Air and Space this Week

Item of the Week

March 3: A Good Day to Celebrate Pioneering Exploration and Discovery

Originally appeared March 1, 2021

KEY WORDS: Alexander Graham Bell Period-Luminosity Relationship Henrietta Leavitt Cepheid Variable N.A.C.A. James Doohan Pioneer 4 Apollo 9 Pioneer 10

Some days of the year just have more aviation- and Space-related anniversaries than others. One of my favorites for exploration and discovery is March 3…

1847: The Birth of Alexander Graham Bell

The ability to communicate across great distances has been the focus of considerable effort, from Anasazi watchtowers to semaphore and heliostats to electrical clicks on Mr. Morse's telegraph wire. As every schoolkid knows, a big step forward in distance communications was made by Alexander Graham Bell, when he invented the telephone. Of course, others were working on the same idea, but Bell beat them to the Patent Office, securing rights to the device on March 7, 1876, a few days *before* he gave a shout-out to Watson.

Now that a wire could carry the human voice, a much richer amount of info than any telegraph could convey. A mere 39 years later, Bell would place the first coast-to-coast long-distance call, again to Mr. Watson. Others fought Bell's patents, and it almost got revoked, but the U.S. Supreme Court intervened.

Bell was an accomplished inventor; the telephone was perhaps the best known of his creations, but the others were significant, too. Among his notable successes: the metal detector (he used it in an attempt to find the bullet that killed President Garfield), the audiometer (even today widely-used to test hearing), and the photophone (which used a beam of light to transmit sound). He also made a big improvement in Edison's phonograph, the graphophone.

References

https://www.alexandergrahambell.org

History.com: https://www.history.com/topics/inventions/alexander-graham-bell

AGB papers at the LoC: https://www.loc.gov/collections/alexander-graham-bell-papers/about-this-collection

PBS: https://www.pbs.org/transistor/album1/addlbios/bellag.html

1912: The "Period-Luminosity Relationship"

Astronomy, like other sciences a century ago, was a very male-dominated field. But one of the biggest discoveries of that era was made by a woman.

Henrietta Swan Leavitt graduated from the pre-cursor of Radcliffe College in 1892. After graduation, she traveled extensively at home and abroad, losing her hearing in the process. She ended up near Harvard, where she took a volunteer position at its observatory, one of a cadre of human "computers" utilized by Harvard College Observatory director W.H. Pickering to process astronomical data, a very exacting, yet tedious, task in the pre-computer days.

One of the chores assigned to Ms. Leavitt was the determination of star brightnesses from photographic plates taken with the HCO telescope. She devised a system of comparison stars to aid her in her task, a system that was adopted by other observatories world-wide.

Her primary contribution came after she had actually been hired by HCO. Astronomers knew how to related a star's apparent brightness to its actual distance, but to do so one had to know how bright the star was in an absolute sense; that is, what would its apparent brightness be at a "standard distance." [Astronomers use a distance of 10 parsecs as the "standard." Remember the Item a while back on Astronomical Trigonometry? A star that shows an annual parallax shift (due to the Earth's motion around the Sun) of one second of arc is said to be at a distance of 1 parallax-second, or *parsec*. That equates to a distance of 3.26 light-years. Since no star is that close to the Earth, the "standard distance" was set at 10 parsecs.]

The trick was, then, to be able to determine a star's absolute brightness. Ms. Leavitt conducted a painstaking analysis of stars in the Small Magellanic Cloud, and discovered that 1777 of them varied with brightness over time. She even found that 47 of those variable stars changed brightness in a very regular pattern, similar to that of some stars in the Milky Way, most notably the star Delta Cephei (which, oddly, never received its own name).

The Small Magellanic Cloud, whether it was actually in the Milky Way or not, was known to be farther away from Earth than most stars.

Ms. Leavitt noticed an odd thing about the 37 stars that varied like Delta Cephei. The brighter Cepheid variables in the SMC consistently had a longer period of brightness variation than the fainter ones. Since all of the stars in the SMC were more-or-less the same distance from Earth, Leavitt could treat the observed magnitudes of the Cepheids there as a direct indication of those stars' absolute magnitudes. She had found that the period of a Cepheid variable was directly proportional to their absolute brightness, an extraordinarily important discovery!

Now astronomers had a tool that worked at much greater distances than the parallax method. The distance to any Cepheid could be found by measuring its period of variability, determining its absolute magnitude from Leavitt's relationship, then comparing the magnitude so determined with the apparent magnitude of the Cepheid in question, and from that determining its distance.

Edward Pickering published her research on the Cepheids of the SMC in March 3, 1912, Harvard College Observatory Circular (vol 173, pp 1-3), "Periods of 25 Variable Stars in the Small Magellanic Cloud," see here. In the paper, he clearly indicated that he was reporting on work done by Ms. Leavitt. But he was the only person listed as the author of the report. Over the next decade, many stellar distance determinations were made using the Cepheid Period-Luminosity relationship.

Pickering was the brother of the Director of the HCO, W.H. Pickering, when Ms. Leavitt made her discovery. Even though it was her work, Pickering sought to claim all of the scientific credit, and was successful in doing so for many years. Other pioneering work was conducted at HCO by the "Computers," including some amazing analyses of stella spectra by Annie Jump Cannon (a whole 'nother story!), where the credit was usurped, at least initially.

[**Teachers/Students:** Need a good topic for a Women's History Month of other spring semester paper? The story of Henrietta Leavitt, Annie Jump Cannon, and the other HCO computers would make a wonderful topic! In addition, there was another episode in astronomy where a female grad student, Jocelyn Bell, discovered the first-known pulsar on February 24, 1968, an event that resulted in her professor being awarded the Nobel Prize. Bell, who actually made the discovery, was not included in the award, at least, that one. See also here, here, and here.]

Ms. Leavitt lived quietly after deriving the P/L relationship, continuing to be a research assistant. She died young, on December 12, 1921. Such was the impact of her discovery, and the obscurity in which she worked, that she was nominated for the Nobel Prize in Physic for 1926, five years after her death (the nominator thought she was still alive).

At that time, the astronomical "Great Debate" of the day concerned the nature of some types of nebulae, such as the nebula in Andromeda designated "M 31" on the list compiled by Charles Messier. Were such nebulae objects within the Milky Way, or were they separate "island universes," like the Milky Way but separated from it by vast distances?

Henrietta Leavitt knew that her Cepheids could tell which view was correct, IF they could be found in M 31 or any of the other spiral-shaped nebula then known. But she would pass too soon…

Two leading astronomers of the day engaged in a debate on the topic in front of members of the National Academy of Science, on April 26, 1920, at the Smithsonian's National Museum of Natural History. Harlow Shapley presented for the former position; Heber Curtis for the latter. Shapley was as much trying to make an impression to support his candidacy for the directorship of Harvard College Observatory as he was trying to convince the audience on the notion that all nebulae were "local." Curtis' default victory was soon reenforced by observational proof.

The Carnegie Institution's Edwin Hubble, using the then-largest-in-the-world 100" Hooker Telescope on Mt. Wilson near Los Angeles, acquired a photographic plate of the Andromeda Nebula on October 5/6, 1923, in which he found a Cepheid variable. Using Leavitt's P/L relationship, he showed that Andromeda was much-too-much far away to be part of the Milky Way; it had to be a completely-separate "island universe" (aka "galaxy")!

References

Henrietta Leavitt: https://www.aavso.org/henrietta-leavitt-%E2%80%93-celebrating-forgotten-astronomer and

More on Henrietta Leavitt:
https://school.bighistoryproject.com/media/khan/articles/U2_Henrietta_Leavitt_2014_840L.pdf

The HCO "Computers": https://en.wikipedia.org/wiki/Harvard_Computers

The March 3, 1912 HCO circular: http://cwp.library.ucla.edu/articles/leavitt/leavitt.note.html

P/L Relationship: https://en.wikipedia.org/wiki/Period-luminosity_relation

The discovery plate of the Andromeda Cepheid: https://obs.carnegiescience.edu/PAST/m31var

The *Hubble Space Telescope* has imaged Hubble's first Andromeda Cephid:
https://www.nasa.gov/mission_pages/hubble/science/star-v1.html

1915: The establishment of the National Advisory Committee for Aeronautics

The N.A.C.A. was established as a Federal agency, with the mission "to undertake, promote, and institutionalize aeronautical research." It was very effective, and would morph into the National Aeronautics and Space Administration on October 1, 1958, a reflection of our Nation's new space-faring capability.

N.A.C.A. research led to many important advances.

One of the biggest problem engineers faced as airplane engines became larger and more powerful was keeping the engines from overheating. Air cooling was easier, but was becoming less effective with ever-larger engines. Liquid cooling would work, but required a LOT more weight. Militarily, an air-cooled engine could withstand battle damage better than a liquid-cooled system, which had vulnerable plumbing and radiator. Air-cooled engines needed to have a large amount of air circulate around the engine cylinder heads, which caused undesirable drag. The solution to the problem for air cooling was found by N.A.C.A. research – a cowling that increased airframe streamlining while ducting air around the cylinder heads. The agency conducted comprehensive research into airfoil design and aerodynamic compressibility, and made important advances in engine turbosuperchargers and the laminar-flow wing. N.A.C.A. research and facilities made supersonic flight possible.

Research efforts by N.A.C.A. and its successor agency, NASA, have been recognized by the award of the prestigious Robert J. Collier Trophy. Twenty times. And with many, many other awards and recognitions.

References

Wikipedia's N.A.C.A. page is a good summary:
https://en.wikipedia.org/wiki/National_Advisory_Committee_for_Aeronautics

N.A.C.A. history: https://history.nasa.gov/naca/overview.html

N.A.C.A. page on the U.S. Centennial of Flight Commission's website:
https://www.centennialofflight.net/essay/Evolution_of_Technology/NACA/Tech1.htm

N.A.C.A. and NASA history: https://www.hq.nasa.gov/office/pao/History/SP-4406/cover.html

N.A.C.A./NASA Collier winners: https://history.nasa.gov/SP-4219/Contents.html

1920: Birthday of actor James Doohan

He wasn't an engineer, but he played one on TV. A very good one, even if he was occasionally a bit confused about time. The inclusion of a *Star Trek* character is pertinent here as an engaging cultural reference. Further, the technology presented in *Star Trek* is widely recognized as having inspired considerable engineering innovations. Don't think so? Here's documentation:

https://www.sciencenewsforstudents.org/article/star-trek-technology-science

https://www.techrepublic.com/article/tech-leaders-share-how-star-trek-inspired-them-to-pursue-a-career-in-technology

https://www.nerdunion.us/2015/08/07/star-treks-impact-on-technology

The Smithsonian Channel's *Building Star Trek* (2016):
https://www.smithsonianchannel.com/details/show/3436402

1959: Launch of *Pioneer 4*, the first "successful" U.S. lunar fly-by mission.

Not long after the U.S. entered the Space Age with the launch of *Explorer 1* (February 1, 1958), NASA began launching spacecraft to explore the newly-discovered Van Allen radiation belts and the characteristics of Earth-Moon Space. Four attempts were made later that year. The booster for *Pioneer 0* (aka *Able 1*) blew up seconds after launch; *Pioneer 1* also suffered a launch vehicle failure, but it did obtain a little data on very-high altitude conditions before it crashed; and *Pioneer 2* suffered a similar fate when its third stage failed to ignite. The next attempt was with a different spacecraft type, and managed by the U.S. Army Ballistic Missile Agency. *Pioneer 3* missed the Moon and fell back to Earth, but it did make it over 100,000 km away from the Earth, and returned usable data about the Van Allen Belts.

The fifth time was the charm (shades of Swamp Castle!). *Pioneer 4* was almost identical to its immediate predecessor. It carried a souped-up Geiger counter and a lunar photography experiment. It launched OK, but missed the Moon by 60,000 km, too far to trigger the photography setup. After flying sorta near the Moon, it entered into solar orbit.

While *Pioneer 4*'s success might seem modest, it was an important accomplishment at the time, and was a foreshadowing of the rapid growth in aerospace technology that would soon follow.

Pioneer 4 lived up to the its namesakes!

1969: Launch of *Apollo 9*, a manned Earth-orbit test of the Lunar Module.

The first human expedition to the Moon required the development of a number of new technologies. Perhaps foremost among them was the special craft needed to allow the Moonwalkers to land safely on the Moon and then take off again to attain lunar orbit. This was an enormously-difficult and totally-new engineering project. Of course, the resulting spacecraft, the Lunar Module, would require a test under real conditions before being sent to the Moon, and *Apollo 9* was the pioneering mission to conduct it.

References

Apollo 9 basic info: https://www.nasa.gov/mission_pages/apollo/missions/apollo9.html

Apollo 9 Mission Report: https://www.hq.nasa.gov/alsj/a410/A09_MissionReport.pdf

1972: Launch of *Pioneer 10*, the first spacecraft to fly by Jupiter.

Pioneer 10 really, really lived up to its namesakes! It was NASA's first mission to Jupiter, and its first spacecraft to be launched with enough speed to escape the Solar System completely. The images it returned were our first close-up look at Jupiter. It was designed to make the 21-month journey, but its signals were received for 28 more years! *Pioneer 10* was also the first Solar System probe that could not rely on solar power; it used a radio-isotope thermal generator instead. The power, communications, and tracking technologies proven during the flight pioneered the many outer Solar System exploration probes that followed.

References

NSSDCA: https://nssdc.gsfc.nasa.gov/planetary/pioneer10-11.html

NASA summary: https://solarsystem.nasa.gov/missions/pioneer-10/in-depth

NASM: https://airandspace.si.edu/collection-objects/pioneer-10-11/nasm_A19770451000

Pioneer Missions: https://www.nasa.gov/centers/ames/missions/archive/pioneer.html

Summary: OK, let's review. March 3 is the birthday of a pioneer in communications technology, a pioneering discovery in astronomy by a gender pioneer of the field, a Federal agency that pioneered many discoveries in aeronautics, the birthday of an actor who portrayed an engineer in a pioneering television program, and three Space missions that pioneered our way to the Moon and beyond.

Hmmmm, there seems to be a unifying theme here (PIONEERS). *Keep this day in mind if/when you want to convey the importance of exploration, discovery, and innovation.*

Last Edited on 28 February 2021