RASC SUDBURY ASTRONOMY CLUB: SOLAR OBSERVATORY PROJECT 1980 - 1989 by STEVE DODSON

In the first few years of its existence, the new Sudbury Astronomy Club drew on the knowledge, skills, and energy of its members to engage in a bold project that earned it a lasting place of honour in the Sudbury Community.

This project succeeded through a unique partnership between the Club and another remarkable organization founded in the early 1980s, the Science Centre that became Science North. Both the Club and the Science Centre focussed rising community interest in Science.

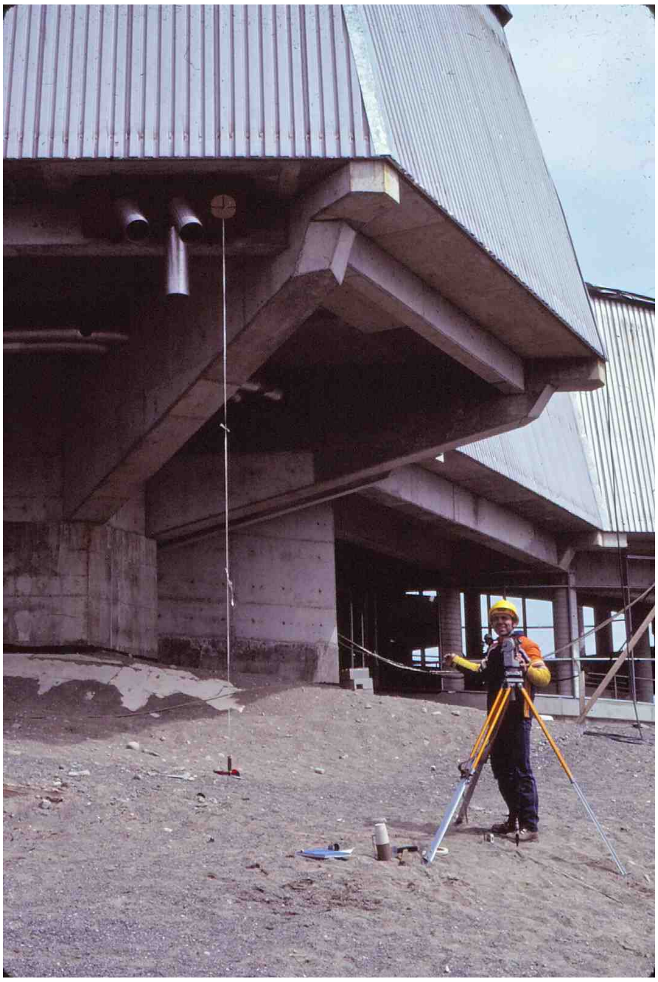
How did this partnership come about? I was a high school Science Teacher in North Bay, and I commuted to Sudbury to meet with the "Sudbury Science Center Study Team. I enthusiastically advocated for the inclusion of Astronomy in the programs of the Science Centre to be. I proposed rich program of astronomical activities That could give real observing experiences for daytime visitors by building a unique multi-mode Solar Observatory.

But neither the Club nor the Science Centre could create the hoped-for Solar Observatory on its own. The Project would require a Partnership. The Planners of Science North, including the director, Dr. David Pearson, and the architects were willing to adapt the building to interface with Solar Observatory Optics, and members of the Club were willing to contribute their knowledge and hands-on skills. In return the Club gained a sense of purpose, confidence, and stature in the Community.

Before the "Snowflake" building punctuated the Sudbuy Skyline, while I was still a teacher in North Bay, I worked with the Study Team to integrate the optical requirements of the Observatory into the architectural plans for the building; and on blending astronomical content into the overall exhibit program. I worked closely with Architect Blaine Nichols and Exhibit Program Developer Taizo Miake.

1 - 1485 Before the Skin Went On The Building (Late 1982) plans were in place for integrating the Solar Observatory into Science North

2 - 1218: (1983) Surveying to Find the North-South Line from a Beam Tube. The Solar Optics insde and out must be mounted along this line.



3 - 1217 (1983) The Beam Tubes on a Steel Box are mounted under the floor before the outer skin of the building was completed (TOP)

4 - 901 (March 1985) With the Skin on the building and the Perforated Optical Flat Mirror completed, the Mirror is held in a fork mount that rotates within a Beam Tube. (BOTTOM)

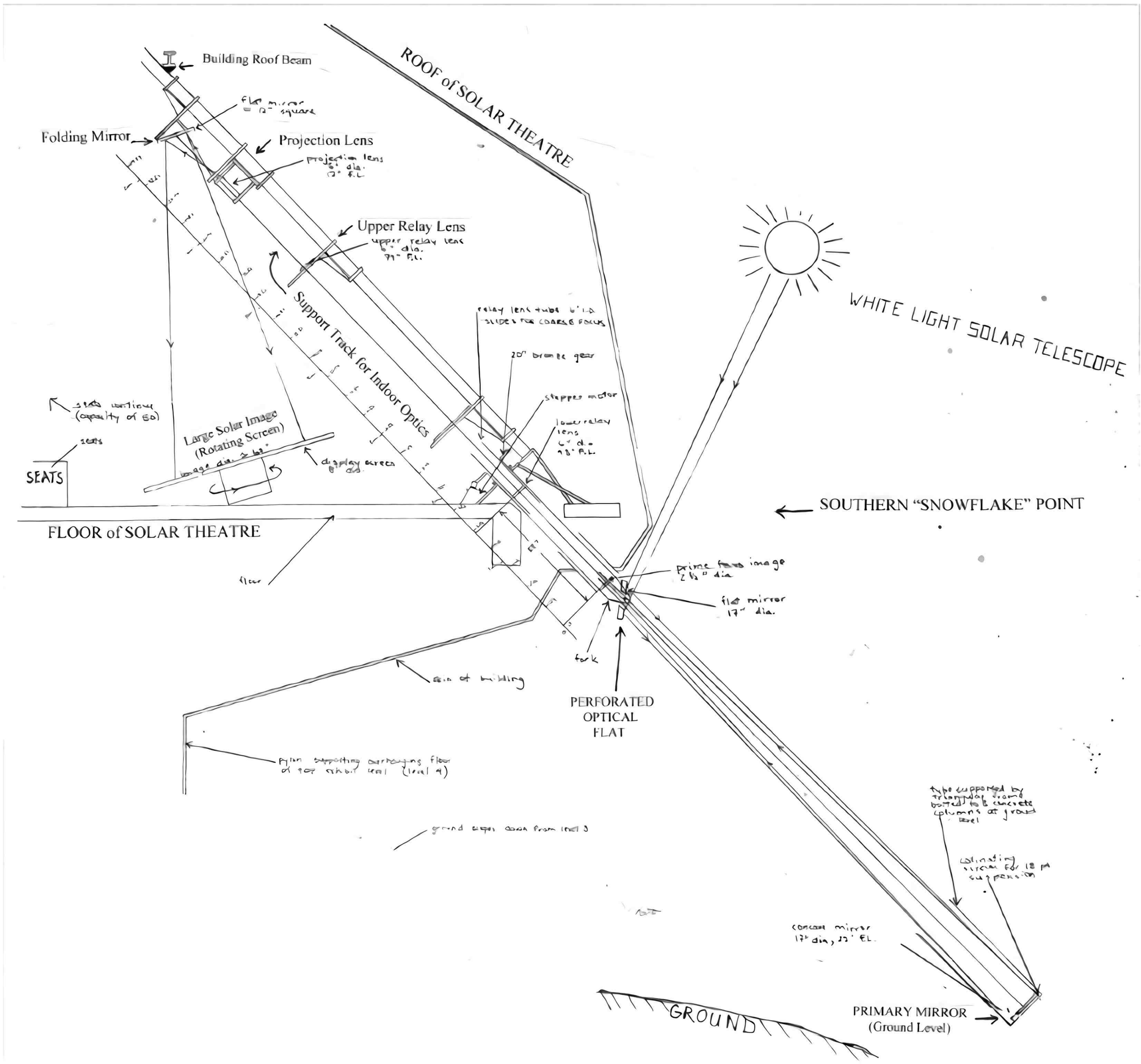
The Lenses and 17 1/2- inch Telescope Optics of the Solar Observatory Instruments need to be aligned with a "Polar Axis" parallel to Earth's Axis, and inclined at 46 1/2 deg. for our latitude. The Sun-tracking Optical Flat Mirror rotates around that axis, reflecting a wide beam of sunlight down to an imaging mirror at ground level. Then the light reflects back UP the Polar Axis, and through a central perforation in the Flat Mirror and into the interior of the Observatory.

Beam Tubes at 46.5 deg. allow the focussed beams of Sunlight into the building.

Before the concrete was poured for the snowflake shaped upper floor, I specified a rectangular gap in the floor to allow entry of focussed beams of sunlight. I designed a heavy steel “Beam Tube Box” to hold 10-inch diameter stainless steel “Beam Tubes” that would allow mounting of the Solar Observatory optics. A shop-ready drawing was made by engineering student Jeff Joupi, and fabrication was contracted out to Drummond, McCall & Co. by Science North Shop Manager Andy Moore.

Before the Skin went on the building, the box was fabricated and mounted beneath the gap in the floor. In order to provide a stable path for a stationary focussed beam of Sunlight to maintain alignment as the future optics follow the Sun across the sky, a “Polar Axis” would need to be established between optics on the Ground, the Beam Tube, and lenses inside the building. Since Sudbury’s latitude is 46.5 degrees, this Polar Axis is inclined at 46.5 degrees towards the North. If the building were not in the way, this axis would point to the Sky's North Celestial Pole near Polaris.

Since Polaris was hidden by the building, I had a job of Surveying to do, part of it assisted by Greg Beach, VP of the Sudbury Astronomy Club, on one of the coldest nights of the Winter of 1984. The Polar Axis and beaming optics align along the slanted 46 degree line seen in Illustrations - 5,6. The surveying determined where the concave "Primary Mirror" needed to be located on ground supports on a North-South Line beneath the Beam Tube, and at the exact distance from the building consistent with the 46.5 degree inclination.



5 - PROJECTING AN INDOOR IMAGE OF THE SUN WITH A FOCUSSED POLAR ALIGNED BEAM

Section View of the Solar Observatory in the southern-most point of the "Snowflake". A Beam of Sunlight is reflected by the Optical Flat Mirror mounted in a rotating Fork just outside the building. From the Flat the Beam goes down to a Concave Mirror at ground level which focusses the Beam, allowing it to pass through the Centre Perforation in the Flat and on into a train of optics inside the darkened interior space. Notice the 8-foot rotating Screen supported by the Theatre Floor.

(Drawing completed by Observatory Staff in 1985 ... Scanned and labled in 2022)

6 - 899 (March 1985) The 17 1/2 - inch, long-Focus Primary Mirror is located at the lower end of the White Tube on a steel Base Triangle. The 17 1/2-inch Perforated Flat Mirror is above the top of the scaffold. Compare with the right half of the diagram (#5) on the previous page. The long inclined Polar Axis (46 deg.) is easy to visualize here! During the day, the Flat Mirror rotates about this axis.

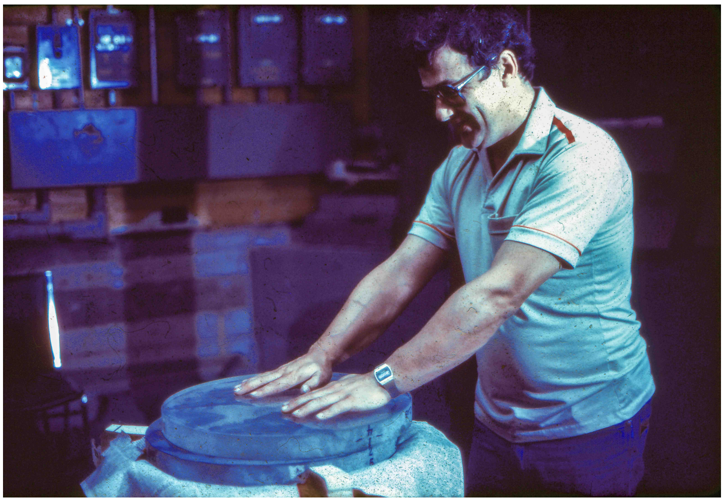
HOW VOLUNTEERS FROM THE SUDBURY ASTRONOMY CLUB MADE THE CUSTOM SOLAR OPTICS

The Large Custom Optics needed are very valuable and would normally be prohibitively expensive. These include the 17.5 inch Perforated Flat Mirror, and the 17.5-inch Concave Primary mirror. We will now look in detail at the processes by which members of the Club created them.

It all started with the delivery of three large boxes each containing a 17.5- inch diameter, 1.5 - inch thick Pyrex disk.

7 - 679 (July 1983, Bottom of Previous Page) Unboxing the Pyrex Mirror Blanks Outside the Old CKSO Studio. From left to right: Steve Dodson, Greg Beach, Carl Hoeg, and Fred Boyer. Fred was President of the Sudbury Astronomy Club and Greg was VP. Carl was the Instrumentation Coordinator.

One of these blanks would become the Perforated Optical Flat Mirror, and one would be ground and polished to a Concave Parabolic Profile to serve as the Primary Imaging Mirror. The third would be shaped to a deep spherical curve needed for testing the accuracy of the first two mirrors. The first step was "rough grinding" with coarse carborundum (no. 60). At the time, with the Science North building an uninhabitable construction site, the headquarters for the development of the scientific programming was the basement of the Old CKSO Studios. We set up a temporary ``Optical Workshop in a basement electrical room.



8 - 707 (July 1983) Getting Ready to Grind in the CKSO Electrical Room ... Greg with Grit, Carl with the Blanks, and Fred wtih Water (Top Right 9 - 708, July 1983) Greg Spreading Grit, Fred adding Water.

(Bottom:10 - 709, July 1983) Fred Pushing Glass. Grinding is a mostly back & forth motion.

When one glass disk is pushed back and forth over another with Water and Grit inbetween, TWO things happen: First, the little ripples, hills, and valleys on the two glass surfaces are smoothed away.

Second: (and this is a ``Universal Law`` of all optical work) the Top Disk will start to become curved in (``Concave``), and the Bottom Disk will start to become curved outwards (Convex). This is a GOOD thiing, when we are making a Concave Primary Mirror. But it is a BAD thing when we want to make an Optical Flat! Our first goal was to make an Optical Flat. We controlled the tendency of the glass disks to become curved by frequently flipping over the pair of disks we are grinding together!

.. We also promoted "flatness" by using all the 17 ½- inch Disks in Rotation. Having two extra disks provided four extra surfaces that could each be ground below or on top of the chosen flat surface. In this way we actually ended up with several flat surfaces, though they were not all brought to a final finish.

After about 20 hours of grinding all the surfaces flat, our Mentor, Ken Odaisky, examined the surfaces with a magnifier, finding them uniformly ground. We then repeated the process with no. 80 grit (17 hours), and no.120 grit (8 hours). Grinding with the no. 60 and no. 80 grits produced a ``crunching`` sound! Switching to no. 120 proceeded with a ``whisper``.

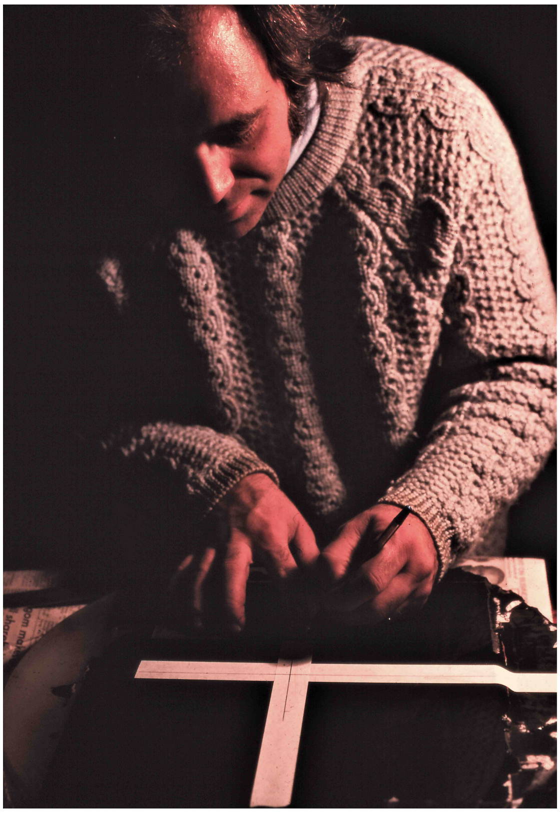
By mid-November 1983,we were meeting in the CKSO basement electrical room in evenings and on weekends, and 40 hours of grinding had been accomplished. We were now ready to refine the surfaces with ``fine grinding``.

But first we had to address the need to create a central perforation in our Flat. We melted pine pitch, and poured it onto the middle of the Flat, using it to ``glue`` a cover plate of window glass onto surface no.1 to protect it during centre-boring.

11 - 720 (late November 1983) Attaching the Cover Plate to the Flat (Surface no.1)

Left to right: Greg Beach, Alan Ward, Fred Boyer

(BELOW) 12 - 721 ... Steve Marking the Centre of the Flat for Boring



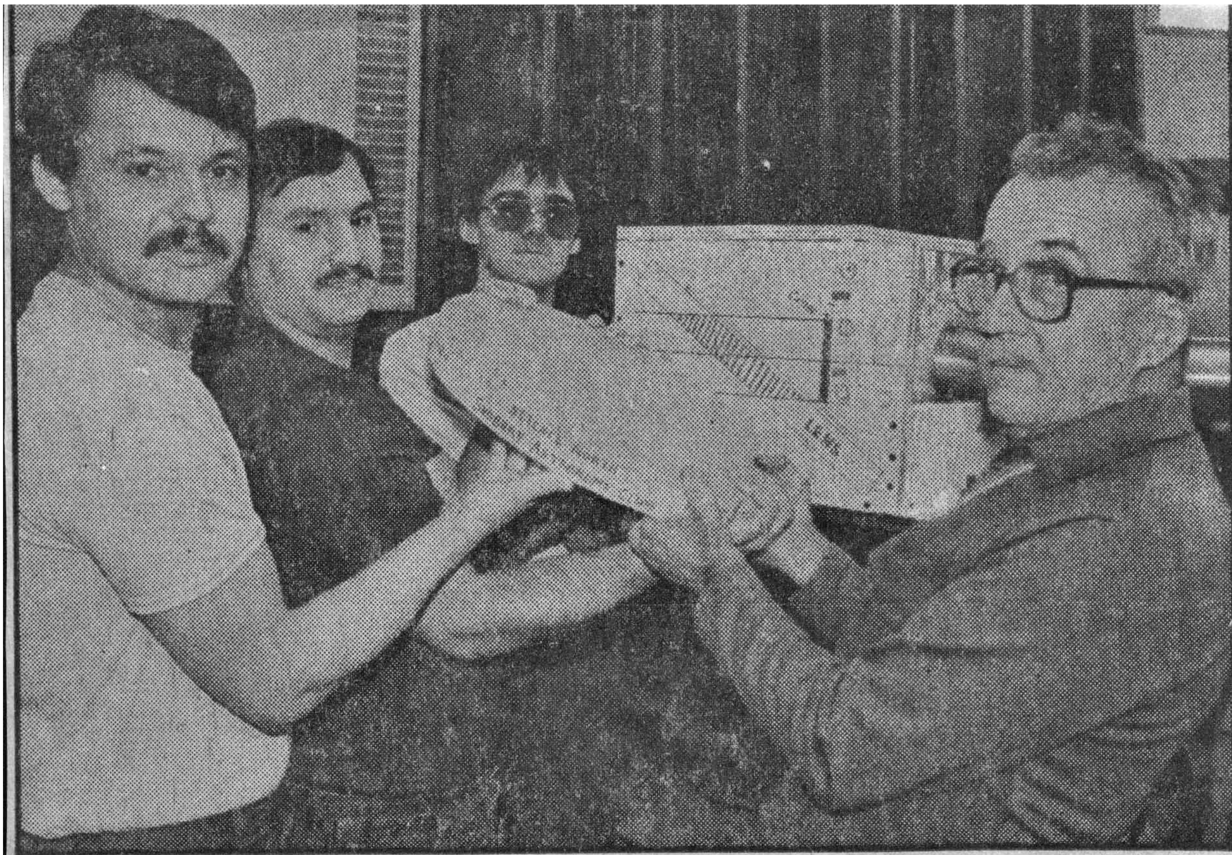
13 - 724 (late Nov. 1983, BELOW) Flat Placed in Guide Box for Boring. Notice the white tube nea the Center of the Flat, which will guide the Boring Tool.

With the Flat protected by the pitched-on Cover Plate and centre-marked, we placed it in a specially constructed Guide Box at a 46.75 degree slant. The white tube seen near the top of the last illustration served to guide the Boring Tool towards the centre of the Flat.

We were very fortunately able to obtain the loan of a 4-inch Boring Tool from the Ontario Department of Hightways to bore through the center of the Flat. To properly support and protect the Flat during boring on a machine lathe, we packed wet plaster around it.

14 - 723 (Late November 1983) Securing the Flat in Plaster for Boring... (left to right) Greg Beach, Gerry Bourque, Carl Hoeg

15-725: (Below, left to right) Alan Ward, Carl Hoeg, Gerry Bourque, Tin Chee Wu, Greg Beach, Ken Odaisky.



The patient and meticulous members of the Sudbury Astronomy Club have helped bring a one-of-a-kind telescope system into focus at Science North. Club members Carl Hoeg, Gerard Bourque, Alan Ward and Ken Odaisky have been busily developing the system from scratch.

—Photo by John Lightfoot

'One-of-a-kind' telescope going in at Science North

The brainwork and elbow grease of the Sudbury Astronomy Club is helping to make a unique vision a reality.

Using $15,000 worth of telescope-making and optical materials, the club is constructing a telescope system worth half-a-million dollars for Science North.

The science centre is developing a system of four solar telescopes to beused in one of the five object theatres at the centre.

"Visitors sitting in the theatre will see a huge image of the white sun splattered with dark sun spots, a brilliant prism of colored light eight feet long, a red fileter view of the sun showing flames leaping from its surace and hear the sun via a radio telescope," said Jim Marchbank, director of development.

The image is possible through outside lenses on the ground below the object theatre where reflectors and dishes will be mounted on a steel frame. The systems will have sun-tracking capability to ensure that the brightest images possible are being reflected up through holes in the floor and into the theatre.

"We're doing everything from scratch, using some unique techniques in developing these telescopes and have invented a new type of lens for the prism projection scope," said Steve Dodson, program planner for physical science.

"Over the past year, the tremendous amount of work that the planning and lens preparation requires could not have been done without the help of the Sudbury Astronomy Club," Dodson said.

Club vice-president Greg Beach said the most time-consuming part of the work has been hand-grinding the lenses.

"We're not even close to being finished with the grinding and it has already taken 36 hours of patient rubbing in trying to get the surfaces of the three discs flat," Beach said.

The grinding process involves rubbing the surfaces of two glass discs together in a set pattern of strokes.

Following the tried and true methods of the early lens grinders, the club is preparing three 17-inch discs simultaneously.

Before the final lens polishing begins, a hole is put through the exact centre of one glass disc, one lens must be made concave and the other perfectly flat to within a few millionths of an inch. The flat surface will be used as a reference in the lens grinding and optical workshop at Science North.

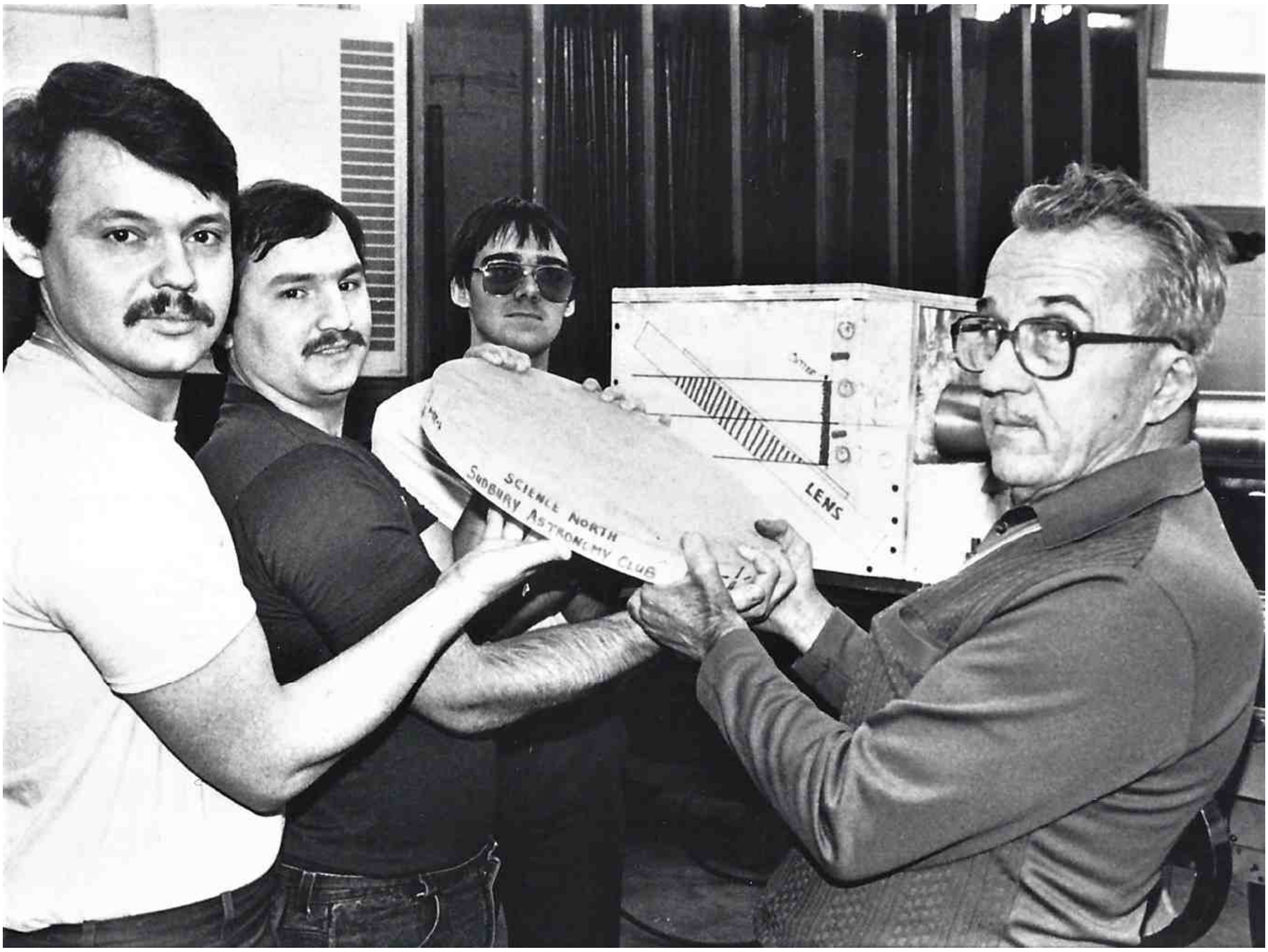
Sudbury Astronomy Club members will be on the top exhibit floor at Science North's opening to assist visitors at the lens grinding and optics workshop.

Other citizens have been co-operating with Science North in development of the project.

Lively High School modified a tool loaned by Falconbridge Ltd. to bore a four-inch hole in one of the 17-inch lenses.

The school's technical director, Richard Dow, worked with Science North's Eric Radke in setting up the machine. Radke and Conrtad Morin constructed a specially-designed box to ensure the hole would be drilled at the precise angle required.

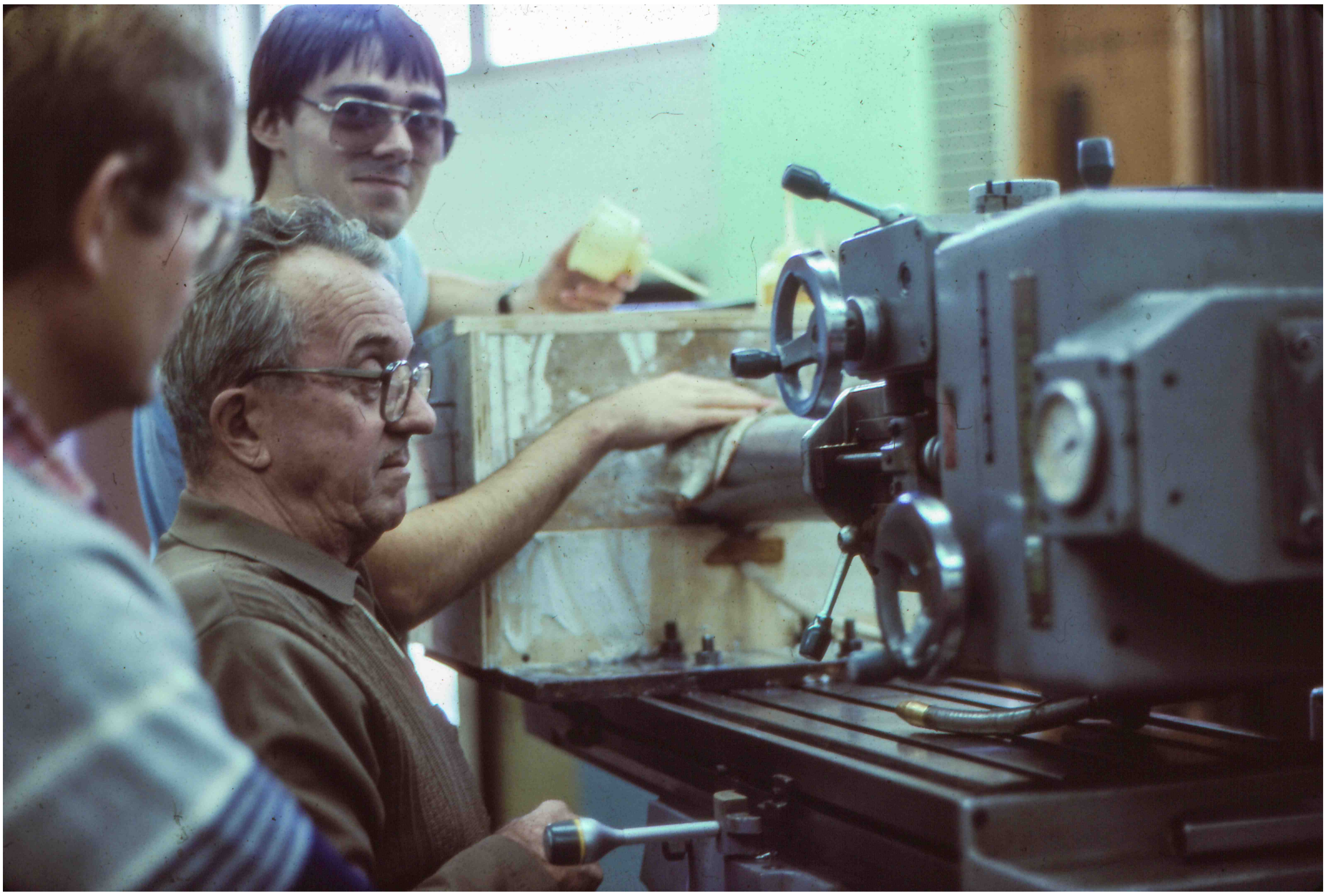
16 - (Previous Page): Sudbury Star Article, Early December 1983



17 - Direct Scan of Sudbury Star Photo ... Carl Hoeg, Gerry Bourque, Alan Ward, and Ken Odaisky (right). The Guide Box is at the centre, and the Coring Tool enters the Box from the right. The Flat is already mounted <u>in</u> the box, and Disk no. 2 is being held in front to show the orientation of the Flat inside the Box. Photo taken in the Machine Shop of Lively Sec. School.

With the kind cooperation of Richard Dow, Technical Director of Lively Secondary School, the Guide Box containing the Flat, and the 4-inch Diamond Coring Tool were mounted on a large Lathe in the Lively Secondary School Machine Shop.

At 9:00 AM Saturday December 10, 1983, Several members of the Sudbury Astronomy Club, lead by Ken Odaisky and carrying Horton`s cups, gathered in the Lively Sec. Machine Shop. We were prepared to take what ever time was needed to penetrate several inches of Pyrex, creating the central Perforation. We carefully followed Ken`s lead, since he had years of experience in machine shops at INCO. The entire operation proceded very smoothly and took only 5 hours! We were all home in time for Supper.



18 - 726 (December 10, 1983) The Guide Box and Flat have been Mounted on the Lathe, and the spinning coring tool has started to penetrate the Glass. Ken Odasky is keeping a careful watch on the process.Wilf Meyer is in the left foreground and Alan Ward is in the background adding cutting fluid.

19 - 727 (Bottom of Previous Page) Same Scene as 18 - 726 from the far side of the Lathe. From left to right: Wilf Meyer, Tin Chee Wu, Ken Odaisky, Alan Ward, Gerry Bourque, Carl Hoeg.

20 - 733 (Same session in the Machine Shop): Boring into Glass generates heat, and the cooling effect of the Cutting Oil is not enough to prevent excessive heat. Since Snow was an available resource outside the shop door, we made good use of it to keep the diamond boring tool cool. Here Dr. Dave Turner is assisting by replenishing our supply of cooling snow!

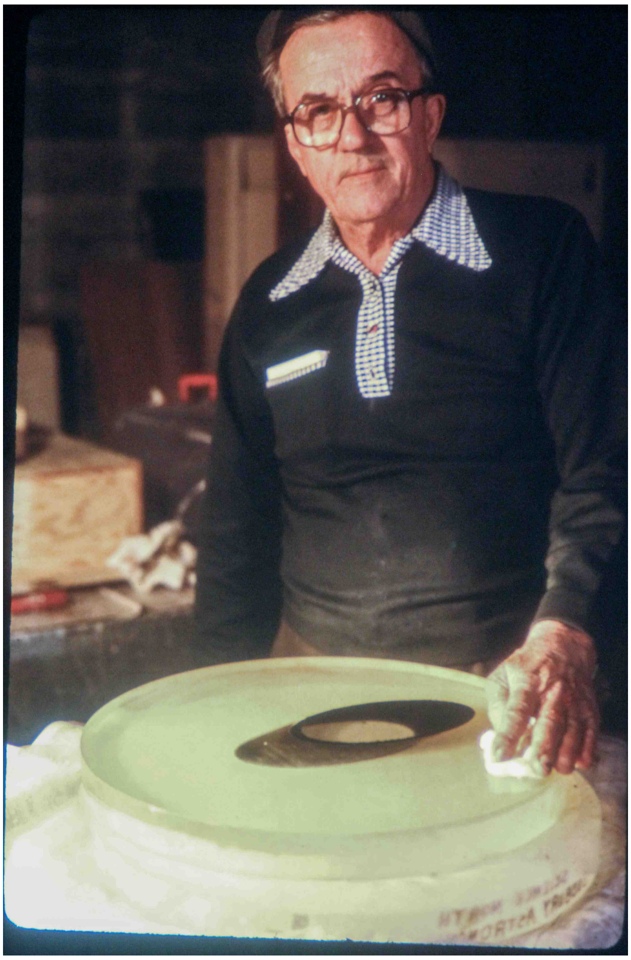
In the week of Dec 12, 1983, back in the basement of the CKSO Building, we eagerly pried open the guide box, cracked the plaster, and carefully freed the Optical Flat which now had a 4-inch-wide centre bore.

21 - 805 (Mid - December 1983,bottom of previous page) Ken Odaisky, Alan Ward, Carl Hoeg, and Gerry Bourque with the newly-perforated Optical Flat.

22 - 804 (January 2004) Carl Hoeg with the Optical Flat almost free from the plaster. The window-glass Cover Plate, which protected the flat from chipping during perforation, will be removed by re-melting the pitch holding it in place.

23 - 807 (Below) Here the Flat is completely removed from the Guide Box, and the Core removed from the bore can be seen in front of the Flat. From left to right: Ken Odaisky, Gerry Bourque, Alan Ward, Carl Hoeg, Tin Chee Wu.

No Sooner had we separated the Core from the Flat than we started talking about putting it back! Ken explained that putting the Core accurately back in place mounted in black pitch would allow the fine grinding and polishing stages to proceed more smoothly and accurately. When the Flat was accurately polished, the pitch would be melted and the Core released permanently.



24 - 809 (January 1984) Ken has re-mounted the core inside the perforation with black pitch, in preparation for fine grinding and polishing.

FINE GRINDING THE FLAT (80 hours; Completed Feb 19, 1984)

In fine grinding, the action is the same, but the coarse (no. 60, 80, and 120) grit is replaced by seven finer and finer grades of microgrit, from no. 220 to no. 4000! Each grade removes the pits in the glass left by the previous grade.

Frequent cleaning of old abrasive and ``sludge`` is necessary in fine grinding to control scratches. We also needed to limit the transfer of heat from our hands at this stage. Even that small amount of heat could raise fine ridges in the glass, which would then be ground away to make depressions (troughs) that appear when the glass cools.

For that reason we held the disks in specially-made frames when cleaning the surface being ground.

25 - 739 (February 1984, Basement of CKSO) Alan Ward is cleaning the front surface of the Optical Flat, prior to switching to a finer grade of Microgrit. Oak Barrels provide a very stable base for grinding and polishing.

26 - 740. Alan is carrying disk no. 2 and will lower it onto the front surface of the Flat, which has been prepared with Microgrit and water. Barrels provide a very stable base for grinding and polishing.

27 - 747: (lower right) Tin Chi Wu is pressing disk no. 2 into the microgrit on the Flat, and Alan is removing the carrier frame.

28 - 744 (January 1984) Alan Ward Fine Grinding, Flat on Bottom. In addition to pushing the glass back and forth, two rotations are involved. After several back-and forth strokes, Alan will rotate the top disk one way, and take a step around the barrel in the other direction. In maybe 5 - 8 minutes he will have been around the barrel about 3 times, and the water- microgrit slurry may be getting a bit dry. This cycle is called ``a wet``. The blanks will be washed, and more water and microgrit are added.

By the time we completed the final stage of fine griding (no. 4000 we had perfomed 504 Wets!

29 - 749 (Feb 19, 1984, Electrical Room in Basement of CKSO) FINE GRIDING OF FLAT COMPLETED Tin Chee Wu, Steve Dodson, Alan Ward, Linda Hayward, Ken Odaisky, Carl Hoeg

PEOPLE WHO SIGNED THE LOG ON SUNDAY FEBRUARY 19, 1984
FINE GRINDING OF OPTICAL FLAT COMPLETED, TOTAL OF 80 HOURS OF GRINDING!

Carl Hoeg Alan Ward   Greg Beach Tin Chee Wu Steve Dodson
Ken Odaisky   Denis Desmeules   Wilf Meyer   Dave Turner
Gerry Bourque (Absent: Fred Boyer, Linda Hayward)

OTHER TASKS ACCOMPLISHED BY CLUB MEMBERS IN 1984:
* Polishing, Testing and figuring to high accuracy of the Optical Flat
* Grinding and Polishing of a Long-Focus Objective Mirror on Disk no. 2
* Grinding and Polishing of a Short Focus Spherical Mirror on Disk no. 3
* Assisting in Surveying for Mounting the Objective Mirror at ground level
* Assisting in creating mountings for the Indoor Optics

The action of Polishing is similar to fine grinding, but instead of Microgrit we use Cerium Oxide Slurry, and instead of pushing glass across glass, we push the fine-ground optical surface across a lap of Black Swiss Pine Tar Pitch. The Pitch Lap was made on one side of Disk 3.

30 - 820 (October,1984, on Science North 4th Floor) The polished Flat (Letter ``F``) is on a Test Stand, and the Short Focus Spherical Mirror (Letter "S") is on the right. Ken Odaisky

In March 1984 a 20-inch diameter Brass Drive Gear was custom-ordered from the Thomas Mathis Co. of California This is the gear that would slowly turn the Polar Axis Assembly to track the Sun during a day`s observation. Around this time, the Optical Workshop was moved from the basement of the CKSO Building to the newly - completed Science North 4th Floor, where the set of 17 1/2- inch Solar Optics was completed over the final months of 1984.

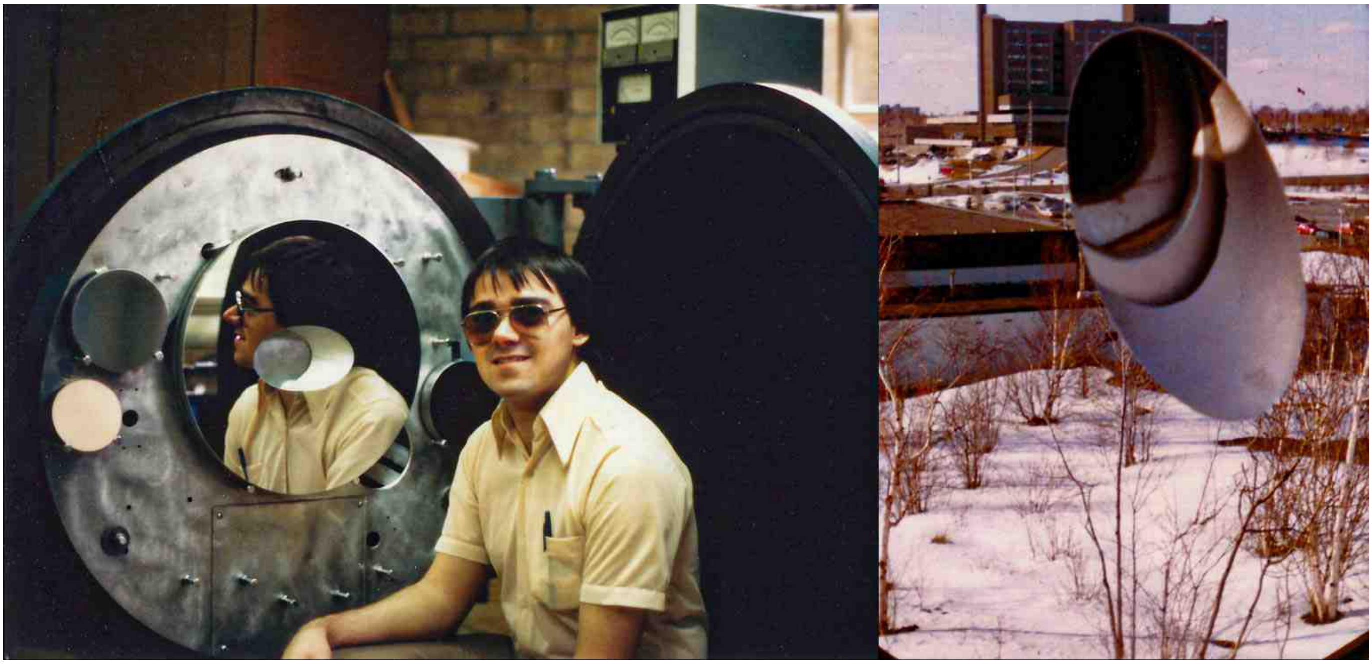
While the Solar Flat was being finished (``figured``) to an exceptional degree of flatness, Science North Shop Personel (Ron Lalancette, Andy Moore & others) were installing the 500 lb Polar Axis Assembly and Mounting Fork inside one of the Beam Tubes. (Sept 1984). The East-West rotation around Earth`s polar axis was impressively solid and smooth.

LATE AUTUMN 1984 - ALL THREE 17 1/2 -inch OPTICAL SURFACES POLISHED

31 - 824 (December 1984) Optical Test Photos Confirm the Solar Flat is Finished! The fully-polished Flat has the necessary degee of ``flatness``. Examining the evidence are (left to right) Ken Odaisky, Ken`s son Bob O`daiskey, Greg Beach, Steve Dodson, Alan Ward, and Gerhard Schinko.

In January 1985 Alan Ward and I took the finished Optical Flat to the lab at the David Dunlop Observatory in Richmond Hill, Ontario, to have a thin film of shiny aluminum deposited on the polished surface in a large Vacuum Tank.

32 - 1134 (Januay 1985) Alan Ward with the Freshly-aluminized Solar Flat in front of the Vacuum Tank at the David Dunlap Observatory.



33 - (Left) Same photo as 32 ... (Right) With the Flat located outside the building in its Mounting Fork, Ramsey Lake road and the Hospital are reflected in its shiny coatings. Notice how the holes in the round steel enclosure and the Mounting Fork line up with the tilted Polar Axis, providing a channel for the Beam of Focussed Sunlight.

34 - 850 (February 1985) In the Optical Workshop on the 4th Floor of Science North, Steve is seen with Alan Ward assembling the supporting structure of the Mirror Cell for the Concave Long-Focus Primary Miror, which will form the light from the Perforated Flat Mirror into an image of the Sun.

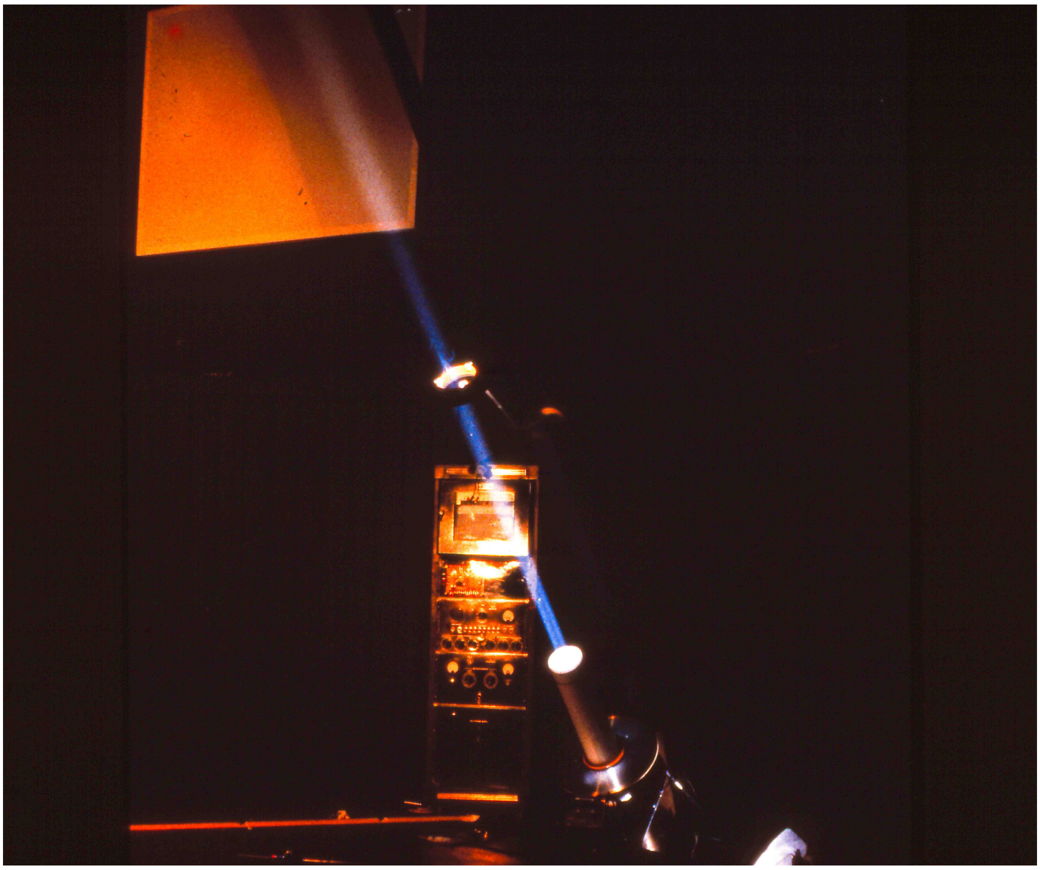
35 - 852 (February 1985) Ken Odaisky and Gerhard Schinko are installing the Mirror Cell on the Triangular Base Frame at the Bottom of the Polar Axis.

36 - 853 (February 1985, Top) Steve and Ken Odaisky prepare to install the Primary Mirror.
37 - 854 (Bottom) Ken and Steve moments after Primary Mirror Installation. The White tube will enclose the Mirror and Protect it, while allowing passage of the focussed beam of Sunlight up the Polar Axis.

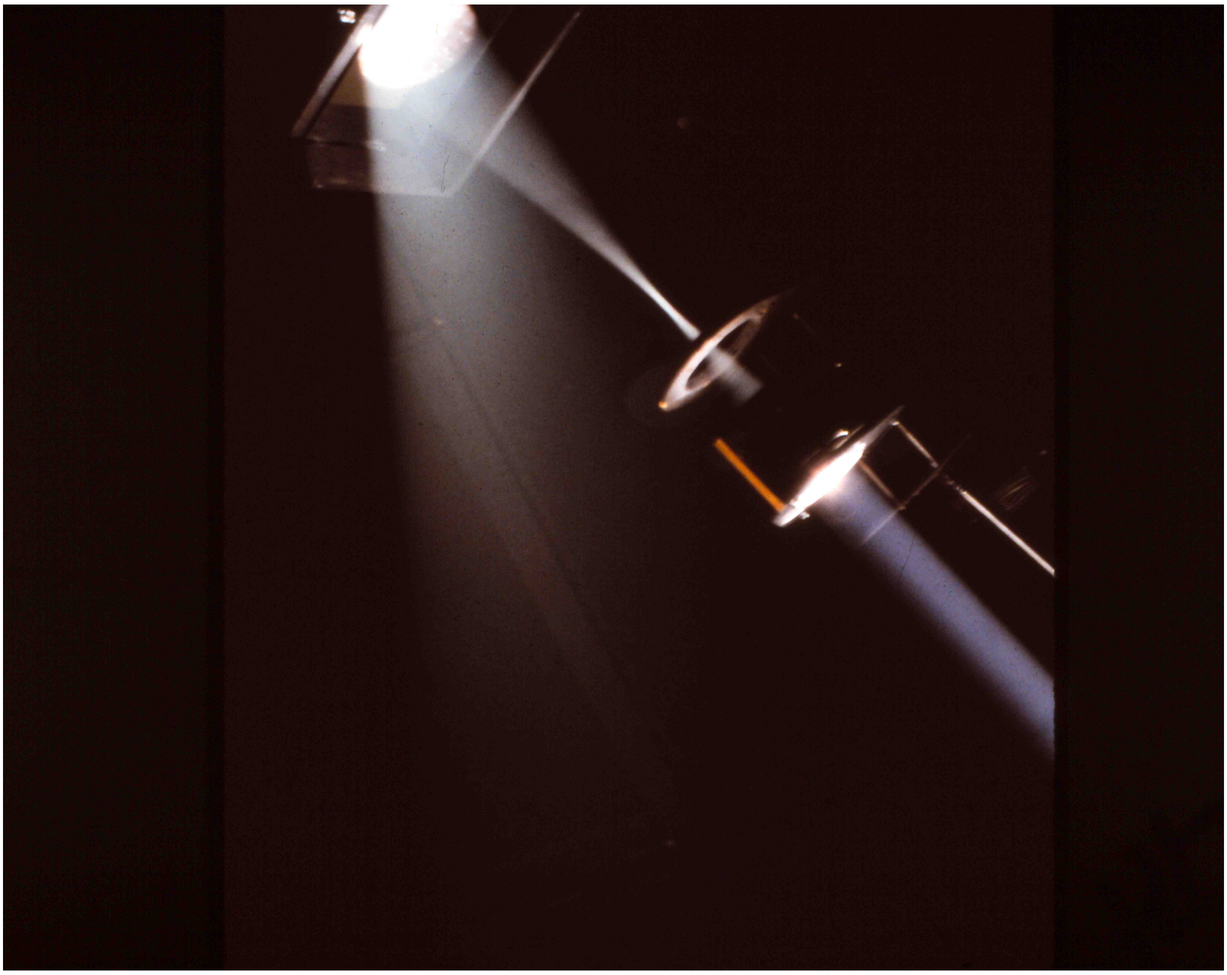
38 - 894 (March 1985, Above) Club President Fred Boyer standing on a scaffold next to the Mounted Flat. The tube protecting the Primary Mirror is in the bottom half of the picture.

39 - 896 (Right) The Flat is catching sunlight and reflecting it down to the Primary Mirror at ground level.

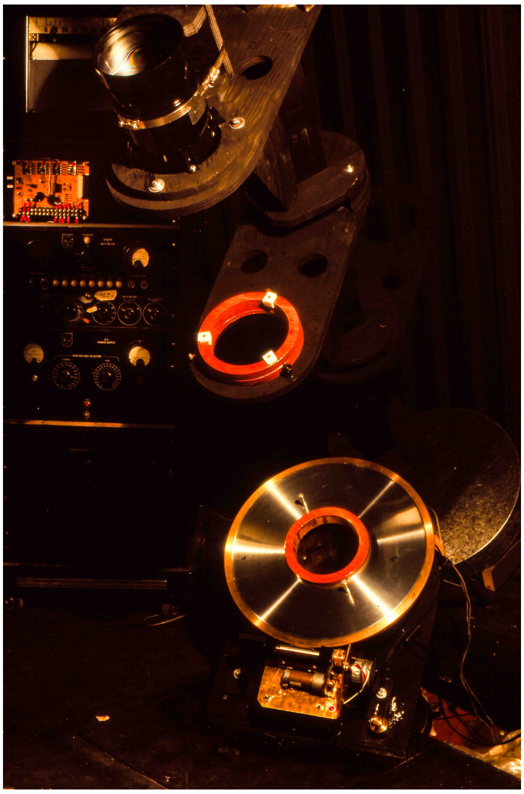
While the 17.5 - inch Solar Optics were being installed outside (first 3 months of 1985), work was proceeding indoors as well. I performed ``ray tracing`` calculations and drafting, and tests to defne how the concentated beam of Sunlight would be processed into an image. The Drive Gears and Mechanisms were installed to track the Sun. As these aspects of the Observatory came together, the large dark space of the Solar Theatre was pierced on sunny days by a diagonal shaft of brilliant light stretching up the Polar Axis.



40 - 904 (March 1985) ``Relay Lenses keep the Beam concentrated and ready to form an image.
At the Bottom, surrounding the hollow Polar Axis Extension, is the 20-inch Brass Drive Gear. The lower Relay Lens is hidden inside the Polar Axis Extension, and the Upper Relay Lens is the small bright object just above the rectangular rack.



41 - 1152 (February 1985) The Beam of Sunlight seen on the previous page now passes through an imaging lens (an aerial camera lens which I brought back from the Stellafane Telescope-maker`s Convention in Vermont). The expanding cone of light is then directed downwards to the large Rotating Screen by the Plane Mirror at the top.



42 - 902 (Left, March 1985) The Polar Axis Extension has been removed to show the Brass Drive Gear that keeps the Solar Image motionless on the Large Rotating Screen. The Lower Relay Lens has been moved to the Oak Ring (Cell) at the centre of the picture.
43 - 1457 (above) Steve shows the Sun and the Solar Spectrum on the Large Screen to a seated audience.

Notice the large ring-like Oak Cell near the centre of the view in Illustration 42. That important item was machined from Solid Oak by Ken Odaisky, along with the similar ring on the Brass Gear. The ring at the centre of the photo was made to hold the lower relay lens, which was originally mounted inside the Polar Axis Extension.

There is an interesting Story behind the reason for the move of the Relay Lens to Ken`s Oak Ring! We originally purchased two identical 6-inch f8 Refractor Lenses to serve as Relay Lenses. But when we tested the indoor optics, we found that the resulting Solar Image was too small! We needed a Lower Relay Lens of much longer focal length, and such lenses were hard to find!

But Ken had made a refracting telescope with a lens of nearly 8 foot focal length, and he was finding the big telescope hard to handle. He needed to cut down the length of the scope by using a lens of much shorter focal length. So we traded, and Ken made the Oak Cell for the Solar Observatory. Ken`s lens was installed on March 26,1985. We got the large Solar Image we wanted. Ken got a much more portable telescope!

April 1985 was a ``Banner`` month for the Solar Observatory! Large Sunspot groups festooned our Solar Image on April 28, and the Planet Venus was visible in the Lower Relay Lens!

We had a very Famous Visitor in April 1985: The First Candian to fly on the Space Shuttle, the recently returned from Space: Marc Garneau!

44 - 905 (Previous Page, April 1985) Canadian Astronaut Marc Garneau touring the Outdoor Installation of the Solar Observatory. From left to right, Steve Dodson, Ken Odaisky, Alan Ward, and Commander Garneau at the Base Triangle. Mark is pointing to the Solar Flat and Beam Entry.

SOLAR OBSERVATORY RECEIVES TWO IMPORTANT VISITORS IN 1985!

In April Marc Garneau visited Science North and spent considerable time inspecting the Solar Observatory indoors and outdoors. He saw Sunspots and the Solar Spectrum on the large indoor screen, and was very interested in all the equipment and mechanisms. Members of the Sudbury Astronomy Club including President Fred Boyer and me were thrilled to conversing with an astronaut who had recently flown in space.

In the Summer of 1985 we received Dr. Tom Clark, the director of the McLaughlin Planetarium in Toronto. He was enthusiastic about the excellent displays, and the smooth functioning of the equipment. He reacted with a touch of irony. He had contracted with a US Company to install a much smaller Solar Display, and it didn`t work! He had paid the Company about SIX times the budget for our Solar Observatory Project, and it was in-operative!

VOLUNTEERS AWARDED

Mona Lemay, left, a volunteer coordinator for Science North and Alan Ward, centre, were awarded with a placque by Ken Odaisky in honor of the 3,500 hours of time the pair donated when building the solar observatory at Science North. Both volunteers are also members of the Sudbury Astronomy Club.

45 - Mona Lemay of Science North Recognizing the Volunteer Work of Alan Ward and Ken Odaisky ... Sudbury Star Photo and Caption (1986)

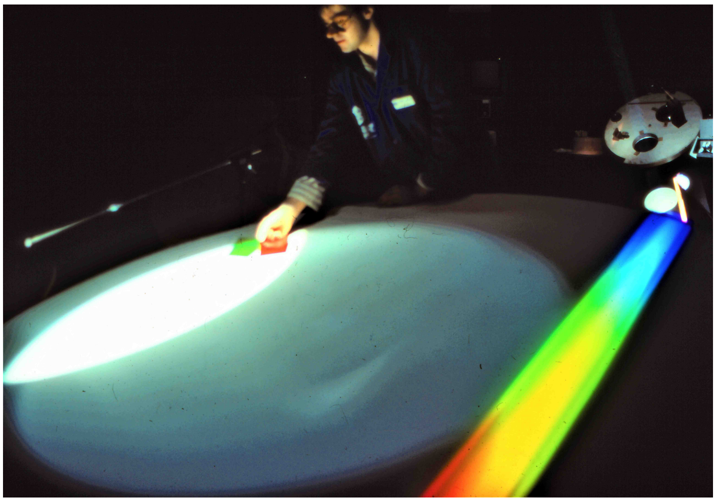
INNOVATIVE SOLAR SPECTRUM DISPLAY

Everyone enjoys seeing a rainbow! The display of ``rainbow-like`` Spectral Colours in the SolarObservatory had unique features beyond being available indoors!

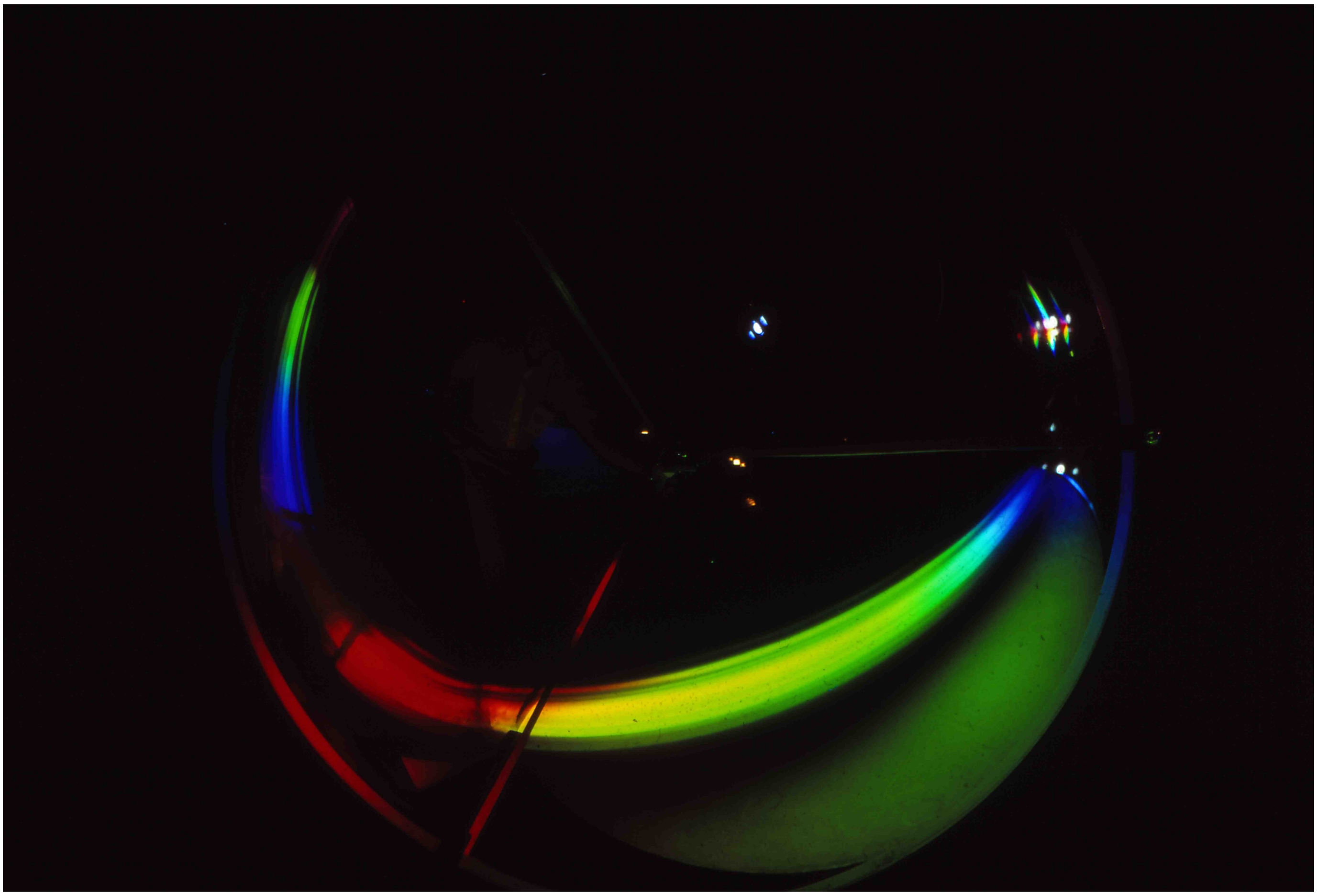
First, it is much brighter while still being spread out over at least 2 meters. Second, it shows fine details (See Illustration 52) and has very vivid colours.

Most Spectrographs use round objectives to collect light, then block most of the light with a narrow slit. Our design avoids this loss of light by collecting the Sunlight with a slit-like Mirror. The Slit Mirror rotates to track the Sun (Illustration 46). The Slit Mirror is flexible, and is tuned to an Off-Axis Parabolic Shape. All of the light collected ends up in the Spectrum Display!

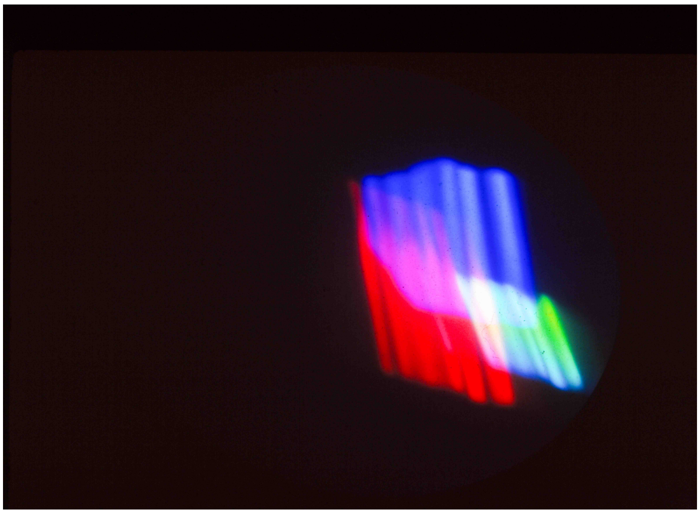
46 - 1228 (left) The Spectrum Heliostat has a 9-inch Drive Gear to track the Sun. The 2-inch wide box tube supporting the Strip Mirror changes tilt during the year to reflect the Sunlight up the Polar Axis as the Sun drifts North or South. Adjusting screws seen below the box tube allow the curve of the Stip Mirror to be tuned to focus the Sunlight (achieving an off-axis parabolic shape).
(Photo taken in May 1987 after the heliostat had been in service for over a year)



47 - 1209 (March 1987, Above) Alan Ward Demonstrating the Solar Image and Spectrum.
48 - 1224 (May 1987, Below) Children Playing with Spectral Colours



49 - (May 1987) Solar Spectrum Display Captured by an All-Sky Camera.



50 - 1390 (Left) Three Children Holding Mirrors Experiment with Spectral Colours

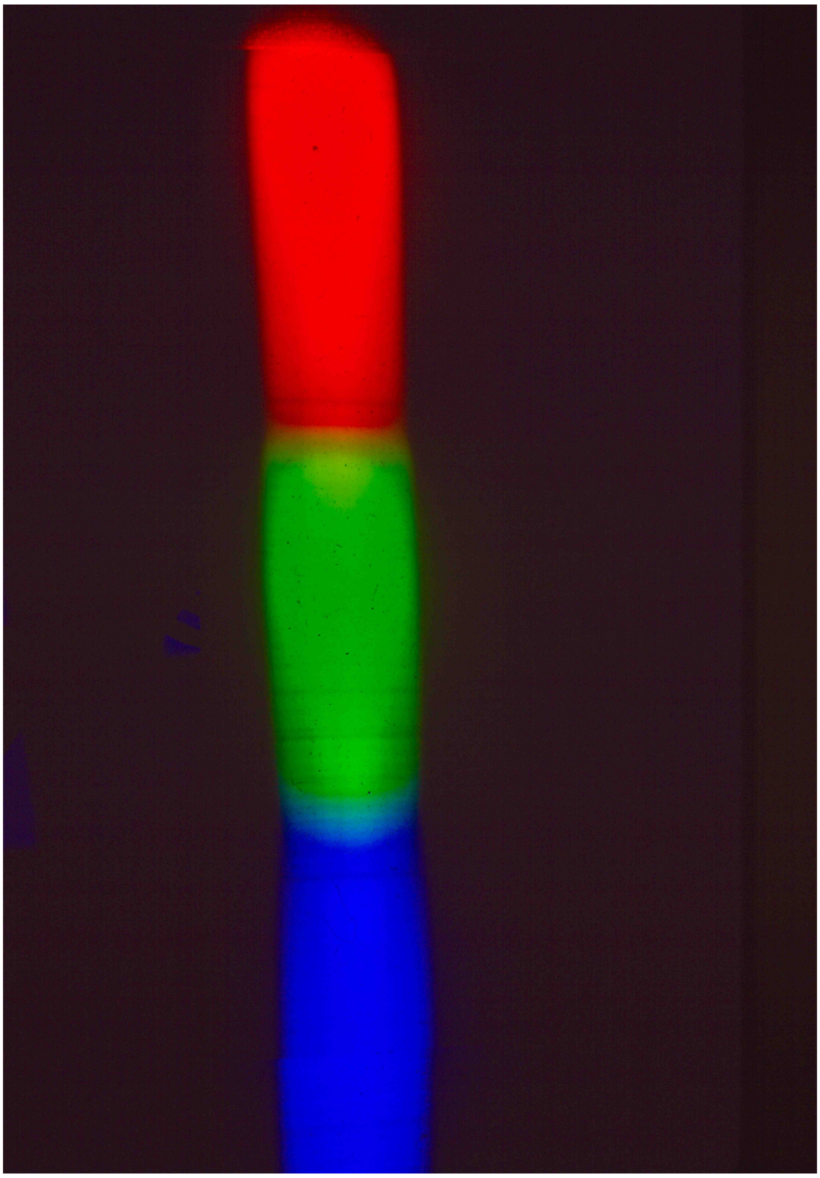
51 - 1227 (Above) New Colours Made by Adding Spectral Colours with Mirrors. Notice where Red and Violet overlap Magenta is produced.

52-1393 (August 1988)

Our Spectrum Heliostat Display Resolves Fraunhoffer Lines!

Note that the Kodak film emulsion layers make the Spectrum appear as three separate colour areas. The dark horizontal Fraunhoffer Lines cross the bottom of the red area and four or more cross the bottom third of the green area.

First studied by Joseph Fraunhofer, these lines originate in the Sun`s atmosphere, where each element in the Sun`s atmosphere reveals its presence by absorbing light of a specific wavelength (colour). The element Helium was discovered in this way in the Sun`s atmosphere before it was known on Earth!



THE HYDROGEN ALPHA TELESCOPE

Sunspots, and other features of the dazzling ``white`` surface of the Sun are fascinating, but if we can strip away all of that flood of light except for the red light of a specific wavelengh emitted by a Hydrogen in thin layer called the Chromosphere, an even more dynamic orb appears!

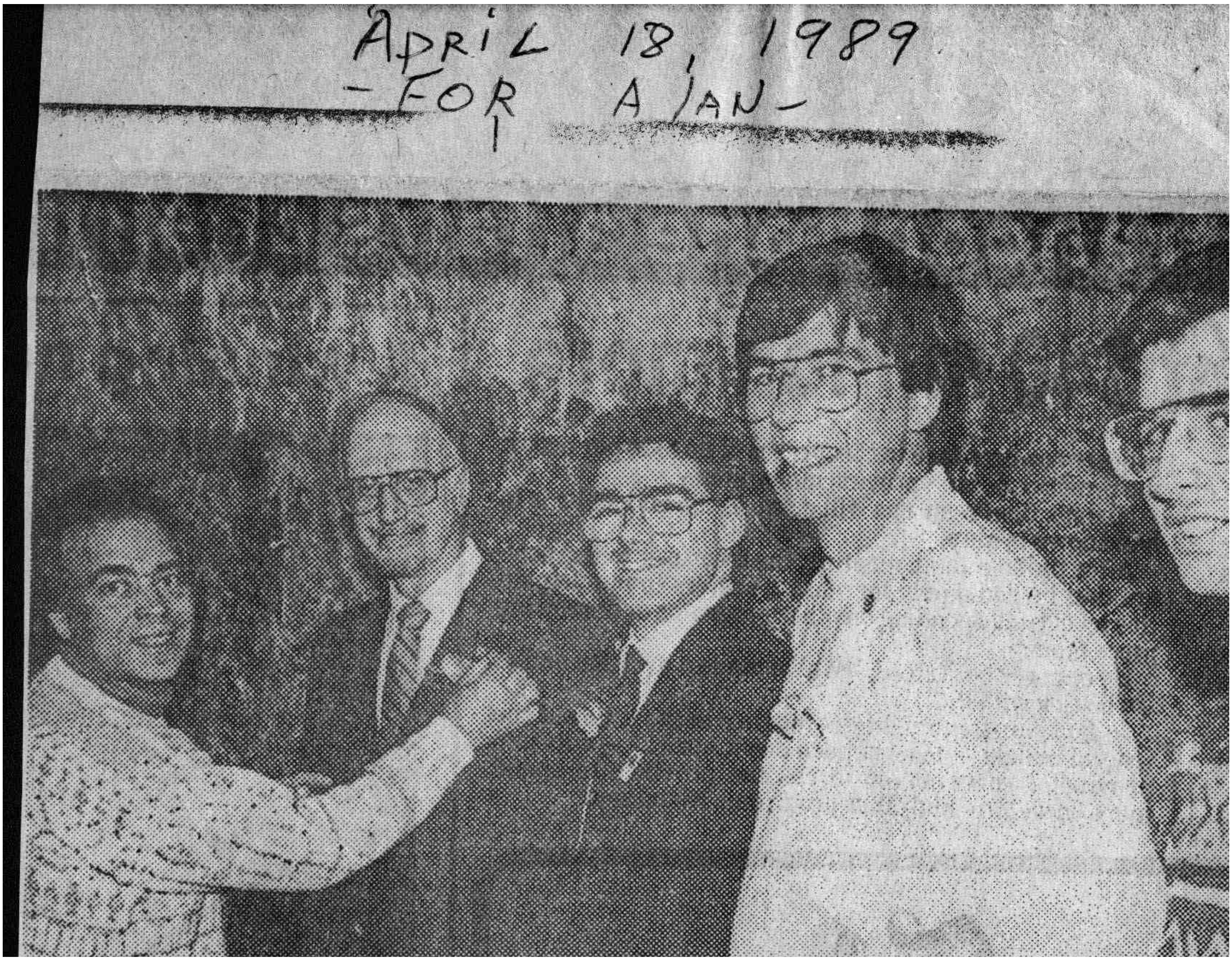
The Chromosphere is a thin skin of hydrogen that sits on top of the brilliant white ``Photoshpere``, and the special red light it emits is called Hydrogen Alpha. The wealth of detail that appears in hydrogen-alpha light is fascinating even if there are no sunspots!

But the real attention getters in hydrogen-alpha light are the fast-changing bright erruptive projections that appear to leap off the edge of the solar disk. These feathery flame-like projections are called solar prominences. They change minute by minute, and sometimes come with solar flares.

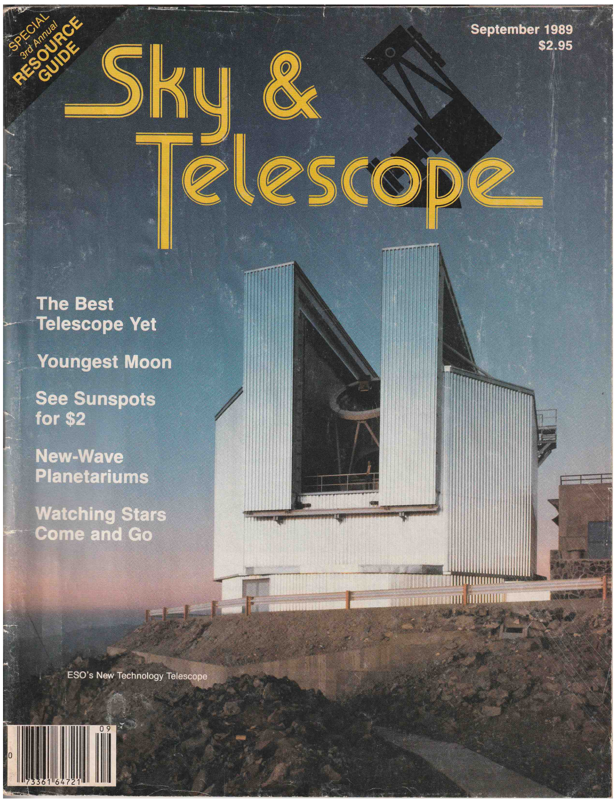
All of these hydrogen alpha features are visible indoors through the special filters and eyepiece of our Hydrogen-aApha Telescope.

53 - 1222 (August 1985) Pierre Harrison is Observing the Sun in Hydrogen-Alpha Light. The eyepiece he is looking into is at the end of a slanted 10-foot-long Telescope Tube that extends downward through one of the Beam tubes to a 4-inch Flat Mirror outside the building. The Drive Gear is just below the oak face plate of the Telescope.

54 - 1455 (February 1989, Below) The Solar Observatory with Three Different Displays of the Sun and its Light! School kids seeing a live dsplay of the Sun`s disk and Spectrum, and seated observer viewing the Sun in Hydrogen Alpha light (volunteer Ted Tuori, to left of disk image. This Photograph was published in Sky & Telescope Magazine.



55 - (April 18,1989) Volunteer Appreciation Night at Science North. Steve Dodson (left) giving a Volunteer Recognition Pins to Ted Tuori, Alan Ward, Harold Healy, and Ed Morris, recognizing the vast amount of skilled volunteer work by many members of the Sudbury Astronomy Club.



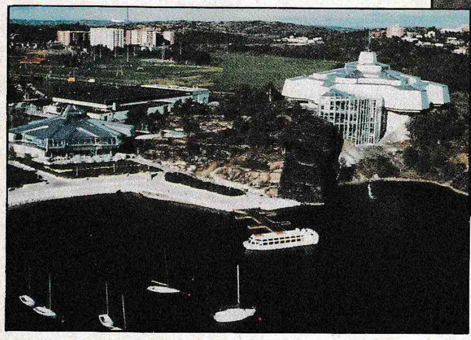
As of August 10,1984, total volunteer time on the job was 1492 hours. Several hundred more hours were contributed before completion. The hundreds of hours of work contributed by <u>Alan Ward and Ken Odaisky</u> cannot realistically be measured. The involvement of some of the other members of the Sudbury Astronomy Club can be approximated as follows:

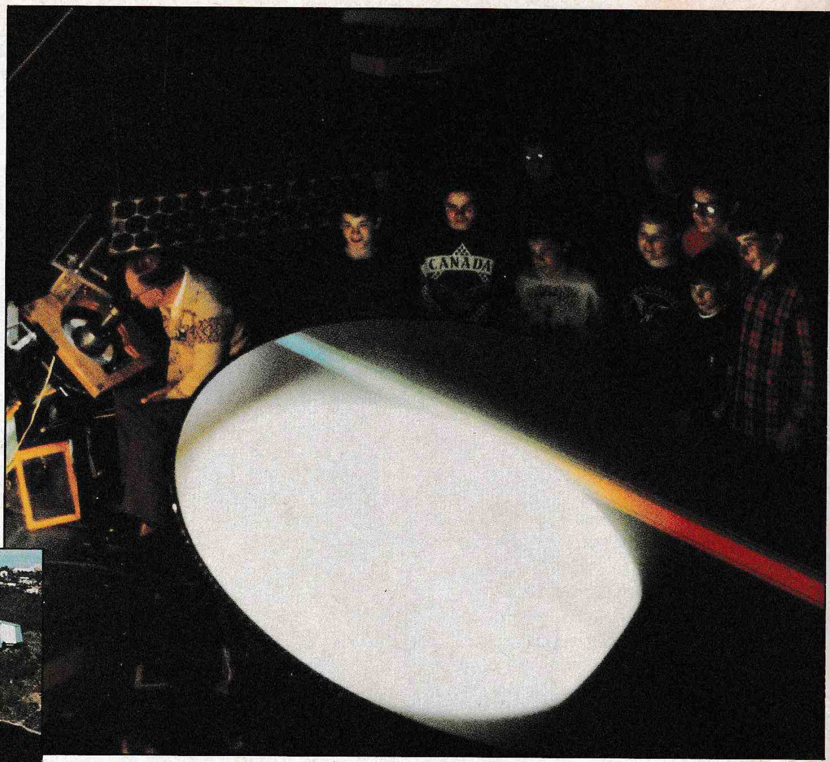
Fred Boyer: 65 hours
Bob O`daiskey:47 hours
Greg Beach: 165 hours
Carl Hoeg: 97 hours
Tin Chee Wu: 135 hours
Gerard Bourque: 95 hours

56 - (September 1989) Cover of the Issue of Sky & Telescope containing publication of the Solar Observatory (Article on the next page)

Florida, recently opened a new 60-foot-diameter star theater. It uses a Jena Spacemaster DP3 projector, the latest incarnation of the familiar "ant" from the German town where the star projector was invented nearly 70 years ago. Unlike many of its predecessors, which could be computerized only by adding extra equipment, the new machine has a computer built in. Two more control some 200 special-effects projectors. They work in concert to provide stunning automated shows that can depict almost every celestial phenomenon imaginable.

Other planetariums have taken computerization a step further. The McDonnell Star Theater in St. Louis, Missouri, Hansen Planetarium in Salt Lake City, Utah, and quite a few others around the world are home to the latest innovation in planetarium technology — the Digistar computer-graphics projection system (*S&T:* December, 1985, page 534).





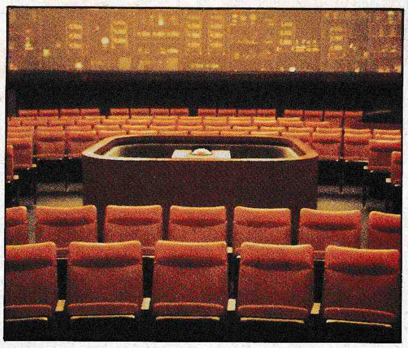
Science North (*left*), recently opened in Sudbury, Ontario, is attracting many visitors with its innovative exhibits and emphasis on hands-on learning. At the facility's Solar Observatory Theater (*above*), young astronomy buffs view a white-light image of the Sun, along with a solar spectrum, relayed from a heliostat mounted outside the building. Courtesy Steve Dodson.

Digistar processes an astronomy data base on a VAX computer and projects selected views onto the dome through a fisheye lens coupled to a video monitor. Rapid manipulation of the data base can result in computer-simulated starship flights through Orion or all around the galaxy.

HANDS-ON ASTRONOMY

As fun as it is to sit back and enjoy the show on the dome overhead, sometimes it's a joy to dig in and get involved. Visitors to the Yokohama Science Center in Japan are presented with an array of interesting activities. After traveling to the stars in the computerized Space and Omnimax Theater, they can peruse five floors of books, videocassettes, videodisks, computer programs, satellite and radio transmitters, television and graphics displays, and classrooms. Every corner is set up with an experiment designed to teach the rudiments of some scientific discipline.

Astronomy buffs visiting Science North in Sudbury, Ontario, find displays and experiments on the nature of light. According to director Steve Dodson, Science North is dedicated to a challenging ideal — that anyone should be able to come in and *do science* at some level. Says Dodson, "It is an open-laboratory concept, with no plexiglass, buttons, or levers intervening between the visitors and the real gear and tools of scientists."



The St. Louis Science Center's McDonnell Star Theater looks different from most planetariums because of the conspicuous absence of a giant ant-shaped projector. Instead it has a Digistar video projection system, which uses a computer and fisheye lens to project star images from a high-intensity video screen to create a variety of effects. Courtesy John G. Wharton.

Among its many fascinating exhibits, Science North features the Solar Observatory Theater, where visitors "play" with sunlight. They do this in a darkened lab, surrounded by live and videotaped displays of the Sun's disk and the solar spectrum. Another popular activity occurs in the center's optical workshop. There people watch demonstrations of optical systems, experiment with lenses, and learn how to build a telescope.

This "up close and personal" approach to teaching and learning astronomy is proving as appealing to visitors as sitting back and watching the wonders of the universe float by on a dome — perhaps even more so. The message planetariums and science centers are enthusiastically sending to the public: *Everyone* can have fun with science.

Carolyn Collins Petersen is a research assistant at the University of Colorado's Laboratory for Atmospheric and Space Physics. Through her company, Loch Ness Productions, she has written planetarium shows in use in more than 300 star theaters worldwide.

57- Sky and Telescope Article pubished in the September 1989 Issue describes Science North and the Solar Observatory.