting of the Advisory Committee was to be held in Ottawa on July 26-27, 1967, for the specific purpose of discussing the Feasibility Study. Copies of the Study, and an outline of the CARSO proposal, were circulated well before the meeting, and members were invited to submit written comments; these too were circulated. Van den Bergh was not a member of the committee but he submitted a short paper summarizing his earlier remarks and expanding them with specifics from the Study⁵⁷.

The Toronto astronomers were very disturbed by the Feasibility Study and, before the Advisory Committee could meet, MacRae wrote to O.M. Solandt, chairman of the newly formed Science Council, to present their position. Solandt recorded the approach in a memorandum which was seen by Prime Minister Pearson⁵⁸.

"Professor Donald MacRae, Head of the Department of Astronomy at the University of Toronto wrote on June 30 and later called to discuss the problems of the Mt. Kobau National Observatory. There is to be a meeting of the Committee that is guiding the project in Ottawa on July 26th. In preparation for the meeting, the members have received a voluminous report by consultants on the whole Mt. Kobau team. Dr. MacRae is very disturbed by the information contained in the report on the visibility from Mt. Kobau. Based on the experience of last winter, there will only be 800-1000 useful viewing hours a year which is only enough to support 2-3 full time observers. This compares with about 2500 hours per year in the better sites in Chile. There were only about 15 nights out of 100 during which observations have been taken reasonably satisfactorily. DOT weather reports from nearby sites confirm the observations taken on the mountain top and also indicate that this was not an exceptionally bad winter. He suggests that the reason Mt. Kobau was chosen is because its summer weather is exceptionally good. Unfortunately, summer is not good for observing. At the 49th parallel, observations are virtually impossible in June and are limited in May and July. I questioned him carefully about why the site had been chosen. He says that the evidence is reasonably good though by no means conclusive, that the "seeing" as opposed to visibility on the Mt. Kobau site is as good as can be found in Canada, though not as good as is found at Kitt Peak or in Chile.

He is also disturbed by the growth of the Mt. Kobau scheme. It now envisages moving virtually all the activities of the Federal Government in the field of astronomy to the Mt. Kobau site. The total cost is now estimated at about \$29 million. It will include not only the 150" telescope but also an 80" telescope primarily for positional astronomy. He feels that if \$29 million is spent on this institute, there will be no money left for the universities. He feels that even if the universities are given full opportunity to use the facilities at Mt. Kobau, many of them will not prove suitable for university work. He feels that the emphasis in the program is on positional astronomy and the time service and not in the kind of forward-looking research that universities would like to follow. He also said that a good deal of the expenditure was being devoted to providing facilities for tourists. The report visualizes as many as 30,000 visitors per month during the summer.

Professor MacRae also outlined to me the great advantages that could be gained by having a major telescope in the Southern Hemisphere. He said that a group of astronomers at the California Institute of Technology had already located a suitable site in Chile and were well on the way to designing a 200" telescope for this site. The estimated cost of the project was \$20 million. The Cal Tec people had tried to get help from the Ford Foundation without success. They are now seeking partners in the venture and have suggested that Canada might become a half owner of the scope for \$10 million. Professor MacRae considers that the project would be far more valuable to Canadian universities than the Mt. Kobau project. I urged him to try to get this proposal into written form and to seek the support of other universities for it. In the meantime, I said I would discuss both problems with Dr. Harrison. I also urged Dr. MacRae to present his misgivings about the Mt. Kobau proposal clearly and firmly at the meetings on July 26th and to urge other university representatives to do the same if they shared his views."

Mr. Pearson objected to the fact that Solandt had "urged [MacRae] to get this proposal into written form and to seek the support of other universities for it". He commented: "I wish he had not done this – it involves the govt. in some responsibility if the support is secured".

MacRae may have spoken to some fellow members of the Advisory Committee about his approach to Solandt, but he did not inform government members of the Committee, and there is no mention of the approach in the minutes of the meeting. The above memorandum has only come to light, twenty years after the event, with the opening of Privy Council files.

Those files contain a later memorandum to the Prime Minister⁵⁹, which reminds him of his reaction to the Toronto approach and outlines some subsequent developments.

"At that time you agreed that a change in the location of the observatory at Mount Kobau was not possible, and that the Science Secretariat might consider undertaking a study to see if the scale and scope of the project should be changed, having in mind Dr. MacRae's criticism: purportedly representative of the feeling of the universities. The Science Secretariat has considered this matter and now reports that to economize on the telescope itself at this stage would involve costly redesign and would leave the Dominion Observatory with an instrument which would have no significant scientific purpose. Under the circumstances they suggest that the most effective means of controlling costs, would be for the Secretariat to maintain close liaison with the Treasury Board, in order that appropriate pressure for maximum possible economy on the ancillary aspects of the project, can be exercised. The Science Secretariat has also indicated that the Department of Energy, Mines and Resources is suggesting substantial economies in the total program, [to] affect supporting facilities rather than the telescope itself.

In the light of these comments it does not appear that the study by the Science Secretariat on the Queen Elizabeth II Telescope project would be useful, and if you agree, I shall inform the Science Secretariat not to proceed with it."

The memorandum went on to assure the Prime Minister that his concern about appearing to commit the Government to support for the CARSO project had been conveyed to Dr. Solandt, "who now appreciates that the difficulties with scientific priorities and expenditures with which the Government is attempting to cope at this time, make it clear that the above mentioned proposal is out of the question in so far as the Canadian Government is concerned". The same message had been conveyed to Dr. J.M. Harrison, who "will exert his efforts to avoid any embarrassment which would be caused by selling co-operation with the California Institute of Technology, in Chile, to universities, in the expectation of Government support".

When the Advisory Committee met on July 26-27, 1967 it was of course unaware of the MacRae's approach to the Science Council, or of the Government's reaction to it. It was clear from the beginning however⁶⁰ that the Committee, which had been so united in support of the telescope and of the National Observatory at its first meeting, was now divided into two groups, one consisting of astronomers from eastern universities, the other of representatives of government and of western Universities. Eastern astronomers insisted that from the beginning, due in part to the reference to "a spur of the Great American Desert", they had been "under the impression that the climatic conditions at Mount Kobau relative to optical observing were among the best on the continent - if not in the world – and it was in this climate that [they] had planned ... to centralize almost all Canadian astronomy there¹¹⁶¹. Dr. G. Herzberg expressed the view of most of the other members⁶². He had "never gained this impression. The impression gained was that Mount Kobau has the best climatic conditions for a telescope to be located in Canada. ... The seeing disk is on the average less than half of what it is in Victoria and, in a not negligible percentage of the nights it is very much less than that."

This dichotomy led to two positions about the telescope: on the one hand the amount of observing time, and its distribution, could not satisfy the need of the eastern astronomers which was unacceptable in a national telescope; on the other hand there was a need for the national telescope to be in Canada, for the training of young astronomers, for the continuation and expansion of existing programs, and as a matter of prestige.

The two positions could be reconciled if Canada were to join in the CARSO project. With the understanding that a vigorous attempt would be made to do so, the Committee passed, unanimously, two resolutions, one calling for the completion of the Queen Elizabeth II telescope and the optical shop, the other for participation in the Carso project. These resolutions were forwarded to the Minister⁶³.

It was recognized that the government could not be expected to finance the two projects at the same time. Drastic cuts in the scope of the Mount Kobau development, particularly of the Visitors Centre, and delay in the transfer of other instruments, was recommended, and a small committee, independent of the National Advisory Committee, was set up to seek provincial and industrial funding for the CARSO cooperation. The membership of the committee was:

> Professor D.A. MacRae, Toronto, Chairman; Professor W. Wehlau, Western; Professor G.A. Harrower, Queen's; Dr. G.J. Odgers, DAO; Dr. J.L. Locke, NRC.

A first meeting of the committee was held in Toronto on October 1st, 1967; it was attended by Dr. H.A.Babcock, Director of the Mount Wilson and Palomar Observatories, and by E.A. Ackerman, Executive Officer of the Carnegie Institution. They outlined the suggested terms of the agreement⁶⁴, that Canada should assume half the costs of the project and receive half the observing time, and that as much construction as possible would be undertaken in Canada, although a study would be required before the proportion of Canadian content could be established. The estimated capital costs were \$18,000,000; the operating costs were more difficult to estimate, but would be in the range \$250,000 to \$800,000 per year. Ackerman proposed a period of approximately 12 months for exploring the possibilities of a joint venture.

The primary hope of the committee was that the costs would be met by the government instead of, or in addition to, the costs of the Queen Elizabeth II telescope. While Harrison made it clear that the Department could not support the project financially he agreed that the polishing equipment and the services of the design team and opticians would be available⁶⁵. This would be a major contribution to the costs. For the rest the Committee proposed to approach provincial governments.

In late February 1968 Babcock came to Ottawa and outlined the Carnegie proposal on CARSO to Dr. Schneider, President of the NRC⁶⁶. The reception was enthusiastic but, like EMR, NRC was not in a position to assist in the financing.

Meanwhile the Toronto attack on the Queen Elizabeth telescope didn't cease; rather it increased in intensity. It is a remarkable fact that nothing, not so much as a single letter, was ever forwarded to us for Departmental comment. We heard rumours, some fairly detailed. Letters from distinguished astronomers in several countries, praising the telescope sites in Chile, and "Dear Mike" letters from former colleagues at the University of Toronto were deluging the Prime Minister's office. There were personal attacks on me, suggesting that as a non-astronomer I was incompetent to direct the project. The case was used as the basis for a campaign against direct government involvement in science. We shall see later that some, at least, of these rumours were completely false, but they made for bad relationships.

One thing at least was definite. Dean Vincent Bladen appeared before the Senate Science Policy Committee in mid-March 1968, warning against narrow scientific nationalism, and deploring the idea of a National telescope taking precedence over a share in an American one in Chile. Bladen must also have had a chat with Simon Reisman, Deputy Minister of Industry, his old colleague of Auto Pact days, who twitted me one day about wanting to "build a telescope on a mountain where the sun never shines".

The attack had its desired effect. On December 7, 1967, Finance Minister Benson announced that the government found it necessary to curtail expenditures in a number of areas. One of them was the Queen Elizabeth Telescope project; the schedule for its construction would be stretched out and construction of the optical shop would be postponed. The project had been slowed down, not stopped, and planning must continue. It was not a happy climate in which to do so. We shall digress from the story of the conflict to review these developments.

Post Phase I Studies

Climate and Seeing

The most important work done related to the investigation of climate and seeing. Too late, it completely supported Odgers' appraisal with incontestable scientific evidence.

Living quarters were established on Mount Kobau during the summer of 1967. They included offices, dormitory facilities for 16 people, kitchen and workshop.C.J. [Jock] Crawford, who had represented Sanderson on the mountain, transferred to the Departmental staff and continued to manage the facility⁶⁷. At the same time a standard weather station was installed and made regular measurements of wind direction and velocity, temperature, rainfall, relative humidity and evaporation. Results from the 100-foot mast, erected in September 1966 to establish the boundaries of ground turbulence, were inconclusive and a 200-foot mast was erected. It fell in a heavy ice and wind storm and was not replaced. MacRae used this as another basis of attack on the Mount Kobau site, despite the fact that the same thing had happened at the CARSO site in Chile⁶⁸.

By good fortune a dedicated amateur astronomer, E.L. Pfannenschmidt, became available to carry on regular site testing. A mechanical engineer, he had been a co-founder of the Friends of Astronomy in Germany; on emigrating to Vancouver he joined the local Centre of the Royal Astronomical Society of Canada and became co-director of its telescope committee. He visited the mountain late in 1966 with a group from the Centre, was fascinated with its potential, and happily accepted a position on the Observatory staff. When the camp had been established he took up permanent residence and began a long series of climatological and site-testing observations.

There are two points which may usefully be made here. The first concerns the northern latitude of Mount Kobau. Because of this, the number of viewing hours in the summer are very much fewer than in the winter. In the research here described the viewing period is taken as beginning 1/2 hours after sunset and ending 1/2 hours before sunrise. At the height of summer this leaves about six hours. On the other hand, during the depth of winter the viewing period is almost twice as long. The viewing hours could be extended by using the coudé focus during twilight hours; this had proved feasible on the 48-inch telescope at Victoria. Use of the telescope could be increased still more if the coudé spectrograph were used in twilight hours for infrared spectroscopy⁶⁹.

The second point concerns the viewing requirements for the different applications of the telescope. Spectrographic plates are exposed over an extended period of time, often several hours. If a cloud should pass over during this period the observation isn't lost; it is only necessary to extend the observation appropriately. For photometric measurements an extended period of completely clear sky is needed, and the same is true for photographic observations. We saw that, in planning the design of the telescope, provision was made for changing from a spectroscopic mode at the coudé focus to a photometric mode at the Cassegrain focus with a minimum delay, in cases where the weather improved during the night. This is of limited value; one would not likely have a photometrist and a spectroscopist standing by all night waiting for a possible weather change.

Beginning in July 1967 cloud cover was measured, visually by Pfannenschmidt, and instrumentally with an automatic all-sky camera. The camera was lent to the project, and the films were analyzed, by the Upper Atmosphere Research Section of the NRC, through the courtesy of P.M. Millman. Having regard to the limitations outlined above, there are 3190 night-time hours per year at the latitude of Mount Kobau. For a 39-month period beginning in July 1967 the yearly average of usable observing time was 1363 hours, on 221 nights, 123 of which were totally clear. This value was almost exactly in the middle of the range Odgers had suggested. Rather stringent conditions were imposed; for example to be regarded as usable time the sky had to be clear to within ten degrees of the horizon, and there had to be at least two continuous hours of such conditions. To be rated as of photometric quality, five consecutive hours of sky clear to within five degrees of the horizon and of good transparency was demanded. By this definition 106 of the 221 nights, or 29%, were photometric.

We saw in Chapter VII that a simultaneous four-channel photometer was developed at Victoria for use on Mount Kobau⁷⁰. This instrument was operated during the summer months of 1968, 1969 and 1970. Criteria of good photometric viewing were developed, based on the actual observational results. The agreement with the visual evaluation described above was reasonably good; the visual observations were actually more demanding than the instrumental ones. Even when the sky is clear the image of a star in the telescope may differ in size, shape or steadiness from its theoretical value. This poor "seeing", is caused by the turbulent mixing of air volumes of different temperatures with resulting refractive inhomogeneities in the atmosphere. While the cause of poor seeing was qualitatively understood at the time that Pfannenschmidt began his work, there was not good agreement among astronomers on the best way to measure the effects quantitatively.

E. Brosterhus, who had been involved with site testing in Europe, and who was carrying on similar work in Ottawa, was placed in charge of site testing on Mount Kobau in March 1967 and made frequent visits to the mountain. The researches which he supervised broke new ground in site testing⁷¹.

A plane monochromatic wave from a star, after passing through a disturbed atmosphere, will emerge with a slightly distorted wavefront. The light rays, which are perpendicular to the wave front, will enter the telescope at all possible small inclinations to the principal ray. The result of this is predominately determined by the aperture of the telescope. For a large telescope the random direction of the rays is averaged over a large area and therefore approximates the direction of the principal ray. The image will be diffused, but stationary, and the image size is a direct measure of the seeing.

A telescope of small aperture on the other hand cannot average the ray directions; each bundle of rays produces a sharp image which moves about in an erratic way to trace out a circular disk of the same diameter as the diffused image seen in the large telescope. It is thus a good measure of the seeing to be expected in the large telescope; Petrie and Odgers were using the appropriate instrument in their initial field tests. Telescopes of intermediate size, on the other hand, show a combination of the two effects, a fuzzy disk-like appearance which changes constantly.

There is a second effect of atmospheric turbulence, the variation in the light from the star owing to the changing energy distribution in the wave front. This is called "scintillation". It is not regarded as of great importance in evaluating a site since its effect can be eliminated by observing over a length of time sufficient to average out the variations.

When Pfannenschmidt began his observations in mid-1967 he used the Questar telescope to measure the image motion of Polaris. The telescope was not driven, but Polaris tracked across the field of view very slowly. A reticule wire in the focal plane of the telescope was adjusted parallel to the star track and image motion was measured in terms of the width of this wire. This allowed a continuing estimate.

Another way of measuring image motion is to photograph the star trails over a period of time, usually two minutes. This was done using the 16-inch telescope when it became available in October 1968. The trails show clearly the variations in motion and in brightness of the star image. The values of image motion obtained in this way were smaller than those obtained by simultaneous visual or photometric observations. This is believed to be due to the larger aperture telescope; the fact that there is appreciable image motion suggests that a 16-inch telescope is not "large".

In 1967 a photoelectric seeing monitor was installed on Mount Kobau. This was designed in Ottawa by C.L. Morbey and Brosterhus, and was built in the Observatory shop. A six-inch Cassegrain telescope focuses the star image on a reticule marked with ten identical cycles of lines, each consisting of six opaque and six transparent lines of different widths. The telescope is pointed at Polaris and held motionless there. The diurnal motions of the star cause its image to move across the field of the telescope, and hence across the various lines on the reticule. Typical records are shown in the samples reproduced on the next page, in which the upper line of each set of figures is made by the direct image of the star, the lower one by the image as it moves behind the three widest slits. If the image were a perfect point it would be cut off instantaneously as it moved behind an opaque line and would reappear instantly as it moved out of the opaque area. The "wings" of the image are therefore a measure of the diameter of the stellar image. The high frequency oscillation is due to scintillation.

The agreement between Pfannenschmidt's observations and those produced by the image monitor was remarkable, except for periods of very high fluctuations, which were not of much astronomical interest. The image motion over the 39 months had a median value of 1.2 seconds of arc, a mean value of 1.5. These are very close to the values obtained by Odgers. The claims made for Mount Kobau, both as to the number of clear hours and of the quality of seeing, were substantiated.

Water Supply

E.C. Halstead made additional studies⁷² of the potential water supply on Mount Kobau, this time of ground water. Five observation wells, ranging in depth from 60 to 270 feet, were drilled in the vicinity of the peak during the summer of 1967, and a 150-foot production well was drilled at the top of Mount Kobau in 1968. A 47 hour production test of this well yielded water at a rate of 7.5 imperial gallons per minute. This would provide a good auxiliary source of water.

Telescope Design

The delay which followed the submission of the Phase I feasibility study made for serious problems for the engineering consultants. They had assembled highly competent design teams, both on the west coast and in Toronto, and could not afford to maintain them without a contract. If they were assigned to other work it would be difficult to reassemble the teams.

To meet this problem Treasury Board⁷³, on February 29, 1968, approved a contract "to replan and reschedule the design of the Queen Elizabeth II telescope (telescope, controls, enclosure and dome) to meet revised completion date that results from an imposed funding schedule: This will be known as Phase II." The contract provided \$1000 per day, to a maximum of \$40,000. The consultants final report was submitted in April 1969⁷⁴.

The Optical Shop

We saw earlier that in early May 1966 the Board of Governors of the University of British Columbia approved the assignment of five acres as a site for the Institute headquarters and the optical shop, subject to approval of the final design. Treasury Board authorized⁷⁵ the production of the designs and the procurement of the equipment for the shops at about the same time. The plans were produced and accepted by the Board of Governors, and an announcement to this effect was made at a press conference in mid-December 1966⁷⁶. Later it was realized that the designs did not provide adequate temperature control. New plans were prepared, providing the outer tower with double walls filled with four inches of insulation⁷⁷.

Beginning in October 1966 and continuing through March 1967 orders were placed for the equipment needed for the machine shop – the lathes, milling machine and other similar tools, as well as work benches. As these materials were delivered they were placed in storage with a commercial storage firm in Vancouver⁷⁸.

Three polishing machines were needed, of 40-inch, 60-inch and 150-inch capacity. Orders for the two smaller machines were placed with an American firm, Optics for Industry, of Milwaukee, at a total cost of \$46,000 US⁷⁹. The large machine could not be bought on an "off the shelf" basis. An agreement was reached with the AURA group to share the costs of designing the polishing machine for the primary mirror. A complete set of drawings was obtained at a cost of

\$4870⁸⁰, tenders were called, and an order for the machine was placed with the Canadian Aviation Electronics Machinery Limited (CAE), of Vancouver, in June 1967 at a cost \$188,051⁸¹.

In the process of grinding the primary mirror, the first operation would be to produce a spherical profile. In order to test this, a 100-inch spherical cast aluminum form, known as a Hindlesphere, was needed. A contract to produce the casting, using the AURA pattern, was made with the Aluminum Company of America at a cost of \$14,795 US⁸²; a contract for the rough grinding of the form was let to Allis Chalmers of Milwaukee for \$5000.

This progress was not matched with progress on the optical shop itself. The request to enter into tender for its construction was with Treasury Board for several months⁸³, and toward the end of 1967 it was becoming increasingly clear that the entire project was under review. This was confirmed on December 7, by the announcement by Finance Minister Benson, already described, of the "stretch-out" of the Queen Elizabeth II project and the postponement of the optical shop.

The urgency for proceeding with the grinding of the mirror did not go away. The mirror itself, with a final diameter of 157 inches (next page), was completed examined and accepted by the end of 1967 and it was necessary to arrange with Corning to store the finished blank⁸⁴. The machine shop equipment had arrived, 97 pieces of it, and was in storage. By February 1968 the Hindlesphere had been completed, by June the smaller grinding machines were finished and the large



grinding machine was nearing completion. After testing under full load it would need to be stored. The annual cost of storing all this equipment was expected to reach \$25,000. If construction of the optical shop was to be delayed, would the government approve the rental of a temporary one? The coarse grinding of the Hindlesphere and of the primary mirror, would take two years, and would not require a controlled environment.

The contract for a temporary shop was never approved, and all the equipment had to remain in storage. As the costs mounted, an agreement was reached with the University to store the blank and the large grinding machine on the campus. The grinding machine had to be dismantled for the move and reassembled after it, and the mirror blank, before shipping from Corning, had to be encased in bullet-proof steel. Odgers wrote in defence of this expenditure⁸⁵:

"It seems ridiculous to have to protect a large mirror against rifle shots but we are advised that such protection is necessary and is provided for mirrors in transit through the United States."

The Working Group on Astronomy

Meanwhile the controversy over the telescope continued; something had to be done to resolve the impasse. The Department, and NRC asked the Science Secretariat to step in. It set up a small Working Group⁸⁶ of senior scientists to consider the relative merits of the Queen Elizabeth Telescope and the southern hemisphere proposal, from the point of view of scientific excellence and in the context of the total effort devoted to astronomy in Canada. As time permitted they were also to consider the appropriate allocation of resources to astronomy in relation to other fields of scientific research and to consider the recommendation of the Glassco Commission that all government astronomy should be combined under one agency.

The establishment of the Working Group coincided with major changes in the Government. Pearson retired in April 1968 to be replaced as Prime Minister by Pierre Elliott Trudeau. He called an election in June, and was returned with a majority. Jean-Luc Pepin, who had been Minister of our Department since December 1965 continued in that position until after the election. He was succeeded by J.J. Greene on July 6. The Working Group, set up in early June when Pepin was minister, reported in mid-August to Greene.

The Group was chaired by D.C. Rose, recently retired Associate Director of the Division of Pure Physics, NRC. C.S. Beals and W.H. Wehlau, head of astronomy at the University of Western Ontario, were the other members; D.I.R. Low, an officer of the Science Secretariat, acted as secretary. They travelled across Canada during the first half of July 1968 holding meetings in, in order, Toronto, Vancouver, Victoria, Penticton, Ottawa and Quebec. Fiftyfive briefs were presented, and Dr. H.A. Babcock met the Group at the conclusion of their tour to supply details about the CARSO proposal.

Harrison⁸⁷ was present at the Ottawa meeting and was "startled to hear Dr. MacRae state categorically that the Mount Kobau site would be of no use to eastern astronomers.



Roy Dancey, Chief Optician, second from left, examines the finished mirror blank. The diameter is 157 inches.

... There were no more than 1400 observing hours to be expected at Mount Kobau. Each graduate student required 200 to 300 hours observing time. If half the time were available for universities there would be no chance for graduate students to make proper use of the facility."

These figures were something new. Harrison made some "horseback calculations": considering the capital and operating costs of the CARSO telescope, the cost per student would be about \$150,000 per year. "If Dr. MacRae's figures are correct I am sure that many eyebrows will be raised at the cost of astronomy and the advisability of investing that much for graduate research in a foreign country."

Did the CARSO offer provide the best opportunity for Canadian astronomy? Our Departmental attitude was well expressed by Harrison in an internal memorandum⁸⁸ to the Deputy Minister.

"It seems unreasonable to me that Canada can be an equal partner in the Carso project, regardless of organization, unless her astronomers have the capability to counterbalance U.S. astronomers. Our geological scientists, for example, exert a strong influence in international sciences because [they] are among the best trained and equipped in the world. I cannot imagine that Canada, without a first-class telescope and opportunity to develop its expertise at home, will ever have a large voice in international astronomy or that it could ever become anything but an appendage to U.S. capability. ... I would, therefore, be reluctant to see Canada participate in the CARSO project without a major installation in Canada."

Shortly before the Working Group was to present its report, some disquieting information on the reason for the CARSO approach to Canada⁸⁹, came to light. They had hoped to get a major grant from the Ford Foundation but insisted that the telescope should be used exclusively by highly qualified scientists, and not by graduate students. This elitist attitude was not acceptable to the Foundation, the grant was refused, and the approach was made to Canada. It may have been true that Canadian astronomers would have unrestricted access to half the observing time on the CARSO telescope but would graduate students be welcomed? This information was passed to the Working Group, but was not made public.

Beals had begun the operation convinced that the Queen Elizabeth Telescope should be built on Mount Kobau, but he surprised his old colleagues in Victoria by proposing that it should, instead, be built in Chile. Odgers reported⁹⁰ that, "in making this proposal he referred to the Toronto group as being 'very persuasive with politicians' and he was really telling us that we *had* to agree with them".

This inference is borne out by subsequent correspondence⁹¹. In a letter to Wright, Beals recalls the atmosphere:

"There were deep and irreconcilable divisions within the Committee and I wished many times that I was on some other planet. In the end it came to the point where each had to give up something or end in complete indecision that seemed certain to be fatal. I refused to accept any solution that did not involve the use of the 157-inch mirror, the optical shop and the experience of the group including Odgers, Richardson, Dancey & Co. that had been assembled to do the Canadian telescope. The other side refused to accept any solution that did not involve a Chilean or comparable site."

In the end the Working Group proposed⁹², as its first recommendation, that "a wholly Canadian owned telescope, using the 157-inch mirror blank already made for the Mount Kobau telescope, be built on a suitable site in ... Chile". A site for the telescope was to be negotiated with the AURA group. "If negotiations for such a site are unproductive, our alternative recommendation would be to join with the Carnegie Institution in their project to build a 200-inch telescope plus two smaller telescopes [in Chile] and to complete the construction of the 157-inch telescope on Mount Kobau."

The report was considered by the Cabinet Committee on Priorities and Planning, chaired by the Prime Minister. It found the recommendations unsatisfactory. To build the Canadian telescope in Chile would cost a great deal more money than to build it in Canada, and would be politically unacceptable; to build it in Canada and to buy in to the CARSO telescope as well was simply too expensive. The decision was made to recommend to Cabinet that the Queen Elizabeth telescope be cancelled.

Here a mistake was made that had serious results. Instead of waiting until the full Cabinet had endorsed the Committee's recommendation, someone instructed the Department to announce the cancellation immediately. This was contrary to Privy Council instructions. Moreover the details of the decision were garbled in transmission to us. Our press release was not only premature, it was incorrect. Its gist: for reasons of economy all work would stop on the development of the telescope, and an effort would be made to dispose of the mirror blank and the polishing machines purchased at a cost of \$1,500,000. Further, the government did not intend to proceed with the alternatives recommended by the Working Group. However, "because it is the best viewing site in Canada", Mount Kobau would be maintained on a continuing basis for universities for the conduct of astronomical research."

This press release, which implied that the government was abandoning "large-telescope" astronomy entirely, was a very damning statement, and quite untrue. To quote again from a Privy Council document⁹³: "The Queen Elizabeth II Project was cancelled on the basis of scientific advice against proceeding with it, and on the basis of budgetary exigencies. ... [There was] a clear undertaking by the Government to examine alternatives to the Queen Elizabeth II Project: at the very least, those alternatives outlined in the Working Group's report."

There were demands in the press and in the House that the report of the Working Group be released. This could not be done. Until the Government had formulated a policy on astronomy, which was made difficult by the press release, the report must remain unpublished.

Reflections on the Cancellation

It may be useful, twenty years after the cancellation, to consider what went wrong. A first question has to be – why did communications between the Privy Council Office and the Department break down so completely? How did the misunderstanding about the press release arise, who ordered the Department to issue it prematurely and who conveyed the entirely erroneous details of the decision? Why were the university attacks on the Queen Elizabeth telescope not referred to the Department for comment? The Privy Council files shed some light⁹³.

Our Deputy Minister wrote to R.G. Robertson, Clerk of the Privy Council, on October 4, 1988, complaining about the lack of communication on astronomy. Robertson replied:

"I was surprised and rather dismayed to learn from your letter of October 4th that you feel that consultation on astronomy between the Privy Council Office and your department has been unsatisfactory. My reaction was mitigated somewhat, however, because I do not believes that there is much ground for concern on that score"

"As regards exchanges of correspondence on astronomy over the last two and a half years, our files indicate that very few letters were addressed to either Mr. Pearson or Mr. Trudeau, and that you or your minister have copies of all of them, with the possible exception of a letter received last fall, to which a simple acknowledgement of receipt was sent by Mr. Pearson.

I certainly agree with your suggestion that your department could not be held accountable for the formulation or implementation of policy, if it did not have access to the relevant papers. I can assure you that no such papers have been denied to your department."

So much for the swarms of letters which were "deluging the Prime Minister's office".

In his reply Isbister became more explicit.

"For your information merely, your letter of October 8 surprised me by saying that copies of all the letters addressed to Mr. Trudeau or Mr. Pearson have been supplied to my Minister or to the Department. As far as this Department is concerned, we have been informed by others but not by your office of letters sent to Mr. Pearson from University of Toronto faculty, from the Chairman of the Science Council and from a U.S. Astronomer. Perhaps all of these and others were sent along to my former Minister. If so, I agree that this is my problem, not yours".

I cannot find that the problem was ever solved. Whatever caused it, it was a great pity. Had we been able to state our position, we might have changed the course of events. At least it would have reduced the bitterness between the two sides. One must also wonder why, if the Privy Council was convinced that the Mount Kobau site was a poor one, Departmental officials were not reprimanded for their bad judgement.

More importantly, how did the disagreement between government and university astronomers come to exist, and why did it become so bitter? The fundamental reason was that we believed that the telescope had to be built in Canada or not at all. We understood that Beals had been assured of this by senior officials of Treasury Board. I wonder if it was true? I have not found any reference in the Observatory files or in Beals' personal papers to support it. Van Steenburgh insisted on a Canadian telescope, but perhaps he was wrong.

A second reason for the failure is that we moved too fast. If it had taken us a few years instead of a few months to obtain approval for the telescope, the climate and the seeing on Mount Kobau would have been thoroughly understood and its inferiority to other sites recognized. A telescope in Chile might have been supported; there were some very enlightened men in the Pearson cabinet. If not, the university astronomers would have had to accept the fact. As it was, by the time they made their attack there was too much invested, both in money and in commitment, for government astronomers to back down. And always, the spectre of losing everything hung over us. We didn't want to lose a telescope with a potential 40 times that of Victoria's 72-inch!

Finally, the telescope had been approved before there was an effective mechanism in government for the consideration of such projects. The Science Secretariat had just been set up, and the Science Council of Canada was two years in the future. If these organizations had been in effective operation they would have insisted on a more careful examination of the site; they would, as Harrison did later, have calculated the cost per graduate student and compared the telescope's merits with other large-budget science projects.

Would the Toronto astronomers have mounted their attack if Beals had still been Dominion Astronomer and if Petrie had not died? No one can say, but I wish they had been there to fight the battle!

The Post-Cancellation Period

The Government was still considering the report of the Working Group, which suggests that they saw the CARSO offer as providing a good opportunity for Canadian astronomy. But what were the merits of astronomy's needs in relation to those of other pure sciences? The question was referred to the Science Council, which turned it over to its committee on Physics and Chemistry, chaired by H.E. Petch, of the University of Waterloo. The committee was to undertake "a broad general study of the place of astronomy in modern science, of Canada's role in astronomy and of how any activity in the field of astronomy would best be distributed between government, universities and industry⁹⁴". The Committee was to report by September 1, 1969.

Many letters reached the Privy Council office after the cancellation. A large number of these were engineered by two graduate students at Ann Arbor, Michigan, using the membership list of the American Astronomical Society. Others were the result of a campaign by local Centres of the Royal Astronomical Society. There were in addition many unsolicited letters from astronomers, in Canada and from around the world, deploring the decision, particularly the decision to dispose of the assets. As one said⁹⁵:

"The recent decision to sell the assets of the Queen Elizabeth II telescope, including the 157-inch blank and the optical shop equipment, is an unprecedented piece of butchery. All large telescope projects have had financial troubles but were able to survive lacking anyone callous enough to sell them out."

Contrary to what had happened earlier, all of these letters were forwarded to the Department, and we were required to defend a decision in which we had not concurred.

Almost immediately astronomers from a group of western universities banded together in an effort to continue the Queen Elizabeth telescope without Federal support. They hoped to reduce the costs substantially by eliminating all "frills", and to find the money from provincial governments and commercial sources. The founding members of the group were the Universities of British Columbia, Victoria, Notre Dame (at Nelson), Calgary, Alberta and Lethbridge. On December 11, 1968, the acting President of the University of British Columbia, W.H. Gage, made a formal request⁹⁶ that the assets should be turned over to the university consortium. The response⁹⁷ was a temporizing one; the government could not make a decision at this time, but would sequester the assets pending a decision.

The decision, when it came, was favourable⁹⁸. If the consortium would establish itself as a legal entity, and give assurance that it could raise the necessary funds, the Government would turn over to it, outright, the assets, plans and designs and the design and optical teams of the Dominion Astrophysical Observatory would assist the consortium in the completion of the telescope; in the event that the consortium was unable to complete the telescope it might sell or otherwise dispose of the assets, provided that the money so realized was used in the development of other astronomical facilities on Mount Kobau. A press release to this effect was issued on April 24, 1969.

In compliance with the terms of the agreement, the consortium of western universities was formally established with the acronym WESTAR, with Professor Brian Wilson, Dean of Arts and Science, University of Calgary, as Chairman. The University of British Columbia become the "legal entity" which would act on its behalf⁹⁹. The arrangement seemed secure. But no; the consortium was not able to "give assurance that it could raise the necessary funds". Naturally it could not; until it was assured of the assets it could not canvas for money!

This "Catch 22" situation led to further delay. It raised the question of government responsibility in the event that the consortium failed to raise the money. The only assets that it owned would be those given it by the Government; was the arrangement whereby the University of British Columbia assumed the financial responsibility for the consortium legally sound? A lot of time was spent while the lawyers straightened this out, and in the meantime other factors had entered.

The most important of these related to the use of the large polishing machine. With the publication of the Phase I report, word spread quickly about the excellent telescope design, particularly of the interchangeable ends and of the novel mirror support system. The AURA group retained the firm of Dilworth, Secord, Meagher and Associates to assist in design changes for the 150-inch telescope on Kitt Peak and for a sister telescope being planned for Chile. The firm was also retained to do a complete redesign of the Kitt Peak concept for an Anglo-Australian telescope in Australia¹⁰⁰. There were other possibilities, the CARSO telescope, a proposed 150inch telescope in Saudi Arabia and numerous smaller instruments. Why should the Associates not form a consortium to bid on these telescopes?

They did so, being joined in it by Canadian Westinghouse, which had the expertise and facilities necessary for the heavy manufacture, and by Owens-Illinois, which already had a contract to supply the mirror blank for the Australian telescope, and had an excellent optical shop in which to polish it. As a first step the consortium would bid on the Anglo-Australian telescope. The only thing they lacked was a large polishing machine, and they applied to the Government¹⁰¹, through the Department of Industry, to lease our machine. An early decision was needed; the deadline for bids was rapidly approaching, and unless a polishing machine was assured they could not bid. The Department of Industry urged that the request be accepted, thus placing itself in direct confrontation with the Department of Energy, Mines and Resources, which had agreed to sequester the assets for the WESTAR consortium. As a further complication AURA¹⁰² applied to lease the machine to do their own grinding on their mirrors. All of these possibilities would involve transporting the machine to the United States.

Any such solution was inconsistent with our undertaking to WESTAR, which would need the machine to polish the Canadian mirror if they were successful in raising the necessary funds; furthermore their chance of raising those funds would be seriously reduced if the machine were sent out of the country for two or three years. An ideal solution would have been to construct the optical shop as planned and to contract the grinding of one or more of these mirrors while attempting to raise funds. There was a substantial body of support for doing this at government expense¹⁰³. The commercial consortium would have none of it; it wanted to do its own work on its own terms¹⁰⁴.

There was an additional complication. If the DAO was not to have access to a new telescope, at least its existing equipment could be improved. Provision was made in the Observatory's 1969-1970 estimates for the purchase of a new mirror blank for the 72-inch telescope and for the construction of an optical shop in which to figure it. The smaller grinding machines and the machine shop equipment were transferred to the DAO to be used in this shop. Because the Observatory shop would be used in the provision of the WESTAR telescope, this did not constitute a change in that agreement.

THE END OF THE DOMINION OBSERVATORIES BRANCH

The Petch Committee quietly familiarized itself with the status of astronomy in Canada. It convened a series of meetings in Waterloo on July 9 and 10; university astronomers from the east, university astronomers from the west, and government astronomers appeared in separate sessions.

The committee report was submitted, on schedule, by the end of September, 1969. Its recommendations were unambiguous:

1. Canada should join the CARSO project, sharing expenses, responsibilities and observing time on a 50-50 basis; the Canadian contribution, estimated at \$12,000,00 should be paid in 10 annual instalments and should consist principally of expenditures in Canada or in support of Canadian experts working in Chile; Canadian industry would share in the design and construction of the telescope to the maximum possible extent.

2. The optical shop should be built on the campus of the University of British Columbia and should remain the property of Canada, not of the CARSO project; its first responsibility should be to the 200-inch CARSO mirror; after that it might be used to grind the WESTAR mirror and to contract for other mirrors.

3. Government activities in astronomy should be centralized in the National Research Council.

These recommendations were accepted by the Cabinet Committee on Science Policy on October 31, 1969, and confirmed by the Cabinet on November 13. It was stipulated that the transfer of astronomy to the NRC should take effect on April 1, 1970, and that the areas of overlap with geophysics should be worked out in consultation with the NRC.

There was substantial opposition from western Members of the Liberal caucus to participation in the CARSO project; if Canada couldn't afford to complete the Queen Elizabeth II telescope in Western Canada, how could it afford to support a telescope in Chile? For this reason announcement of the decision was withheld pending a final agreement on the transfer of the Queen Elizabeth II assets to WESTAR. It was thought that a positive announcement on the latter would reduce the caucus objections to the former. It was not until April 1970 that the legal problems had been ironed out and that the joint announcement could be made: the assets would be transferred to WESTAR and NRC was instructed to negotiate an arrangement with CARSO, under carefully defined conditions. This decision having been made, the reports of the Working Group and of the Petch Committee were published together under the general title "Canada's Future in Astronomy⁹².

The Honourable J.J. Greene made the formal presentation of the 157-inch mirror blank, the Hindlesphere and the large polishing machine to WESTAR in a ceremony at the University of British Columbia, on June 12, 1970. The long delay in reaching the decision was unfortunate. By 1970, western resentment about the cancellation of the telescope, which WESTAR had expected to lead to generous support of its aims, had abated and the consortium was not able to raise any part of the necessary funds.

The Cabinet decision on the transfer of astronomy to the NRC, reached on November 13, 1969, was to take effect on April 1, 1970; we had a little over four months in which to make the necessary decisions. The first question was, what should be transferred? Clearly the DAO and the DRAO would transfer, but what about the work in Ottawa?

First, Positional Astronomy and the Time Service. As we saw in Chapter VIII, the caesium atom had replaced the rotating earth as the basis for correct time, and the NRC had replaced the Dominion Observatory as its source; the Time Service clearly should transfer. The vagaries of the earth's rotation, as defined by the Photographic Zenith Telescopes, were now a matter for geophysics; this work was retained as a Geodynamics Section within the Seismological Division.

The question of Meteor Research was a more difficult one. The observatories at Meanook and Newbrook was clearly astronomical, and should transfer; on the other hand the study of meteorite craters was a matter for the earth sciences and should remain. The MORP network was a problem; its techniques were astronomical, but Ian Halliday, who was responsible for the network, was also involved in the crater program. There was another complication: any meteorites which the network recovered would go to the National collection, maintained by the Geological Survey. An ideal solution would have been for the MORP network to be retained, and for the National collection to be transferred to us. When the Survey declined to accept this proposal, it was agreed, with Halliday's concurrence, that MORP, and he, should transfer to the NRC.

Solar Physics is a discipline bridging astronomy and geophysics. Because the sun is the only star whose surface can be observed in any detail, its study is important to astronomy, but because of the effects of solar processes on the earth it plays a fundamental role in geophysics. This complexity has made for organizational problems, both in international unions, and in the government. Half the resources of our Geomagnetic Division were committed to studies of geomagnetic variations originating in the sun, and both the NRC and the Defence Research Board had a variety of groups studying solar effects. We suggested that a study be made about the possibility of consolidating these many endeavours in a single organization. Because of the major engineering support that the group would need it was recognized that we could not provide a home for such a group. Reluctantly, and with Gaizauskas' concurrence, we agreed to his transfer.

During the last year substantial financial support was given to astronomy. The MORP network and the Solar Spar were completed, a new mirror blank was purchased for the Victoria telescope and an optical shop was built to polish it. Work on the synthesis radio telescope was begun. Much of this work was made possible by transfer of funds from the geophysics divisions. Since the proportion of the Observatory budget to be transferred to the NRC would be based on the distribution of funds in the 1969-1970 fiscal year, this transfer had to be done with care. It was a matter of great satisfaction to me that we sent our children out into the new world well provided for.

One problem remained. What would be done with the 15-inch equatorial telescope? As we saw in Chapter 6 the public use of this telescope increased over the years to the point that an astronomer, Mary Grey, had been made responsible for the program on a full-time basis. Could this service be taken over by the Museum of Science and Technology? To go a step further, could the Museum take over the Dominion Observatory building as a branch museum dedicated to astronomical and allied displays? A.E. Covington, our colleague in solar radio-astronomy, thought it could be, and enlisted the support of Heritage Ottawa in a campaign to "save" the telescope and the building.

D.M. Baird, Director of the Museum of Science and Technology, was enthusiastic about continuing the astronomical program, but he was not interested in having a museum of astronomy separate from the central museum. Instead a new building, with dome, would be constructed on the Museum grounds and the telescope would be moved, refurbished, and installed in this new home. Until the building was ready the existing observing program would be continued at the Museum's expense. Mary Grey was eventually transferred to the Museum staff, and supervised the program.

The telescope was moved in July 1974 and the installation was completed by May 1975. Since the telescope was once again in use Heritage Ottawa and Covington were content on that score. They had also been worried about the building but it has survived unchanged.

And what should the remaining organization be called? We proposed "Geophysical Sciences Branch" or "Geophysical Branch", but Harrison objected that geophysics had a much wider connotation than the proposed scope of our Branch. This would have been less true if the suggested consolidation of all solar studies in the Branch had been accepted. Harrison suggested "Earth Physics Branch", translated into French as "Direction de la Physique du Globe", and this was adopted¹⁰⁵.

It was Harrison's idea that farewell parties should be held, in Victoria and in Ottawa, to mark the transfer. The reception in Victoria was held in a downtown hotel. Harrison was not able to attend the party and I acted as host. Everyone on the Observatory staff, as well many others with close connections to the Observatory, were invited, and we all had a fine time.







A few days later a similar party, at which Harrison could be present, was held in Ottawa. The astronomers were well launched in their new orbit!

This was not, for me, the end of the Dominion Observatory. That moment came at 1 P.M. Eastern Standard Time on April 1, 1970, when the CBC announced "*The National Research Council* official time signals: the beginning of the long dash - - - ."

Victorian writers frequently supplied an addendum to their novels in which the subsequent history of their characters was outlined for the edification of their readers. Our story, which would otherwise have an unhappy ending, calls out for such a feature¹⁰⁶.

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Our astronomers were initially amalgamated into an Astrophysics Branch of the Radio and Electrical Engineering Division, NRC. In 1975 there was a further reorganization into the Herzberg Institute of Astrophysics under the direction of our erstwhile colleague J.L. Locke. The National Committee of the IAU was transferred to the Council and established as an Associate Committee on Astronomy.

I have not been able to find any evidence that the NRC moved on the Petch Committee recommendation with respect to the CARSO offer. Other exciting possibilities were developing. Shortly after the cancellation of the Queen Elizabeth telescope Graham Odgers had been granted sabbatical leave, to be spent in France. There he met a group of astronomers, led by Charles Fehrenbach and Roger Cayrel, who were planning for a large telescope in the northern hemisphere and were seeking a partner. The triumvirate approached the National Research Councils of France and Canada with the proposal that the two countries should join in the construction of a 3.6 m (142-inch) telescope on Mauna Kea, on the island of Hawaii. The proposal was ultimately accepted; the University of Hawaii became a partner in the project, supplying and maintaining the site and the approaches to it. The Canada France Hawaii Telescope (CFHT) Corporation was set up in 1974. Cayrel was named Project Director, with Odgers as Associate Director. Construction costs were divided equally between Canada and France; observing time is divided between the three partners C/F/H in the ratios 42.5:42.5:15.

France was responsible for the telescope, its drive gears and most of its instrumentation; Canada would polish the mirrors, supply the dome, the telescope drive and control system, the workshop equipment and some of the instrumentation. A CerVit mirror, already purchased by France, would be used.

The Optical Shop, which we had financed in the final year of the Observatories Branch, now proved its worth. The grinding of the new 72-inch mirror for the Victoria telescope and of the 142-inch for the CFHT went forward in record time under the supervision of Dancey. The opening ceremonies for the new telescope were held on September 29, 1979, although the secondary mirrors had not yet been completed. The telescope was equipped for prime focus, Cassegrain and coudé operation. Because of the more southern latitude the telescope had a yoke, rather than fork, mount, but it did incorporate the exchangeable upper end design of the Queen Elizabeth II telescope.

The observatory, and its telescope, has been a tremendous success. At an elevation of 4200m (13,800') it enjoys clear sky 85% of the time; of this, 75% is photometric. The diameter of the seeing disk is normally less than one second of arc and for appreciable periods is as small as 0.5 second of arc.

So, there's our happy ending!

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i) Report of the Working Group In Astronomy;

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- 93. Letter, R.G. Robertson to C.M. Isbister, October 8, 1968. Privy Council File.
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- 99. Letter, B. Wilson to J.J. Greene, July 9, 1969. Dominion Observatory Administration File 6075-1, Part 9; National Archives of Canada, RG48, Volume 41.
- 100. Letter, G.V. Meagher to Telescope Steering Committee, October 17, 1968. Dominion Observatory Administration File 6075-1, Part 8; National Archives of Canada, RG48, Volume 41.

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- 102. Letter, A.K. Pierce to G.J. Odgers, April 17, 1969. Dominion Observatory Administration File 6075-1, Part 9;National Archives of Canada, RG48, Vol. 41.
- 103. This was the solution favoured by the Department. See Memorandum, J.M. Harrison to C.M. Isbister, January 3, 1969. Dominion Observatory Administration File 6075-1, Part 9; National Archives of Canada, RG48, Vol. 42.
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- 106. K.O. Wright, personal communication, with additional information from the two following sources, both of which should be consulted by readers interested in the complete story:

R.A. Jarrell. "The Cold Light of Dawn"; University of Toronto Press, 1988, 171-173.

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