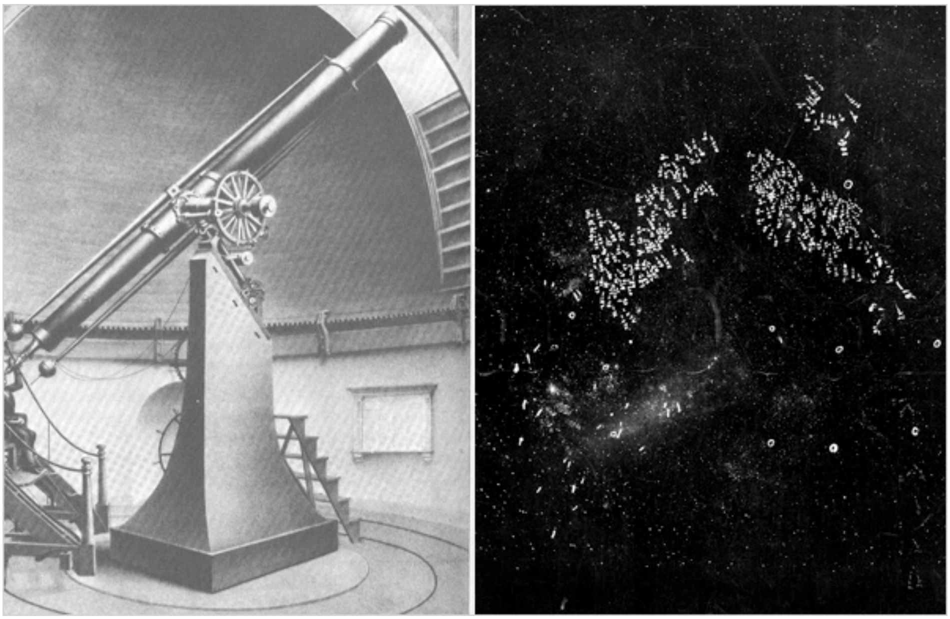
A Trip Back in Time and Space



Harvard College Observatory

The Great Refractor, left, which captured the first picture of a star in 1850, and an image of the Large Magellanic Cloud taken in 1900. More Photos >

By GEORGE JOHNSON
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In the summer of 1889, when this was still an analog world, a young astronomer named Solon I. Bailey carefully packed two crates of glass photographic plates taken at his outpost in the Peruvian Andes for shipment to Harvard College Observatory. Carried down the mountain on muleback and across a suspension bridge to the village of Chosica, the fragile load was put on a train bound for Lima and the long voyage to Boston Harbor.

Multimedia

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For nearly 18 months the data stream continued — more than 2,500 plates from what Mr. Bailey had quaintly named Mount Harvard — followed in the coming years by tens of thousands more from a second Peruvian station in Arequipa. Over the decades more streams came from Chile, South Africa and New Zealand, joining the growing piles

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Harvard's Cosmos

produced by telescopes in Massachusetts.

The accumulated result weighs heavily on its keepers on Observatory Hill, just up Garden Street from Harvard Square: more than half a million images constituting humanity's only record of a century's worth of sky.

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Robert Spencer for the New York Times

Alison Doane, curator of the glass database, compares a chart with a glass plate in her office. The reliance on photographic plates continued until the mid-1980s. More Photos »

"Besides being 25 percent of the world's total of astronomical photographic plates, this is the only collection that covers both hemispheres," said Alison Doane, curator of a glass database occupying three floors, two of them subterranean, connected by corkscrew stairs. It weighs 165 tons and contains more than a petabyte of data. The scary thing is that there is no backup.

For the last few months, Ms. Doane and a few colleagues, along with volunteers from the Amateur Telescope Makers of Boston, have been setting the stage for a mammoth attempt to bring the entire collection into the digital age. The result, if money can be found, will be more than just an archive. Digitized with a custom-crafted scanner already in operation, the searchable online atlas will ultimately show any spot in the heavens as it appeared from the late 19th century to the mid-1980s — an astronomical Wayback Machine.

"Nobody has ever systematically looked at the sky on 100-year time scales," said Josh Grindlay, the Harvard astronomer in charge of the project. "There is this whole dimension that hasn't been explored."

Walking into the plate stacks, housed in a brick annex on the observatory grounds, is itself like a trip back in time: the dimly lighted rows of green metal cabinets separated by little more than a shoulder's breadth, the light tables on which the plates are mounted for inspection with a magnifying loupe, the shelves of old ledgers in which astronomical observations were recorded with fountain pens. All of this is housed in a repository resting on a slab of concrete extending down toward bedrock, with the interior of the building, a cage inside a cage, structurally decoupled from the exterior walls.

"The thought was that in an earthquake the two would shake independently," Ms. Doane explained. "As data goes the plates are pretty sturdy and the collection in good shape. But they are glass and if not used gently, of course they can crack. Murphy's Law will guarantee that your star will be on the crack when you go to look at it."

For years it was rumored that the base of the building rested on leaf springs like those in an old pickup truck. In search of the truth, Ms. Doane crawled, flashlight in hand, down through a trapdoor and into the foundation. No springs in sight, just spiders.

"We actually say there are 500,000 plates, plus or minus 100,000," she said. "That would pretty much slay any curator or librarian to have such a large error bar, but astronomy often has high numbers. A hundred thousand is O.K."

Some plates were borrowed and never returned, still buried perhaps in a pile on some astronomer's desk. Others may have been stolen, and in at least one case, were lost at sea. In July 1944, the freighter Robin Goodfellow, a United States merchant marine ship carrying a load from the South African observatory, was sunk by a Nazi U-boat — the analog version of a hard disk crash.

Others survived a Peruvian civil war, with Mr. Bailey writing in 1893 that he might "have to remove the lenses and use the telescope tubes for cannon." He was joking, but in coming months he did have to barricade the windows of the Arequipa station and bury the lenses for protection.

For all the hardships endured in collecting the data, the biggest threats these days have been bureaucratic. In the 1950s, a budget-wary observatory director, Donald Menzel, suspended the plate-taking operation for a while, resulting in what is now ruefully called "the Menzel gap." And just a few years ago administrators, in search of more office space, ordered the collection compacted from four floors to three.

It could have been worse. "One of the possibilities that was discussed at the time was a closed stack," Ms. Doane said with a shudder. "In other words, basically putting it all in a warehouse."

From Trailblazing to Obsolete

It was here on Observatory Hill in 1850 that the first picture of a star — Vega in the constellation Lyra — was captured by what was then one of the two most powerful telescopes on Earth: the Great Refractor, with its 20-foot-long mahogany veneer tube outfitted with a lens 15 inches across. With the same early photographic technology — the daguerreotype — pictures were also taken of the Moon and Jupiter. But it was not until later that century, with the improvements of glass plate photography, that Edward Pickering, an observatory director, embarked on an effort to map the entire northern and southern skies.

As boatloads of plates arrived at the observatory, each was mounted on a wooden viewing frame and examined by a staff of "computers," women hired by Harvard, initially at 25 cents an hour, because they were good at math. The meticulous work, measuring and calculating the brightness of the tiny spots, required great concentration, and perhaps not coincidentally two of the computers, Annie Jump Cannon and Henrietta Swan Leavitt, were partly deaf.

One of their most important tasks was looking for variables, stars that changed periodically in brightness. While perusing images sent from Arequipa of a pair of nebulae called the Magellanic Clouds, Ms. Leavitt found around 1908 that Cepheid variables (a type first spotted in the constellation Cepheus) could serve as celestial yardsticks to measure large distances in the universe.

The reliance on photographic plates continued until the mid-1980s when electronic imaging came of age. The eyes of the astronomers were replaced by charge-coupled devices, or C.C.D.'s, allowing for faster, more voluminous observations with all the advantages of a searchable database.

"People jumped off the photographic bandwagon and onto the digital bandwagon overnight," recalled Elizabeth Griffin, chairwoman of the International Astronomical Union Task Force for the Preservation and Digitization of Photographic Plates. "Plates archives were closed because no one was contributing to them anymore."

A new generation of astronomers was barely aware that the resource existed. It was not online.

"It is a crying shame," Dr. Griffin said, "because it is tantamount to supposing that astronomy only started in the 1980s." A particularly harrowing case occurred at a Midwestern university. "I was contacted on a Friday night and told the plates were going to be trashed on Monday morning because the builders were moving in," Dr. Griffin recalled. She immediately got in touch with a history of science professor whose name she found on the Web.

"He, of course, was horrified," she said. "He rustled up some strong undergraduates and they spirited the plates away and stuck them in the back of a library long enough so that we could eventually work out a new home."

Custom-Made Solutions

Harvard did not need convincing. In 2001, Ms. Doane and Douglas Mink, a researcher at the Smithsonian Astrophysical Observatory, began exploring if the same sort of technology used to scan the skies could be used to scan the photographic archives.

First they experimented with high-end commercial scanners, only to discover that these were agonizingly slow. "When the scanner was new it would take about 10 minutes per plate," Mr. Mink said, "but then it slowly drifted." Before long it was crawling along at half that speed. Multiply that by 500,000 and you would be scanning eight hours a day for more than 50 years, half as long as it took to accumulate the data.

It was around this time that Ms. Doane described the problem to a meeting of the Amateur Telescope Makers of Boston. Among the members was Bob Simcoe, a retired engineer from the Digital Equipment Corporation, who volunteered to help design a custom machine.

"I got in touch with Alison and came in to visit her on the day she heard that Harvard's library initiative would not provide any funding," Mr. Simcoe said in an e-mail message. "That was probably a good thing since at that time there was not a good understanding of what it really would take to do the project."

The plates had to be scanned with a grain fine enough to capture all the subtleties of a sky packed with stars — but not so fine as to produce a wasteful excess of data. Precision, however, had to be balanced against speed. Achieving the observatory's goal of digitizing the entire collection within five years meant scanning a plate in about a minute, including handling time. Finally, there were practical concerns: the machine had to fit inside the cramped quarters of the stacks, where steel support poles are spaced every 55 inches, chopping the floor into an unalterable grid. No single part could be larger than a four-foot-square window, the only practical way inside.

Within this labyrinth of constraints, Mr. Simcoe and the team found a way to build the scanner. By 2004, with seed money from the National Science Foundation, Dasch — Digital Access to a Sky Century at Harvard — was ready to begin.

High Hopes, Empty Pockets

One day late this spring, Mr. Simcoe and Edward Los, a volunteer from the telescope club who wrote the scanning software, placed an old image of M44, the beehive cluster, into the motor-driven carrier on top of the scanner bed. Clamped in place pneumatically, the plate was rapidly shuttled across the retina of a digital camera, which captured an overlapping mosaic of snapshots to stitch into a single image. So tiny is each star that the machinery must move and position the plate and its heavy carriage to within half a micron (a millionth of a meter). To guard against vibrations, the assembly rests on an air-cushioned granite table that weighs about a ton.

Since the early days of celestial photography, astronomers have had to allow for the fact that plates were made with a variety of emulsions and developed in different ways. Adding to the confusion, pictures of the same patch of sky were taken over the century with different telescopes under different atmospheric conditions and with different exposure times. In Dasch these judgments, once the province of the female computers, are made algorithmically with software developed by Mr. Mink and another researcher, Silas Laycock. When a plate is scanned, the brightness of its stars is compared against known values in an online catalog. The image is calibrated accordingly.

Almost as important as the plates are the metadata — detailed notes handwritten in logbooks and sometimes on the plates themselves. "Somebody's got to type it in," Mr. Simcoe said. "Nobody's got any software that can read cursive writing." As a first step, George Champine, a retired engineer with an interest in astrophysics, has taken 80,000 photographs of the pages, which are slowly being transcribed in India, with help possibly on the way from volunteers at the American Museum of Natural History.

From the beginning, the project's success has depended on enthusiastic supporters. Photon Dynamics Inc. donated the camera. Students from Worcester Polytechnic Institute helped make the plate holder.

"There are only a few individuals on the planet that could have designed and fabricated this device alone and met the requirements," Mr. Champine said. "And Josh and Alison were lucky enough to find them." Now they just have to find more money.

"We're down to our last $2,000," Dr. Grindlay said one morning as the group gathered around the scanner. "Make that $1,000," Ms. Doane said. Before coming in to work she had stopped to buy a camera for photographing more metadata.

So far the team has digitized about 550 pictures of the beehive cluster and is starting on the quasar 3C273. The initial National Science Foundation grant of nearly $500,000 was enough to get things rolling, but it will take 10 times that to complete the task.

With additional federal support uncertain, Dr. Grindlay is taking a cue from the past. In Mr. Bailey's time, astronomical research was financed by philanthropists. Many of the observations from Arequipa were taken by the Boyden telescope (courtesy Uriah Atherton Boyden) for inclusion in the Henry Draper Catalogue of stars.

"I hate to sound crass, but if somebody doesn't give us the five or six million, we're kind of in trouble," Dr. Grindlay said. "This is just the scale where all we need is the right Harvard donor. This would be the modern version of the Henry Draper Catalogue."

"Somebody could easily put their name on this — the world's first time-domain catalog," Dr. Grindlay added. "Do we really want to wait another hundred years to find out with modern instrumentation what the cosmic movie looks like? We've got this chance right here."

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