Optical Sciences Center/College of Optical Sciences 50 years of excellence

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ABSTRACT

Aden B. Meinel established the University of Arizona Optical Sciences Center, now known as the College of Optical Sciences, in 1964 to fulfill a national need for more highly trained engineers and physicists in the optical sciences. Throughout its 50-year history, OSC has grown and evolved in response to industrial demand. It now includes a world-class faculty and an international student body, and its academic programs offer more than 100 graduate and undergraduate courses, an ABET-accredited undergraduate optical sciences and engineering degree program, and outstanding M.S. and Ph.D. graduate programs with extensive distance learning options. Its graduates are in great demand and are employed by national and international governments, businesses and universities. This paper will describe the formation of OSC and its 50 years of excellence.

Keywords: Education, optics, photonics, optical engineering, optical science

1. THE BEGINNING

Aden B. Meinel founded the Optical Sciences Center (OSC) in 1964. Clear, dark desert skies brought him to Arizona in the 1950s to find a location for a national observatory. Kitt Peak, a mountain about 40 miles west of Tucson, was selected, and Meinel became the founding director of Kitt Peak National Observatory in 1958. Meinel left Kitt Peak in 1961 for the University of Arizona, and in 1963 he became head of the department of astronomy and director of Steward Observatory. Meinel was in a good position to start OSC, but what actually triggered the founding?

In the early 1960s many people, especially in Rochester, NY and Boston, felt that academic optics was not covering all the areas of optics. Volunteer groups began formulating recommendations for fixing the situation and submitting the proposals to the board of directors of the Optical Society of America (OSA). [1] In 1962, OSA formed a Needs in Optics Committee [2], which decided the United States needed another optics center in addition to the well-established Institute of Optics at the University of Rochester. Mary Warga from OSA contacted Aden Meinel to get his comments on the need for a second university program for the research and teaching of optics. Meinel, who was involved with both astronomy and space optics, was a strong supporter. He also knew that, because of the Cuban missile crisis and the success of the Corona spy satellite, optical reconnaissance was a top priority for the U.S. government, and financial support might be available for setting up a new university optics center to train Air Force personnel.

Meinel started OSC in Steward Observatory facilities (Figure 2a), and the first optics fabrication facility was off campus (Figure 2b). However, Meinel knew he needed a large building to meet his vision for OSC. Across the street from his office on the University of Arizona campus was a parking lot that he thought would be a great location for the new optics center (Figure 3). He began working on getting funding for what was to become OSC, which was extremely difficult, but when Aden Meinel made up his mind to do something nothing could stop him.

Appendix I describes in Meinel's words what he did to start OSC. In summary, through some very complicated negotiations and good logistical support from the University of Arizona president, Richard Harvill, a consortium of Arizona banks provided a loan to the University of Arizona Foundation to help finance the building; the state legislature appropriated funds to equip the center and establish an academic program; and, with the help of Deputy Undersecretary of the Air Force Harry Davis, Meinel was able to get money from the U.S. Air Force to provide partial support for five years. [3,4] The initial 80,000-square-foot building, now known as the Meinel Building, was completed in 1969 (Figure 6). The completed Optical Sciences Center was dedicated on Jan. 22, 1970, by John McLucas, who would later become Secretary of the Air Force, and Senator Barry Goldwater.

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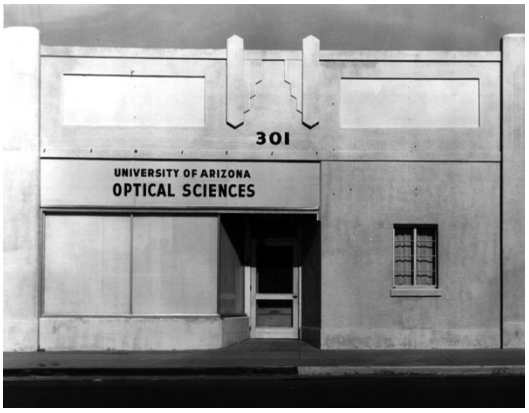
Figure 1. Aden Meinel – Founder of the Optical Sciences Center.

a) Steward Observatory, the University of Arizona.



b) First optics shop – 301 7th Street, Tucson.

Figure 2. OSC's first locations.

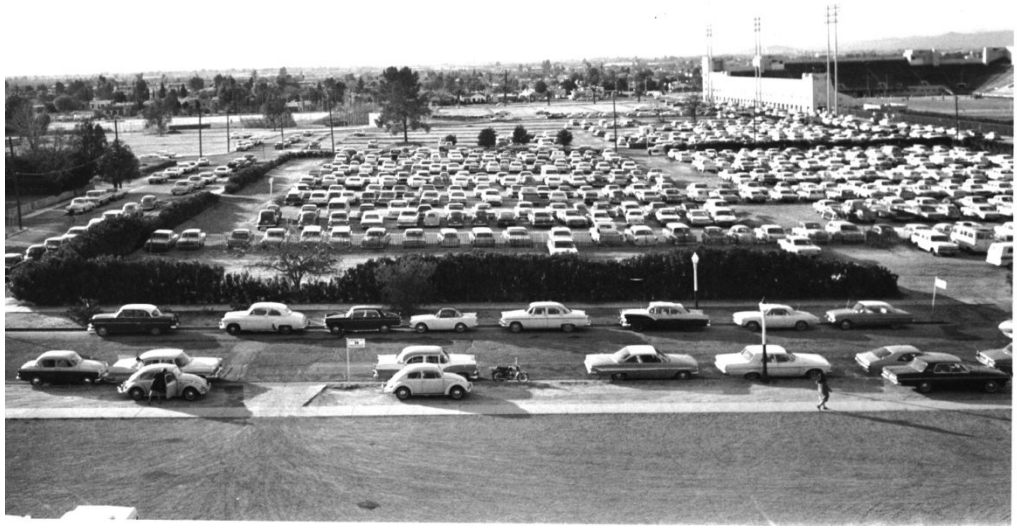


Figure 3. Parking lot at the University of Arizona where OSC was built. Note the football stadium in back.

Figure 4. Group photo of OSC personnel at site where the building would be constructed (1967).

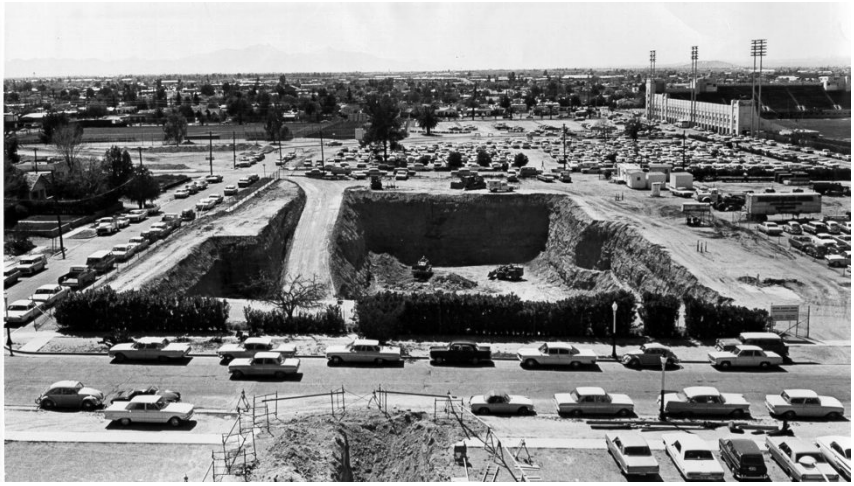


Figure 5. Construction of OSC building (1967).

Figure 6. The first OSC building is completed (1969).

As Meinel stated in his original proposal,

"The [optical sciences] laboratory is designated to fill three purposes: 1) The establishment of a research center for experimental and theoretical optical physics that is responsive to the national needs at the limits of state-of-the-art. 2) The establishment of a strong graduate curriculum in optical physics and technology to produce Ph.D. graduates with a solid theoretical background and a knowledge of technology at an advanced level. 3) The establishment of a center where the emergence of new technology can rapidly be translated into industrial competence through frequent contact with visiting personnel from the optics areas in industry."

2. THE EARLY YEARS (1964-1973)

The building was important, but the people were more important. Word about the center preceded its assurance. Robert H. Noble from Perkin-Elmer, who was especially interested in the academic program, joined Steward Observatory in 1964, followed immediately by Roland V. Shack, who had just returned to Perkin-Elmer from Imperial College in the

United Kingdom. (Shack would become very well-known for his many clever inventions, of which the most famous is the Shack-Hartmann sensor currently widely used in adaptive optics systems.) Stephen F. Jacobs from TRG (Technical Research Group) and Perkin-Elmer was hired in 1965. (Jacobs would have a nearly 50-year career at OSC as the world's expert at measuring the dimensional stability of low expansion materials.) These three appointments were made possible by inclusion of the new optical sciences program in a Science Development Program National Science Foundation grant to the University of Arizona. Because of the 1964 appointments of Noble and Shack, 1964 is taken as the founding year of OSC.

Robert Noble with OSC's first graduate, Jim Mayo (August 1968).

Roland Shack with students (about 1968).

Steve Jacobs with Murray Sargent III (1969).

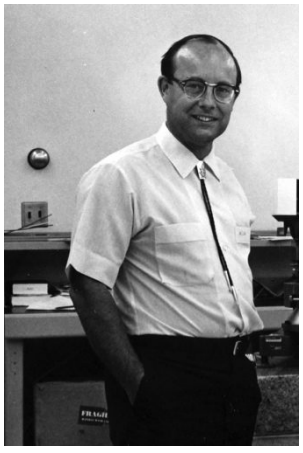
Figure 7. First three faculty hires.

In time it became clear that Meinel was superb in hiring excellent people. His faculty and staff hires worked out extremely well. Meinel had the good fortune to entice Don Loomis, a master optician with whom he had worked at Kitt Peak, to join the group at its inception. Theirs had been, and would continue to be, a very productive partnership. Loomis played a key role in the design of the large 8,000-square-foot (743-square-meter) optics shop and the 100-foot (30-

meter) test tower in the new building. The shop would become essential to many large mirror projects and indeed the entire optical engineering program at OSC. In many ways the optics shop, and the large mirror fabrications that have taken place there, have made OSC unique among the world's optics centers, giving students extremely valuable experience. The shop has seen many projects, but one of particular interest is the Multiple Mirror Telescope (MMT), which shows how unique Aden Meinel was himself.

At one point in the early days of OSC, the optics shop had almost no work. Meinel was afraid he was going to have to fire all the opticians and close it completely. The story told is that one Friday night he went home depressed because he thought he would have to close the shop in the coming week. However, he then remembered a classified spy satellite project that was being canceled, which had seven 1.8-meter-diameter experimental super-lightweight mirror blanks associated with it. So, over that weekend, he designed a multiple-mirror telescope with six primary mirrors (one of the seven blanks could be used as a spare). Up until this time, telescopes had consisted of a single primary mirror, but with Meinel's techniques, the six mirrors in this telescope would act as one much larger mirror. Before you knew it, Meinel had the money to build the MMT, and late one night a short time later a plane landed at Tucson's Davis-Monthan Air Force Base carrying some special cargo. A waiting flatbed truck picked up the precious cargo, and the next morning there were seven 1.8-meter-diameter mirror blanks in the OSC optics shop, and it was once again busy. Not only was Meinel very clever in finding a way to support the shop, but his multiple-mirror primaries technique is now used in almost all large telescopes.

Meinel realized the importance of having faculty with diverse backgrounds and a broad range of optics expertise. In 1966, he hired Philip N. Slater from IIT Research Institute, glass expert Clarence L. Babcock from Owens-Illinois, and a recent University of Rochester graduate, B. Roy Frieden. In 1968, he hired Peter H. Bartels from Ernst Leitz Optical Co., William Swindell from the University of Sheffield (United Kingdom) and a recent Stanford graduate, Jack D. Gaskill. Both Robert R. Shannon from Itek Corp. and William L. Wolfe Jr. from Honeywell joined the faculty in 1969 – in fact, they interviewed for faculty positions the same day. With the encouragement of Steve Jacobs, Meinel brought a powerhouse in quantum optics, Marlan O. Scully, from the Massachusetts Institute of Technology in 1969. (Scully would prove to be key in attracting other top quantum optics personnel, including Nobel laureate Willis E. Lamb Jr. in 1974.) Meinel was a true believer in interdisciplinary research, and the OSC research programs involved a number of faculty from other academic departments from the beginning, including Ralph M. Richard and Allan Malvick in civil engineering, Richard Cromwell in astronomy, and Larry Wheeler in psychology. As contract support developed, James A. Eyer from the University of Rochester joined the faculty as associate director. Bernhard O. Seraphin from the Michelson Laboratory at China Lake was hired in 1970, and Richard L. Shoemaker was hired in 1972.

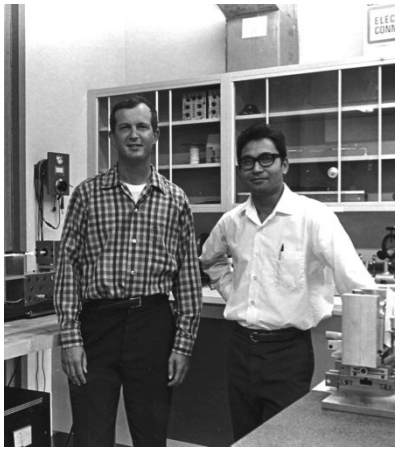


Phil Slater (about 1968).

Roy Frieden (about 1966).

Jack Gaskill (1968).

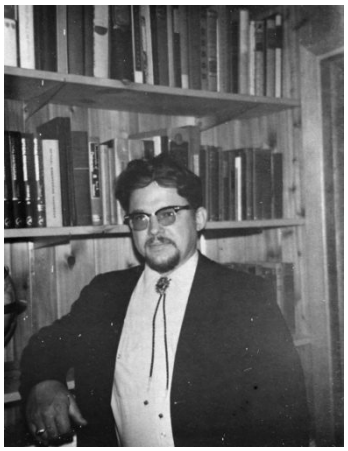
Marlan Scully (1969).



Fred Hopf and Arvind Marathay.

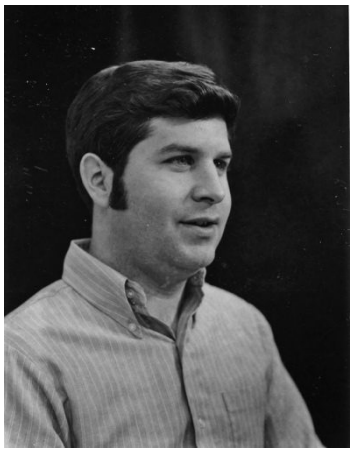
Bob Shannon (1969).

Bill Wolfe (1969).



Jim Eyer.

Francis Turner.



Rick Shoemaker (1972).

Figure 8. Some of the early faculty hires.

Three universities provided 10 of Meinel's early faculty hires. Graduates of the Institute of Optics at the University of Rochester were Jim Eyer, Roy Frieden and Bob Shannon. Marlan Scully, Murray Sargent and Frederic A. Hopf were from Yale, and Roland Shack, Phil Slater, Orestes N. Stavroudis and Arvind Marathay were graduates of Imperial College.

Meinel formed a steering committee comprising Eyer, Noble as director of academic affairs and Slater as assistant director, and the center began accepting students in 1967. The first graduate was an Air Force officer, James W. Mayo, who received an M.S. in optical sciences in 1968. (Mayo has described his experiences as an early OSC student for the College of Optical Sciences website. [5]) Twelve of the center's first 42 graduates were U.S. Air Force officers. The Air Force had a large requirement for personnel with optics expertise, and OSC was able to train the people they needed. The first Ph.D. graduate was Dean McKenney, who received his degree in 1969. His advisor was Arthur Francis Turner, the 1968 OSA president and a pioneer in thin film optics who had been recruited from Bausch and Lomb.

OSA held its spring meeting in Tucson in April 1971, and it was the first chance that many members of the optics community had to visit OSC. It was a great coming-out party. The building was new and magnificent. The faculty, staff and students were so excited about what they were doing. The University of Arizona campus looked fantastic. The optics community from all around the world came away very impressed with the center Meinel had put together.

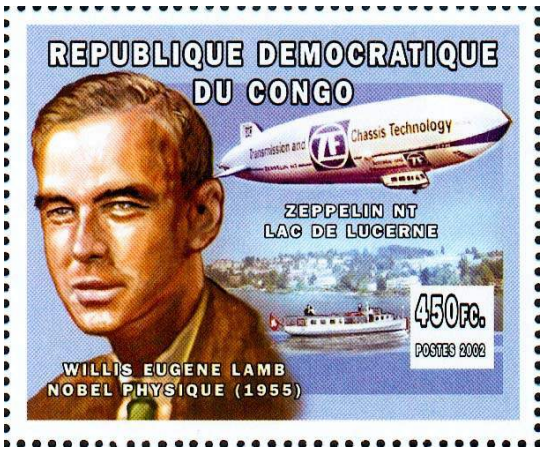
3. THE FRANKEN YEARS (1973-1983)

By 1973 Aden Meinel felt it was time to turn the leadership over to someone else. Peter A. Franken from the University of Michigan was selected to become the second director of OSC. Franken brought with him many of the excellent academic practices he had learned at Michigan. He realized that many of the students were not graduating. They were having a lot of fun, working more like staff and earning high salaries for graduate students. So he formed an exit committee that solved the problem by reducing a student's salary if he or she did not graduate within an allotted time! Jack Gaskill became the director of academic programs, and he did a superb job of recruiting students and providing them with the support they needed. Franken also hired Floyd Lance as business manager and a retired Air Force colonel, Don Hillman, as program manager. Phil Slater was made associate director. (He would remain in this position until becoming chair of the University interdisciplinary graduate program on remote sensing and spatial analysis.) Another important staff hire during Franken's time was Bobbie Doss, who worked in human resources and personnel roles at OSC until 2013.

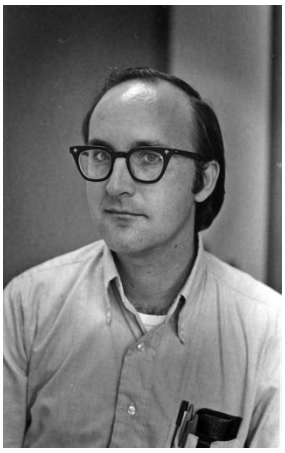
Even though the "big" initial Air Force contract ended during Franken's years as director, it was a time of wonderful growth for the center. Before coming to Arizona, Franken had spent some time in Washington, D.C., as acting director of the U.S. Advanced Research Projects Agency (now called DARPA), and his Washington contacts helped him put together a Joint Services Optics Program that provided OSC with financial support from the Army and Air Force for more than 20 years. OSC also augmented its lab and office space by obtaining rooms in other buildings, including an 8,000-square-foot building on the edge of the University campus.

Figure 9. Peter Franken – Director 1973-1983.

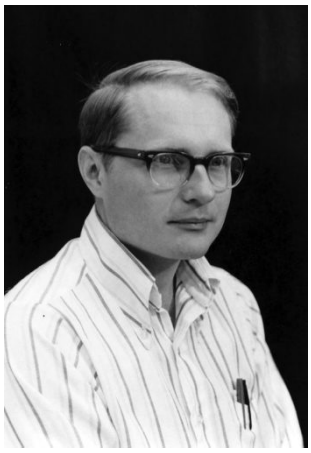
Franken hired many faculty, including Nobel laureate Willis Lamb, Harrison H. Barrett and James C. Wyant in 1974; Eustace L. Dereniak and H. Angus Macleod in 1978; Hyatt M. Gibbs, Dror Sarid and George Stegeman in 1980; and Ursula Gibson and Charles M. Falco in 1982. James J. Burke, who had been a research associate for many years, was made a tenured professor in 1982. Robert E. Parks was hired to be the optics shop manager.



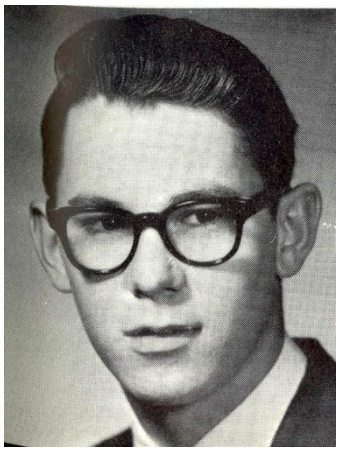
Nobel laureate Willis Lamb.



Harry Barrett.

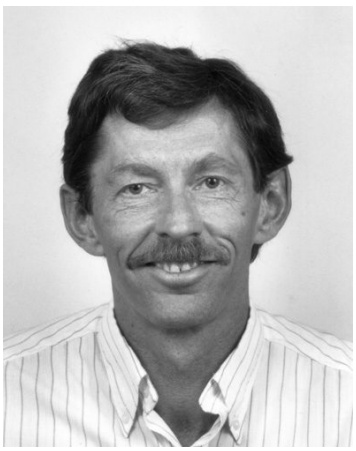


Jim Wyant.



Eustace Dereniak.

Angus Macleod with Floyd Lance.



Hyatt Gibbs.

Dror Sarid.

Charlie Falco.

Bob Parks.

Figure 10. Some of the faculty and staff hired while Peter Franken was director.

Bringing Willis Lamb to the faculty was a very big turning point in OSC's history. For many years, until Nicolaas Bloembergen came to OSC in 2001, Willis was the only Nobel laureate at an Arizona university, and his being here greatly improved the center's stature.

Harry Barrett was another key hire. OSC had been connected to the UA College of Medicine through joint faculty member Sol Nudelman, but Barrett's joint appointment with the department of radiology greatly strengthened OSC's tie with the medical college. This relationship has remained very strong and very important.

OSC offered key contributions to NASA's Pioneer missions. Bill Swindell, Roy Frieden, Ralph Baker and others received several honors for their work processing imagery received from the imaging photopolarimeters on the Pioneer 10 and 11 (originally designated Pioneer F and G) space probes to Jupiter and Saturn. Bill Wolfe, Arthur G. (Jerry) DeBell and James M. Palmer designed and built the solar-flux radiometer for the Pioneer 13 Venus mission. Their device provided data that distinguished between the different types of atmospheric models that had been proposed to explain the high surface temperatures on Venus.

It was a very fun time at OSC. Peter Franken was very good at entertaining, and there were many wonderful parties at his house. He brought the faculty, staff and students together so everyone felt that OSC was one big happy family. The

center's social activities included an annual race of more than eight miles around the Saguaro Monument Loop road. There were many side bets concerning this race, and the author of this article learned he should never get involved with a bet with Jack Gaskill. Even if the bet appeared to be a sure thing, Jack always had something up his sleeve, and the "legal" agreements he put together always favored him in some devious way. Franken and Gaskill were always trying to outwit one another, and when they were on the same side, anyone betting against them was sure to lose. Some of these exploits and adventures are described in the Light Moments column on the OSC website [6].

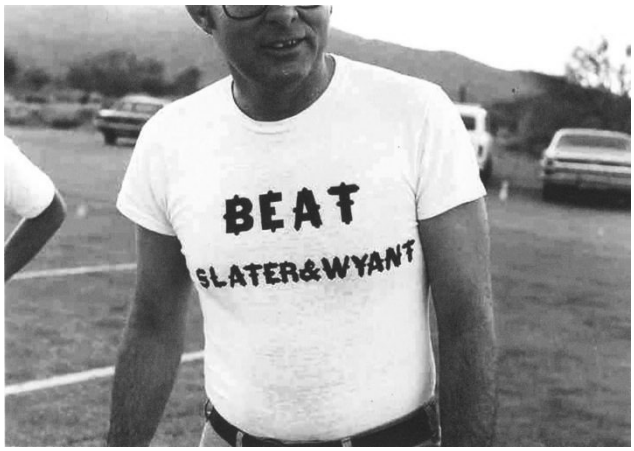


Figure 11. Jack Gaskill and the day of the big race in 1977 (never make a bet with Gaskill!!).

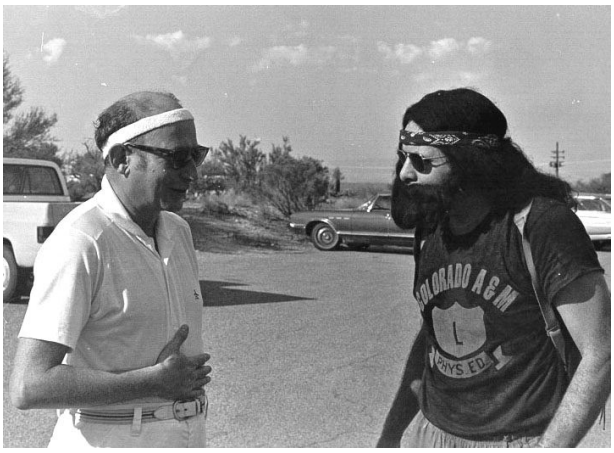


Figure 12. Peter Franken and Jack Gaskill (in disguise) trying to outwit one another (1974).

4. THE SHANNON YEARS (1983-1992)

In 1983, Peter Franken decided to pursue other interests. For a period of about six months, while OSC was looking for his replacement, Harry Barrett served as interim director. Bob Shannon, who had joined the faculty in 1969, became the permanent director.

Shannon and Jack Gaskill started a still-thriving Industrial Affiliates program to get optics companies more involved in supporting the center's academic programs. As Industrial Affiliates, the businesses get to know OSC students and give input in the direction of academics. Some companies also funded research projects at OSC. A state decision package was obtained to establish the Optical Data Storage Center, and Jim Burke was appointed its first director. The decision package provided funding to hire Masud Mansuripur, an expert in optical data storage who currently holds the Chair of

Optical Data Storage. There were many companies, both in the U.S. and outside the U.S., interested in optical data storage, and a large amount of industrial financial support was obtained. The Optical Data Storage Center continued for more than 20 years. Another program started during this time that involved many industrial partners and lasted for approximately 20 years was the NSF-funded Optical Circuitry Cooperative. Hyatt Gibbs was the initial director, and later Nasser Peyghambarian became the director.

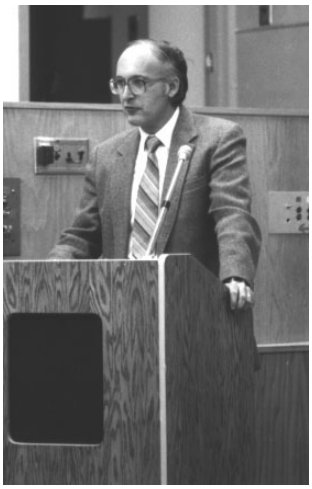


Figure 13. Harry Barrett – Interim Director 1983.

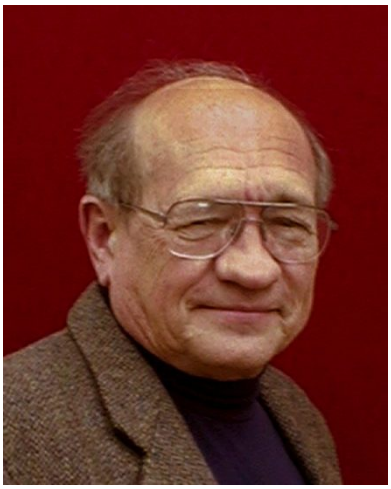


Figure 14. Bob Shannon – Director 1983-1992.

OSC had grown a lot since the initial building had been finished in 1969, and Shannon was able to convince the University to build a 30,000-square-foot (2,800-square-meter) addition on the east side of the original building. This addition, which was completed in 1988, is now known as the east wing. Even the new building addition was not enough space, and 5,000 square feet (465 square meters) of laboratory in the McKale Center was obtained. OSC kept this space in McKale until July 2014.

Figure 15. East wing construction (1988).

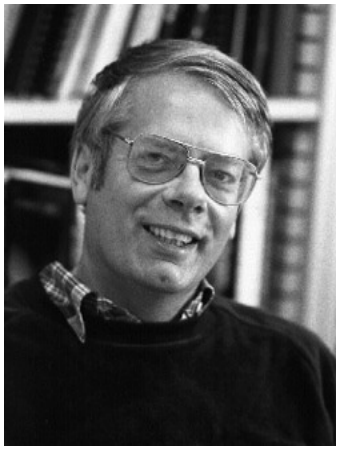
OSC had only a graduate program where the degree was an M.S. or Ph.D. in optical sciences, and industry wanted to hire B.S. optics graduates as well. Bob Shannon and the associate director of academic affairs, Jack Gaskill, were able to

obtain a decision package from the state of Arizona to fund an undergraduate optics program to start in the fall of 1989. At that time Optical Sciences was a center, and not a college, so it could not award a bachelor's degree. An agreement was worked out between OSC and the electrical engineering department for a joint program in optical sciences and engineering, and the degree was awarded by the College of Engineering.

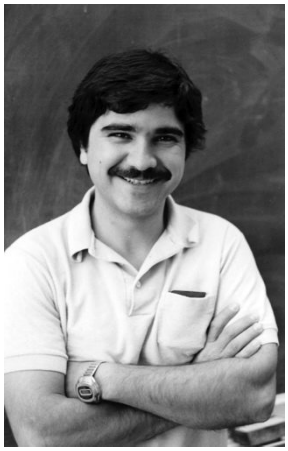
During Shannon's time as director, the tradition of a yearbook was initiated. The yearbook contained pictures of faculty, staff and students. Each year a new photo of OSC personnel was taken, and that picture was put on the front cover. The personnel turned around and a second photo was taken, and this second photo was put on the back of the yearbook. These yearbooks are now prized processions and extremely useful if you have to write a 50-year history of OSC.

There were many faculty hires during Shannon's directorship, including Nasser Peyghambarian, Pierre Meystre and Jerome V. Moloney (joint with mathematics) in 1985; George Lawrence in 1986; Arthur Gmitro (joint with radiology) in 1987; Masud Mansuripur in 1988; Tom D. Milster in 1989; Ewan M. Wright in 1990; John E. Greivenkamp and Katherine Creath in 1991; and Galina Khitrova in 1992. In addition, J. Roger P. Angel from the astronomy department was given a joint appointment in 1984. Angel has been the world's leader in developing new technologies for making telescopes mirrors, and in many ways he has had a career similar to Aden Meinel's.

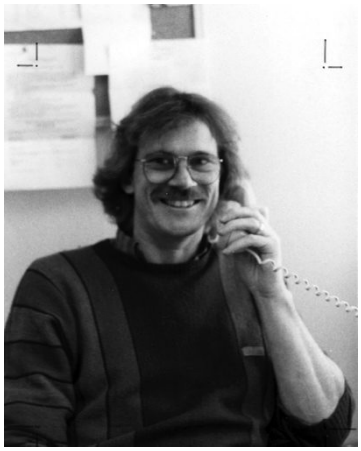
In 1992 Bob Shannon decided it was time to retire as director.



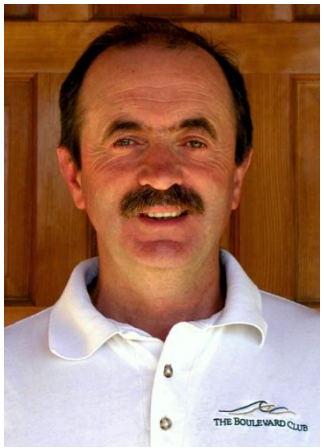
Roger Angel.



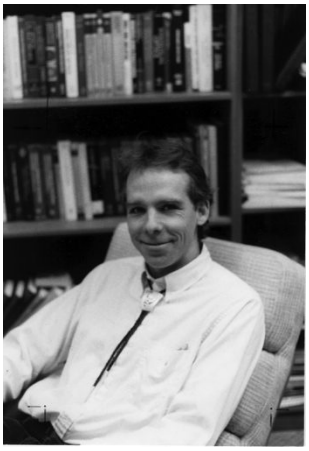
Nasser Peyghambarian.



Pierre Meystre.



Jerry Moloney.

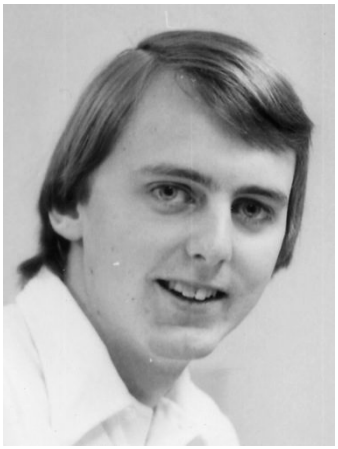


Art Gmitro.

Masud Mansuripur.

Tom Milster.

Ewan Wright.



John Greivenkamp.

Kathy Creath.

Galina Khitrova.

Figure 16. Some of the faculty hired while Bob Shannon was director.

5. THE POWELL YEARS (1992-1998)

A national search for a new director was performed and Richard C. Powell, who had been running the Center for Laser Research at Oklahoma State University, was selected.

During Powell's time as director, OSC experienced some severe financial times, but he was able to work out an arrangement with the University that was probably the most important deal in the history of OSC, with the exception of the one leading to its founding. Powell attempted to get more state funding, but none was available, so he negotiated with the University to give OSC additional overhead return. This was not "guaranteed" funding like state funding, but it rewarded the center if it received additional grants and contracts. The faculty responded very well to this challenge, and the financial situation quickly improved.

OSC had always had a model that included very little financial support from the University. While this sounds negative, it has turned out to be very positive. Not having support from the University has forced faculty members to be entrepreneurial to support themselves, and this entrepreneurial spirit is a fundamental characteristic that carries over to many OSC graduates. It was also extremely important that, right from the beginning, OSC reported directly to the provost. This has been very important for our freedom and probably kept OSC from becoming part of another college.

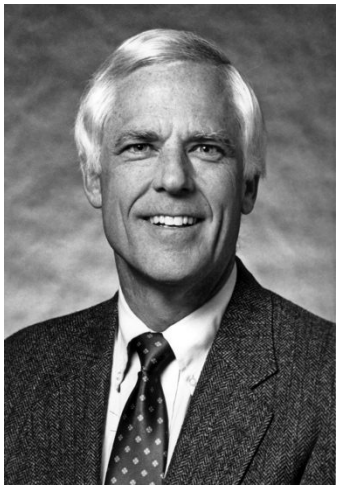


Figure 17. Dick Powell – Director 1992-1998.

The optics industry in Arizona, especially in Tucson, was growing. When OSC formed in the late 1960s, very few businesses in the state based their income on optical technology. In 1979, graduate Robert P. Breault started OSC's first spinoff company, Breault Research Organization. By 1992, there were over 80 optics companies in Arizona, and the optics industry revenue in Tucson alone was over $100 million per year. Business Week recognized the importance of this in the lead story of their November 1992 issue, which designated Tucson "Optics Valley." OSC faculty or graduates founded many of the optics companies in Tucson, and other businesses moved to Tucson because of OSC's reputation. The Optical Sciences Center was doing so well, and Aden Meinel had done such a fantastic job in getting the center started, that it was decided that Meinel should be honored by having the OSC building named after him. The ceremony for the dedication of the Meinel Optical Sciences Building was held on Oct. 28, 1993.

Figure 18. Dedication of the Meinel Optical Sciences Building (1993).

Through much work, Dick Powell was able to get optics selected as one of the Arizona economic development clusters, enabling further financial support through Proposition 301 and the Technology Research Initiative Fund (TRIF). Many OSC faculty hires during the 2000-2012 timeframe were made possible by TRIF. On the national level, Powell helped

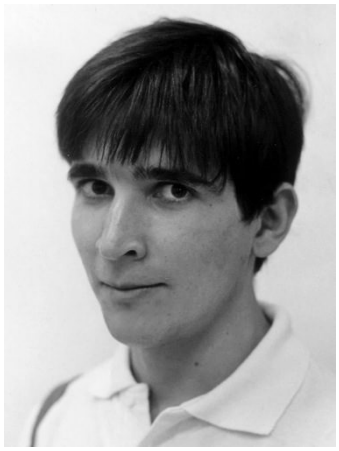
get DARPA to initiate the Precision Conformal Optics Technology program, which was led by Bob Shannon and John Greivenkamp at OSC.

There were many excellent hires during Powell's directorship, including Poul Jessen in 1993; Rolf Binder in 1994; Michael Descour, Mahmoud Fallahi and José Sasián in 1995; and Jim H. Burge in 1997. Glenn Sincerbox, who had a great career at IBM, was hired in 1995 to become the director of the Optical Data Storage Center when Jim Burke retired. Rick Shoemaker, who had been a faculty member since 1972, became the new associate director of academic programs. At the end of December 1998, Powell was appointed vice president of research for the University of Arizona. In this position he could still help OSC.

Poul Jessen.

Rolf Binder.

Mahmoud Fallahi.



José Sasián.

Jim Burge.

Figure 19. Some of the faculty hired while Dick Powell was director.

6. THE WYANT YEARS (1999-2012)

After a very short search, Jim Wyant became the new director on Jan. 1, 1999. Wyant had been on the faculty since 1974, but he had gone to 20 percent time from 1984 through 1997 while he ran the spinoff company WYKO.

Figure 20. Jim Wyant – Director 1999-2005, Dean 2005-2012.

The next 13 years saw good growth for OSC. While the state budget was cut 11 times, for a total cut of more than one-third, contracts and grants multiplied several times over, so the deal Dick Powell had made for more overhead return, instead of more state funding, worked out extremely well. This, plus the TRIF money provided by the state, made it possible to increase the number of faculty and nearly triple the number of students. The distance learning program was greatly expanded, and OSC built two new video-enabled classrooms so lectures could be streamed over the Internet. This enabled industrial workers around the world to take the same classes as local students and obtain either a certificate in optical sciences, if five courses were completed with a B or better, or an M.S. degree, if they completed the same requirements as on-campus students. The undergraduate program was made joint with the entire College of Engineering, instead of just the electrical engineering department, so undergraduates could now major in optics with a minor track in optomechanics, optical materials or optoelectronics. The program also became ABET-accredited. OSC graduate Michael Nofziger was hired to help with the undergraduate teaching labs and to work as outreach coordinator. He has proven to be very effective in recruiting undergraduate students, and in 2011 he was promoted to professor.

Figure 21. Mike Nofziger, outreach coordinator and professor.

Nasser Peyghambarian, who had led a large, well-funded research program for many years, wanted to have a National Science Foundation Engineering Research Center. Like with Aden Meinel, when Nasser decides to do something,

nothing stops him. Peyghambarian succeeded in 2008, and OSC was awarded a five-year $18.5 million NSF ERC for Integrated Access Networks. This ERC was later changed to ten years and $40M.

When faculty teach distance learning courses, they receive discretionary income that they can spend on items such as computers or conference attendance. John Greivenkamp loves antique optical devices, so he decided he wanted to spend his distance learning income to buy antique optics. Through some very careful Internet purchasing techniques, Greivenkamp obtained a fantastic collection of antique and historic telescopes, microscopes, lenses and cameras. He put many of the items on display in the Meinel Building, and thanks to his hard work, the Museum of Optics was dedicated on April 5, 2011. People from around the world visit the museum, and photographs of some items are available online at www.optics.arizona.edu/museum/.

It became clear that OSC needed more space. The center put forward a proposal showing that, if additional research space were made available, the overhead income associated with additional grants and contracts would pay for the building. The plan was very ambitious, and few believed in it, but Dick Powell helped OSC convince the University administration to pay the entire cost of an additional 47,000-square-foot (4,400-square-meter) building, now called the west wing. The increased funding that ensued amazed almost everyone, and the results far exceeded the ambitious plan. The Optical Sciences Center grew enough in size and stature that in 2005 it became the College of Optical Sciences, and Jim Wyant became its first dean.

Figure 22. The Meinel Building (2006).

During the early years, the optics shop was extremely busy and the pride of OSC. Somehow over the years the optics shop became less busy and at times it was a financial burden. An OSC B.S. graduate, Marty Valente, became shop manager in 1994, and while there were faculty interested in the optics shop, none were passionate about it. OSC PhD graduate, Jim Burge, was made a faculty member in 1997, and while he was interested in the optics shop, he was much more involved with Steward Observatory than with OSC. Jim's office was moved from Steward Observatory to the Meinel Building and he was given lab space next to the optics shop and over night Jim and Marty had the optics shop humming again better than ever. The two became a fantastic team, and the shop's activity grew tremendously.

Their partnership brought many great projects to the optics shop. One favorite was the fabrication of the 4.3-meter-diameter primary mirror for the Lowell Observatory's Discovery Channel Telescope shown in Figure 24. [7] A second project, of much interest because of the extreme technical difficulty involved and the superb results obtained, was the fabrication and testing of 1.4-meter-diameter convex off-axis aspherics with up to 300-micrometer aspheric departure. These aspherics were finished using a new method of computer-controlled polishing, and they were measured with two new optical tests: the Swingarm Optical coordinate measuring machine (SOC) and a Fizeau interferometer using a

spherical reference surface and CGH correction, as described in the literature. [8] The optics shop is once again a great showplace and resource for OSC.

Figure 23. Marty Valente, optics shop manager.

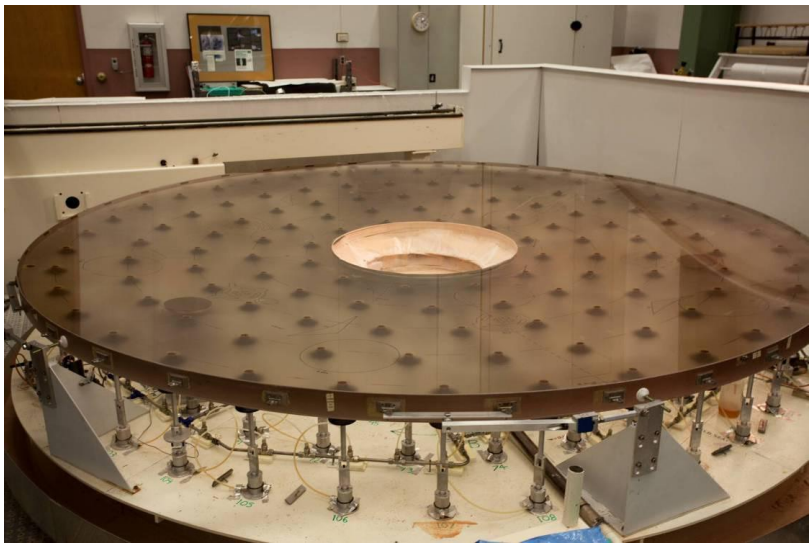


Figure 24. The 4.3-meter-diameter primary mirror for the Discovery Channel Telescope.

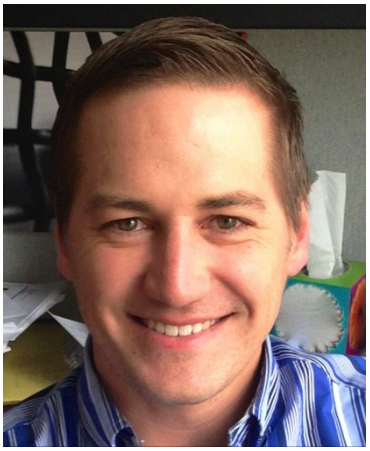
Faculty hired during Wyant's leadership include Nobel laureate Nicolaas Bloembergen, Brian P. Anderson and Grover Swartzlander in 2001; Russell A. Chipman, Franko Kueppers and Matthew A. Kupinski in 2002; Hong Hua in 2004; Stanley Pau in 2005; J. Scott Tyo in 2006; R. Jason Jones in 2007; Robert A. Norwood and Leilei Peng in 2009; Jim Schwiegerling and Miroslav Kolesik in 2010; and Yuzuru Takashima, Milorad Cvijetic, Rongguang Liang and Amit Ashok in 2011. Many joint and adjunct faculty were also added to increase the effective size of the college. Several of these joint professors teach and mentor OSC students and serve on committees as if OSC were their home department, even though the college supplies little, if any, of their salary. Three key joint appointments made during this time were Lars R. Furenlid and Eric W. Clarkson in radiology and Olivier Guyon in astronomy. OSC also obtained its third Nobel laureate in 2005, when adjunct professor Roy J. Glauber was awarded the Nobel Prize in Physics.

In 2007, when Rick Shoemaker retired, Ph.D. graduate Carl F. Maes, who had taught at the Air Force Academy and the University of Arizona physics department, became the new associate dean for academic programs. Patent licensing specialist Amy Phillips was added to the staff to increase the number of patents generated by the college. As a result, approximately half of the patents filed at the University of Arizona are optics-related, with OSC personnel generating approximately half of the University's patent income. Since charitable donations have become so important to universities, OSC also hired a director of development, Kaye Rowan, to work full-time to increase both giving and the number of Industrial Affiliates program members.

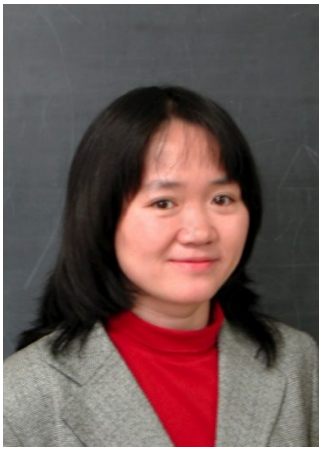
Nobel laureate Nico Bloembergen with UA President Peter Likins and Nobel laureate Willis Lamb.

Brian Anderson.

Russell Chipman.



Matt Kupinski.



Hong Hua.

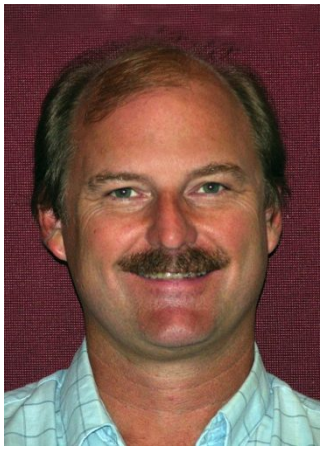
Stanley Pau.

Scott Tyo.

Jason Jones.

Bob Norwood.

Leilei Peng.



Lars Furenlid.

Eric Clarkson.

Olivier Guyon.
(Photo courtesy of the MacArthur Foundation)

Jim Schwiegerling.

Miroslav Kolesik.

Yuzuru Takashima.

Milorad Cvijetic.

Ron Liang.

Amit Ashok.

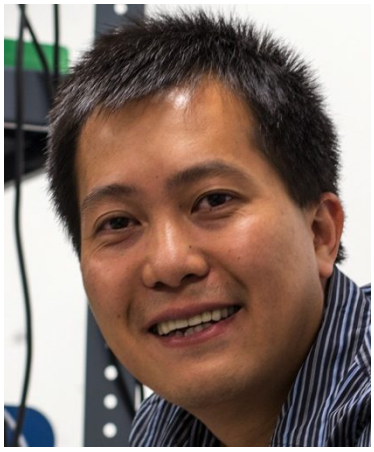
Figure 25. Some of the faculty hired while Jim Wyant was director and dean.

7. THE KOCH YEARS (2012-PRESENT)

In 2010, Jim Wyant decided he wanted to retire as dean, but he remained in the position until 2012, when Thomas L. Koch was hired. Koch came with great academic and industrial credentials. He has degrees in physics from Princeton and the California Institute of Technology. He worked in industry in various roles at Bell Labs, SDL, Lucent and Agere, and in academia as professor and director of the Center for Optical Technologies at Lehigh University.

Figure 26. Tom Koch – Dean 2012-present.

Shortly after Koch became dean, Khanh Kieu, a 2007 graduate of OSC, was appointed an assistant professor in the photonics specialty. R. John Koshel, who had been teaching part-time at the college for several years, was appointed associate dean for academic programs. Development efforts have been enhanced – there has been a major push to increase the number of scholarships for first-year graduate students, and in the last year 20 new scholarships endowed at a level of at least $500,000 each have been added. Tom Koch's tenure as dean has just started, and the future looks excellent.



Khanh Kieu.

John Koshel.

Figure 27. Initial faculty hires since Tom Koch became dean.

8. OSC AT 50

Unfortunately, Aden Meinel passed away on Oct. 2, 2011, at the age of 88, but if he were still alive he would be very proud of the OSC he started in 1964.

The mission of the College of Optical Sciences is to provide an internationally pre-eminent program in education, research and outreach in all aspects of the science and application of light. It has become the largest optics education and research program in the U.S., offering more than 100 courses and enrolling more than 150 undergraduate students and

300 graduate students, with approximately 100 graduate students in the distance learning program. More than 2,400 degrees have been awarded, including nearly 700 Ph.D., 1,200 M.S., and 500 B.S. degrees – the last from an undergraduate program that produced its first graduates only about 20 years ago. The Meinel Building consists of the original 80,000-square-foot (7,400-square-meter) section constructed in 1969, the 30,000-square-foot (2,800-square-meter) east wing built in 1988 and the 47,000-square-foot (4,400-square-meter) west wing completed in 2006.

National and international honors and awards earned by current and past faculty include the following:

Nobel Prizes – 3

National Medals of Science – 2

Kavli Prizes – 1

MacArthur Genius Grants – 2

National Academy of Engineering Memberships – 6

National Academy of Science Memberships – 3

American Academy of Arts and Sciences Memberships – 1

Professional Society Fellowships – 116

Professional Society Major Awards – 65

Professional Society Presidentships – 16

Editorships of Major Professional Journals – 6

Approximately half of the patents filed by the University of Arizona each year come from OSC, as do the majority of UA's successful spinoff companies. (It is difficult to determine the exact number of OSC's spinoff companies, but one estimate gives at least 32 first-generation spinoffs by faculty, students and alumni, and at least 11 second-generation spinoffs from the spinoffs. There is a good chance number is much too small.)

This list of accolades could go on, but we cannot relax. To remain the top optics education and research program in the world, we must continue to recruit the best faculty, students and staff in the world, and we must provide an environment for them to be productive. We must increase our financial support for students and improve our equipment and space. We must continue to expand the primary numbers (revenue, number of faculty, number of students, number of graduates, patents, spinoffs, papers published …). There can be no reduction in the quality of anything.

This is truly the age of optics; optics is the enabling technology for so many critical advances. And as long as bright young people decide to study and work in the field, optics and the College of Optical Sciences will have a great future.

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Appendix I

PERSONAL RECOLLECTIONS OF THE FIRST DECADE

Aden B. Meinel

1975 marks the end of the decade since the formation of the Optical Sciences Center. In looking back to the beginning, the existence of the Center seems logical and inevitable. Yet in reality its prognosis was clouded and its birth difficult. That it actually happened was due to the combined and persistent efforts of many friends of the Center.

The need for an Optical Sciences Center was recognized in discussions of the Needs in Optics Committee of the Optical Society of America. I first became involved by a confluence of events. The first event was an unscheduled visit to my office in Steward Observatory by Ralph Zirkind of the DOD Advanced Research Projects Agency, who was attending a meeting of the American Physical Society on campus. He asked if I would be interested in ARPA funding of a precision large mirror study program. Because my colleagues and I were in the early planning stage for an office and laboratory addition at the Observatory, and having attended a RAND-sponsored meeting on a related topic, we agreed to add this work to the Steward Observatory expansion plans. The second event was a call from Mary Warga from the Optical Society of America office in Washington telling me about their committee. She noted that I had just completed heading the establishment of a new facility — Kitt Peak National Observatory — so would I be interested in commenting on the need for a second university center for optical teaching and research? I agreed to the task.

My report on the need for a new center was well received, but no sponsor was apparent, optics being one field of science outside the sphere of interest of the National Science Foundation. Roderic Scott and Robert Hopkins helped to stir the nascent idea and suggested that the Department of Defense might be the proper sponsor. In the meantime I had become involved in the rapid growth of interest in space optical developments. Associations with the Office of the Secretary of the Air Force and a committee for John McCone headed by James Eyer opened new avenues. It was becoming apparent that a new center indeed was timely. The problem was how to create the center, especially since the scene in Washington had turned adverse to new brick and mortar projects.

Individual events at this point become hard to identify specifically because many friends became interested in supporting the idea of the Center. Two meetings in Richard Perkin's and Roderic Scott's offices at Perkin-Elmer, a visit to Tucson by Robert Hopkins, and a meeting in Dow Smith's office at Itek were important in planning how to proceed. I then had the key discussion with Brockway McMillan, Harry Davis, and Eugene Fubini about making a proposal to the USAF for the Optical Sciences Center. Harry Davis was particularly enthusiastic and agreed his office would endorse the proposal and see if it could be implemented.

With the general idea established, practical problems then came into focus. It was first determined that, indeed, no building funds could be obtained from the Air Force budget. The first of two meetings between Harry Davis and Dan Anderson for the USAF and key Congressional leaders, meeting in the late Senator Hayden's office with Barry Goldwater, an enthusiastic booster from the start, brought forth that Congress would look favorably on a maximum effort to find an avenue to allow the USAF to sponsor the Center, At this meeting President Richard Harvill suggested that the University, with the cooperation of the University of Arizona Foundation, might find a solution to the bricks and mortar problem if the Secretary of the Air Force would indicate an intent to support the Center through a lease fee in the basic contract. The last action by McMillan before leaving as Under Secretary was to endorse this plan of action.

The ensuing phase, with the full support of Alexander Flax, the Assistant Secretary of the Air Force for Research and Development, was largely played between Harry Davis's office, the Air Force and DOD's legal offices, and Congressional staff. In Arizona the same scenario was being played between the University and the University of Arizona Foundation. SAMSO was then asked to sponsor further preliminaries including firming the construction planning. The result of these combined efforts was the drafting of the baseline contract with SAMSO, now concluded.

The concluding event in Arizona was headed by Gil Bradley, now President of the Valley National Bank. He organized a consortium of Arizona banks to provide a loan to the Foundation to build the Center. The state legislature appropriated funds requested by the Board of Regents to equip the Center and establish an academic program. The Regents further selected a site on campus and transferred title to the land to the banks until the day the loan was paid, a date passed in

March 1975. On 25 November 1967 I received a much appreciated birthday resent — the banner headline in the Arizona Daily Star “5.25 Million Contract Awarded UA by USAF.”

Creating a Center is more than hardware. The key is the staff. The word about the Center even preceded the assurance of the Center. Robert Noble, who had discussed the formation of the academic program earlier, joined us in 1964 at Steward Observatory, followed immediately by Roland Shack,, who had just returned to Perkin-Elmer from Imperial College, and Stephen Jacobs from TRG, appointments made possible by inclusion of the new optical sciences program in a Science Development Program NSF grant to the University of Arizona. Included in that grant was a 90-inch telescope project, the first large optics task of the embryonic center. This grant was timely, filling a functional gap between the ARPA contract and the USAF SAMSO contract. As contract research developed, we were joined by James Eyer, University of Rochester. From this point growth was rapid of both staff and research, attested to by the compilation presented in this volume.

The ground-breaking for the Center was a quiet occasion, with the staff standing on the site of our Center. This staff was temporarily located in the Space Sciences Building, having outgrown the second floor of the Steward Observatory offices. The vast hole in the ground, now the world's finest university optical laboratory, filled slowly. Our impatience and need to move into the building grew as the building rose. Finally, in October 1969 the move began.

The completed Optical Sciences Center was dedicated on 22 January 1970 by John McLucas, now Secretary of the USAF, and Senator Barry Goldwater. I remember well on that occasion a combined feeling of relief and apprehension. The building was completed and the staff moved in -- but five years were still ahead before the University would receive title to the building. Would we on the staff be able to meet the expectations for the Center? Would we become what was envisaged as the new Optical Sciences Center by the OSA? Would we become a major contributor to applied optical fields envisaged by the USAF? Four years later, having retired as the first Director of the Center, with the contract renewal signed that assured the final lease payment for the Center and with the new Director in sight, I felt all had been well established. I am certain that the second decade of the Optical Sciences Center will be even greater than the first. The friends of the Center who made the Center possible join me in this prediction.