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THE ARCTIC EXPLORATIONS OF FRIDTJOF NANSEN

The Norwegian scientist Fridtjof Nansen was a marine biologist, oceanographer, intrepid explorer, artist, poet, and humanitarian, as well as a founding father of his country and a Nobel laureate. Near the end of the nineteenth century, he conceived, planned, and promoted a scientific endeavor comparable in scope to modern spacecraft projects. He constructed a specially designed ship, intentionally froze her in the Arctic ice, and used her as a scientific platform, a kind of spacecraft of the time. From 1893 to 1896, he and his crew conducted biological, oceanographic, atmospheric, geomagnetic, and auroral observations. Nansen returned from the Arctic as a hero, much like a modern-day astronaut, and later became responsible for the repatriation of a half-million World War I prisoners on behalf of the League of Nations. Einstein and Freud praised him for "responding to the call . . . not as a scientist, but as a humanitarian."

INTRODUCTION

The international race to claim the Earth's poles captured the world's attention at the end of the nineteenth century. In many ways, that quest was similar to the space race that began nearly a century later. The nineteenth century polar expeditions were not limited to the superpower countries of the time, and the resources expended were far less than the costs of space exploration today. But, as with space exploration, an important objective of polar expeditions was the first presence of man and flag at a previously inaccessible location. The acquisition of scientific observations was included in the planning and justification of these expeditions, but the "presence of man" received the greatest public attention and was a source of national pride. These ventures involved severe isolation and exploration with self-contained and specially designed craft. The missions helped to drive the technology of the period and resulted in the development of vessels specially designed to cope with hostile environments. After years of planning, development, and construction, the ships were launched with great anticipation and celebration. Launching was followed by a cruise during which observations were made and data were collected. After the expeditions, the results were collated, studied, evaluated, debated, and reported, and new expeditions were planned.

The story of Fridtjof Nansen is that of a scientist and an explorer who was more intent on proving a theory than being the first to stand on the North Pole. Nansen, pictured in Figures 1 and 2, conceived, developed, promoted, and conducted an endeavor comparable in scope to modern spacecraft projects. He developed a theory of ice drifts in the polar regions from previous expeditions. He assembled financial support from various sources, including his government, for his program. He

Figure 1. Copy of an oil painting of Nansen as a young man. (Courtesy of the Norwegian Polar Research Institute and Mittet & Co., Oslo, Norway.)

Figure 2. Image of Nansen as it appeared on the (now obsolete) Norwegian ten-kroner note.

planned and constructed a specially designed ship, named the *Fram*, which was intentionally frozen in the Arctic ice for use as a scientific platform—the spacecraft of the period. He conducted biological, oceanographic, atmospheric, and auroral observations from the *Fram*. He returned with a wealth of geophysical data, analyzed them, and with several colleagues, published the many results. Nansen is unique among polar explorers of his time because he was a scientist first and foremost, and his objective was scientific research. He published many articles and books and was an enthusiastic and articulate speaker. He invented the device known as the "Nansen bottle," still used by oceanographers to obtain water samples at different depths. He studied the aurora borealis (northern lights) in considerable detail and, because cameras with the appropriate sensitivity were not yet available, he recorded its complicated forms in drawings and paintings.

Fridtjof Nansen was born on 10 October 1861, on the farm Store-Frøen in Vestre Aker, near present-day Oslo (formerly called Christiania). In 1880, he passed his entrance examination to the University of Christiania and began his studies in zoology. In the spring of 1882, he experienced his first taste of the Arctic region while on the sealer *Viking*. Later that year he was appointed curator at the Bergen Museum, but the exploration of the polar region had become his passion.

For his first Arctic venture, Nansen planned an expedition to cross Greenland. He experimented with various equipment, such as sledges and special clothing, in the mountains near Bergen during the winter of 1887–88. He assembled a team of explorers and selected Otto Sverdrup (later to become a famous explorer himself) as his second-in-command. Nansen adopted a bold new exploration plan that was in direct opposition to the conventional wisdom of that time. He planned to start his crossing of Greenland from the hostile and uninhabited east coast where retreat was impossible. He could only move forward, and this became his motto for life. In his famous 1926 address as Lord Rector of St. Andrews University in Scotland, Nansen stated,

> Let me tell you one secret of such so-called successes as there have been in my life, and here I believe I give you really good advice. It was to burn my boats and demolish the bridges behind me. Then one loses no time in looking behind, when one should have quite enough to do in looking ahead—then there is no choice for you or your men but *forward*. You have to do or die![1]

In the spring of 1888, Nansen defended his doctoral thesis and left a few days later for his Greenland expedition. On 17 July 1888, the expedition disembarked from the sealer *Jason* in two small boats off the east coast of Greenland. The boats were held captive in the ice floes for almost two weeks, but finally reached Cape Tordenskjold at the end of July. Nansen and his expedition skied across Greenland and reached Godthåb on the west coast on 3 October 1888. He was greeted by a Danish official who congratulated Nansen on his accomplishment and informed him that he had been awarded his doctorate. Nansen developed and tested techniques during the Greenland crossing that he later applied to one of the most remarkable expeditions ever conducted.

Fridtjof Nansen married Eva Sars in 1889, a woman regarded by some as the "greatest romance singer that Norway had ever produced."[2] It is said that when he proposed, he added, "But I must take a trip to the North Pole." Eva later recalled her mother's advice: "Remember that you are marrying a scientist and you must never demand more than half of him."[2]

THE PLAN

Following the return of two successful expeditions to Africa led by Henry M. Stanley and sponsored by the *New York Herald*, James Gordon Bennett, publisher of the *Herald*, directed his attention toward the North Pole. Bennett decided to send an expedition to the North Pole at his own expense. George Washington DeLong, a lieutenant in the U.S. Navy, was offered the command. A special act of Congress permitted the expedition's ship to sail under the American flag and to be navigated by officers of the U.S. Navy with all the rights and privileges of a government vessel. A relatively small ship, the *Jeannette*, was fitted for the expedition. She was 142 ft long and had a 25-ft beam, drew 13 ft when fully loaded, and displaced 420 tons. She had not been designed for Arctic service, but every effort was made to strengthen her hull with Oregon pine timbers to withstand the pressure of the ice. "No steamer before her had set out better braced to withstand the Arctic ice fields," observed George Wallace Melville, the *Jeannette*'s chief engineer.[3]

The plan was for the *Jeannette* to sail north through the Bering Sea, between Alaska and Russia, where it was believed that the limit of the Arctic ice was confined to high latitudes because of the warm Japanese current. The *Jeannette* left San Francisco on 8 July 1879; just two months later, on 6 September 1879 (see Fig. 3), she became stuck fast in the ice southeast of Wrangel Island (near 71°35′N and 175°6′W) . The expedition's planners had not realized that, because of the circulation pattern of the ocean current, the ice actually extended down to relatively low latitudes in that region.

The *Jeannette* drifted with the ice in a west–northwesterly direction; she was crushed and foundered on 12 June 1881, north of the New Siberian Islands at 77°15′N

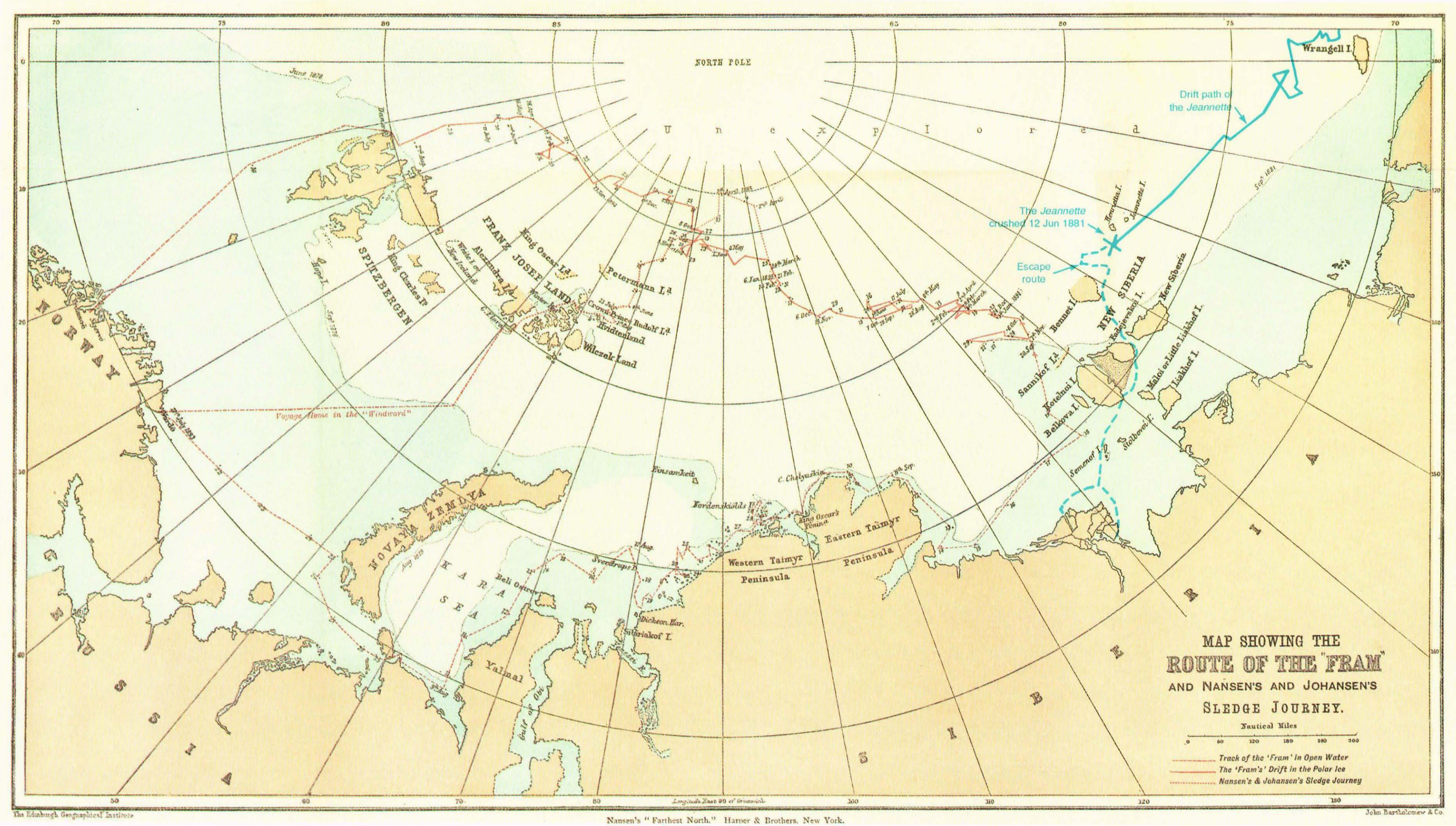

Figure 3. Map showing the drift path of the *Fram* and the sledge journey of Nansen and Johansen. They walked to Cape Flora in Franz Josef Land where they met Frederick Jackson. They then sailed to Vardø and on to Hammerfest on Jackson's relief ship *Windward.* The *Fram* was released from the ice near the west coast of Spitsbergen. The drift path of the *Jeannette* and the escape route of DeLong and his crew are also shown. Had the *Jeannette* survived the crushing ice, she might have continued to drift along the same path that the *Fram* did twelve years later, as claimed by George Melville (chief engineer on the *Jeannette*) many years later. (Reprinted from Ref. 6.)

and 154°59′E, about 500 miles north of Siberia. The heroic crew of the *Jeannette* dragged their boats over the ice, sailed these open boats through the Arctic waters, and ultimately landed at the Lena Delta in Siberia. Only a third of the men survived this incredible journey. In his dying moments in Siberia, DeLong tossed his ship's log over his head, away from the camp fire, in an attempt to save his journal (it was eventually recovered).[4,5]

Three years after the *Jeannette*'s sinking, several articles associated with its ill-fated expedition were found near Julianehåb on the southern coast of Greenland, about 1400 miles away. The *Danish Geographical Journal* for 1885 provided the following inventory of those articles: a list of provisions, signed by DeLong, the commander of the *Jeannette*; a list of the *Jeannette*'s boats; a pair of oilskin breeches marked "Louis Noros," one of the *Jeannette*'s crew who was saved; and the peak of a cap on which was written "F. C. Lindemann," another *Jeannette* crew member who was saved.

The inventory was noted by Fridtjof Nansen in his book *Farthest North*.[6] He wrote, "In America, when it was reported that these articles had been found, people were very skeptical, and doubts of their genuineness were expressed in the American newspapers."[6] *National Geographic* of March 1896 referred to the report of the *Jeannette* articles as a "boyish prank of some member of the Greely relief expedition."

Nansen further noted, "The facts, however, can scarcely be sheer inventions; and it may therefore be safely assumed that an ice-floe bearing these articles from the *Jeannette* had drifted from the place where it sank to Julianehåb."[6] Since the articles were found between 700 and 1100 days after the *Jeannette* foundered, Nansen realized that the 1400-mile distance would indicate a westward drift of the Arctic ice of 1.5 to 2 miles per day. He concluded that "a current flows at some point between the Pole and Franz Josef Land from the Siberian Arctic Sea to the east coast of Greenland."[6] To explain this current, Nansen developed an extensive circulation model, which included possible sources of the water as well as the Earth's rotation. This work was done at a time when the Arctic region was totally unexplored; it was not even known if land or sea existed at the Pole. And some believed in the hollow-Earth theory, in which a source in the Earth's core was believed to show through holes in the polar regions to produce the aurora borealis and aurora australis (the northern and southern lights).[7]

To test his theory, Nansen suggested the following:

> I propose to have a ship built as small and strong as possible—just big enough to contain supplies of coals and provisions for twelve men for five years. The main point in this vessel is that it be built on such principles as to enable it to withstand the pressure of the ice. The sides must slope sufficiently to prevent the ice, when it presses together, from getting firm hold of the hull, as was the case with the *Jeannette* and proposed other vessels. [He proposed to sail his ship and] push our way up past the new Siberian Islands . . . and be right in the current which carried the *Jeannette*. In this manner the expedition will . . . probably drift across the Pole, and onward to the sea between Greenland and Spitzbergen. And when we get down to the 80th degree of latitude, or even sooner, if it is summer, there is every likelihood of getting the ship free and being able to sail again.
>
> . . . It is not to seek for the exact mathematical point that forms the northern extremity of the earth's axis that we set out, for to reach this point is intrinsically of small moment. Our object is to investigate the great unknown region that surrounds the Pole.[6]

Nansen presented his plan in as many forums as he could, and it received mixed reviews. In America, General Greely, the leader of the ill-fated expedition generally known by his name,* wrote in the August 1891 issue of *The Forum* (as quoted in Ref. 6): "It strikes me as almost incredible that the plan here advanced by Dr. Nansen should receive encouragement or support." Greely went on to say, "It seems to me to be based on fallacious ideas as to physical conditions within the polar regions, and to foreshadow, if attempted, barren results, apart from the suffering and death among its members."

PREPARATIONS

In 1890, Nansen directed his attention and efforts to obtain support for his mission. He applied for a grant from the Norwegian government and appealed for contributions from anyone. He assembled more than 444,000 Norwegian kroner (equivalent to about $4 million today). Of this total, 63% came from the Norwegian government, and 24% was contributed by the king. (At that time, Norway was under the control of Sweden; the King of Sweden was sovereign of both Norway and Sweden.) The Royal Geographical Society of London contributed about 5000 kroner. Nansen spent 61% of his resources on the ship, 16% on scientific instruments and supporting equipment, about 10% on wages for the staff, and the rest on operating expenses (primarily provisions for the crew). Nothing could be budgeted for the data analysis activities following the mission. Nansen lamented the inadequate funding and stated after his return that "there is also another lesson which I think our expedition has taught—namely, that a good deal can be achieved with small resources."[6] Many regard the opposite to be true for large scientific endeavors, especially in the exploration of space.

THE *FRAM*

Nansen enlisted the services of a well-known ship designer of the period, Colin Archer. The design specifications for Nansen's ship were simply stated: "(1) that the shape of the hull be such as to offer as small a vulnerable target as possible to the attacks of the ice; and (2) that it be built so solidly as to be able to withstand the

*Lieutenant Adolphus Greely of the U.S. Army was placed in command of a weather station at Fort Conger near the northern tip of Ellesmere Island. This was a part of the U.S. contribution to the International Polar Commission in 1881. Bad weather, poor organization, and other factors combined to make this exercise a terrible disaster marked by starvation and death. Only six (including Greely) of the original twenty-five men were rescued by a relief expedition in the summer of 1884. Greely was later promoted to the rank of general.

greatest possible pressure from without in any direction whatsoever."[6]

Nansen considered many aspects and details of ship design to predict how a wooden ship frozen into ice would react. The sides of the hull were rounded downward to the keel so that the ship would be lifted out of the water by the surrounding ice, instead of being crushed. The bottom was made flat so it would not heel over significantly as it was lifted upward. Nansen made calculations and performed experiments on the friction between ice and wood. The propeller and rudder were designed to be removed through a well from the deck. Everything possible was done to make the sides of the ship as strong as possible with internal frames (see Figs. 4, 5, and 6). The ship was named the *Fram*, Norwegian for "forward," which was Nansen's motto; she had the following dimensions: length of water line, 113 ft; breadth of water line, 34 ft; depth, 17 ft; and displacement, 800 tons. She was rigged as a three-masted fore-and-aft schooner and was also powered by a 220-hp steam engine. In addition, she carried an electric generator, to be driven by a windmill when the ship was locked in the ice (see Fig. 7). The *Fram* was furnished with electric lights.

Scientific instruments were included to conduct meteorological, astronomical, magnetic, and hydrographic observations. The instruments were capable of measuring the direction and intensity of the geomagnetic field. A spectroscope was used to observe the aurora, and an electroscope determined atmospheric electricity. Nansen planned to make pendulum experiments for gravity and geoid determination but was not successful in conducting them from shipboard. He designed a device to take deep-water samples (which became the famous "Nansen bottle") and to measure water temperature and salinity. Nansen left no detail to chance in his preparations, and when later asked whether anything unforeseen had occurred, he replied, "We had foreseen at least five times as much as what actually happened."[6] The *Fram* was successfully launched in the autumn of 1892 and christened by Nansen's wife, Eva.

THE EXPEDITION

The *Fram* left Oslo on 24 June 1893 with thirteen crewmen, including Nansen. They sailed north along the coast of Siberia and entered the ice pack on 22 September 1893. As planned by Nansen, the *Fram* became locked in the ice and began to drift toward the west. But in the spring of 1895, he realized that the drift of the *Fram* would not after all take her across the North Pole (see Fig. 3).

On 14 March 1895, Nansen left the *Fram* with Frederick Hjalmar Johansen, the ship's stoker, in an attempt to reach the Pole by dogsled (see Fig. 8). They reached "farthest north" (the title of Nansen's famous book published in 1897) at 86°14′N on 7 April 1895. Nansen and Johansen then turned south. On 17 June 1896, having walked for a year and three months after leaving the *Fram*, they met the British explorer Frederick

DESIGNS FOR THE "FRAM"

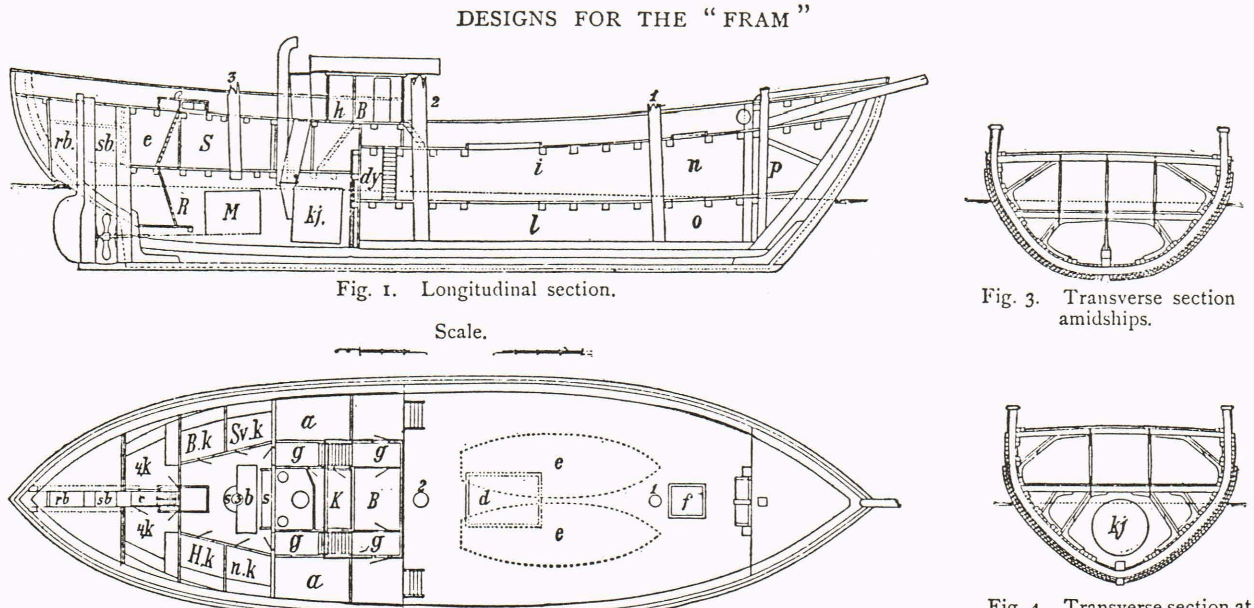

Fig. 1. Longitudinal section.

Fig. 2. Plan.

Fig. 3. Transverse section amidships.

Fig. 4. Transverse section at the engine-room.

rb Rudder-well. *sb* Propeller-well. *S* Saloon. *s* Sofas in saloon. *b* Table in saloon. *Svk* Sverdrup's cabin. *Bk* Blessing's cabin. *4k* Four-berth cabins. *Hk* Scott-Hansen's cabin. *nk* Nansen's cabin. *c* Way down to engine-room. *R* Engine-room. *M* Engine. *kj* Boiler. *g* Companions leading from saloon. *K* Cook's galley. *B* Chart-room. *h* Work-room. *dy* Place for the dynamo. *d* Main-hatch. *e* Long boats. *i* Main-hold. *l* Under-hold. *f* Fore-hatch. *n* Fore-hold. *o* Under fore-hold. *p* Pawl-bit. *1* Foremast. *2* Mainmast. *3* Mizzenmast.

Figure 4. Plan of the *Fram*. (Reprinted from Ref. 6.)

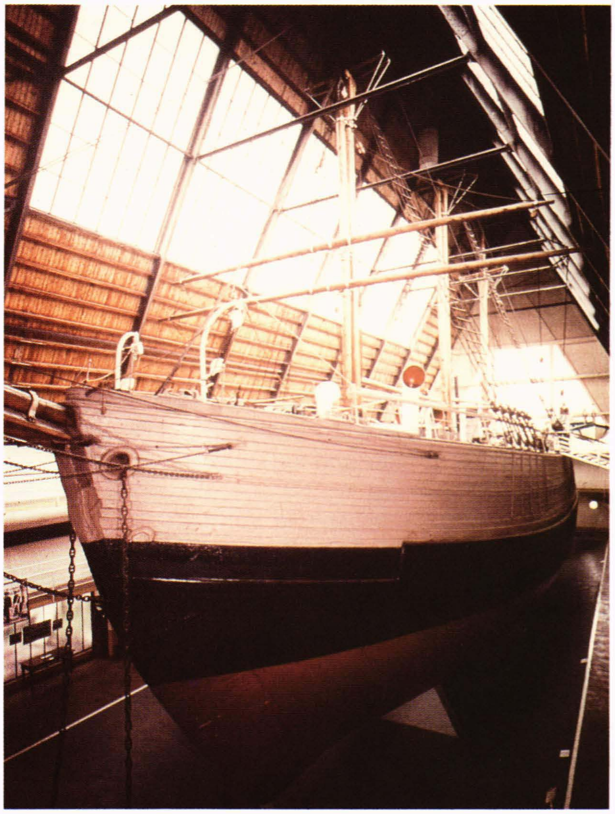

Figure 5. Photograph of the *Fram* in the *Fram* Museum, Bygdoy, Norway. (Courtesy of the Norwegian Polar Research Institute and Mittet & Co., Oslo, Norway.)

Figure 6. Photograph of the *Fram*'s internal bracing (taken by author). Compare with the "transverse section amidships" shown in Figure 4.

Jackson on Cape Flora in Franz Joseph Land—one of the most remarkable chance meetings in history. Aboard Jackson's relief ship, Nansen sailed to Vardø, Norway, on 13 August 1896, and then to Hammerfest on 21 August. At that time, Nansen did not know that the *Fram*,

Figure 7. Photograph of the *Fram* locked in the ice, 1895. (Reprinted from Ref. 6.)

under the command of Otto Sverdrup, had been released from the ice near Spitsbergen, after drifting nearly three years in the ice, on the same day that Nansen had arrived on Norwegian soil again (13 August 1896). The *Fram* returned to Tromsø on 24 August and the next day Nansen arrived from Hammerfest on Sir Robert Baden-Powell's steam yacht to be reunited with his beloved ship. After more than three years in the polar regions in complete isolation, the entire expedition returned home safely.

Nansen summarized the principal result of his expedition as follows:

> As a result of our expedition, I think we can now form a fairly clear idea of the way in which the drift-ice is continually moving from one side of the polar basin north of Bering Strait and the coast of Siberia, and across the regions around the Pole, and out towards the Atlantic Ocean. Where geographers at one time were disposed to locate a solid, immovable, and massive ice-mantle, covering the northern extremity of our globe, we now find a continually breaking and shifting expanse of drift-ice.[6]

The results of the expedition, encompassing a variety of scientific disciplines, were published in several dozen volumes of scientific papers. Nansen described complicated phenomena such as the aurora in a delicate poetic style (recorded 11 November 1894):

> But the northern lights, with their eternally shifting liveliness, flame over the heavens each day and each night. Look at them; drink oblivion and drink hope from them: they are even as the aspiring soul of man. Restless as it, they will wreathe the whole vault of heaven with their glittering, fleeting light, surpassing all else in their wild loveliness, fairer than even the blush of dawn; but, whirling idly through empty space, they bear no message of a coming day. . . . What would it profit even if we could say that it is an electric discharge or currents of electricity through the upper regions of the air, and were able to describe in minutest detail how it all came to be? It would be mere words. We know no more what an electric current really is than what the aurora borealis is.[6]

Figure 8. Nansen (second from the left) and Johansen (fourth from the right) leaving the *Fram* on 14 March 1895, for their fifteen-month sledge journey in the polar region. Otto Sverdrup (first on the left) was the *Fram*'s captain. Johansen was the *Fram*'s stoker and always addressed Nansen as "Doctor Nansen" even when the two were huddled together in a small tent. (Reprinted from Ref. 6.)

Nansen was also an accomplished artist, as shown by his woodcut illustration of the aurora (Fig. 9).

Nansen provided the following account of his temperature and salinity observations:

> The hydrographic observations made during the expedition furnished some surprising data. Thus, for instance, it was customary to look upon the polar basin as being filled with cold water, the temperature of which stood somewhere about −1.5°C. Consequently our observations showing that under the cold surface there was warmer water, sometimes at a temperature as high as 1°C, were surprising. Again, this water was more briny than the water of the polar basin has been assumed to be. This warmer and more strongly saline water must clearly originate from the warmer current of the Atlantic Ocean (the Gulf Stream), flowing in a north and northeasterly direction off Novaya Zemlya and along the west coast of Spitzbergen, and then diving under the colder, but lighter and less briny, water of the Polar Sea, and filling up the depths of the polar basin. These hydrographic observations appear to modify to a not inconsiderable extent the theories hitherto entertained as to the direction of the currents in the northern seas.[6]

While the *Fram* was drifting, Nansen noticed that the ice always moved to the right of the wind direction, and he concluded that this must be the result of the Earth's rotation. Nansen described this observation to Vilhelm W. Bjerknes, the famous meteorologist, during a visit to Stockholm in 1900. Bjerknes assigned a young assistant, V. Walfred Ekman, the task of providing the appropriate mathematical description of this effect. Ekman's mathematics formed the foundation for the modern theory of wind-driven currents.

Figure 9. Woodcut of the aurora borealis by Nansen. It is assumed that the figure in the foreground is Nansen himself. (Courtesy of the Norwegian Academy of Science.)

FURTHER *FRAM* VOYAGES

The *Fram* was used by Otto Sverdrup in a second Arctic expedition between 1898 and 1902. Sverdrup's objective was to find a passage north of Greenland, and he charted more than 100,000 square miles of unexplored territory. Between 1910 and 1912, Roald Amundsen commanded the *Fram*. The goal of his expedition was to reach the North Pole; until the last moments, the voyage was to have included Nansen, who made a difficult decision to remain home (he was almost 49 at this time). When it was learned that Robert E. Peary had claimed the North Pole in April 1909, Amundsen sailed directly south toward the Antarctic (much to the annoyance of Robert Falcon Scott, the British explorer, who was mounting a final assault on the South Pole). The *Fram* sailed to Antarctica (see Fig. 10), where Amundsen dashed to the South Pole and planted the Norwegian flag on 14 December 1911, a month before Scott arrived there.[8] The *Fram* still holds the record for a ship reaching points that are both the farthest north (85°27′) and the farthest south (78°41′).

The Panama Canal was about to be opened in the autumn of 1912, and the *Fram* was offered the honor of being the first ship to sail through it. She was anchored near Colon, Panama, on 4 October 1912, but since she had not been designed for tropical waters, the *Fram* began to rot. After three months, she was forced to return to Buenos Aires and finally sailed back to Norway in 1914. It was discovered that the decay had gone so far that she could not be repaired. In 1935, the *Fram* sailed into Oslo Harbor, where she was removed from the sea and displayed in a special museum; she can still be seen there today.

NANSEN'S FURTHER ACTIVITIES

Fridtjof Nansen is regarded by many as the father of modern Norway because of his activities associated with the dissolution of the union between Norway and Sweden in 1905. He expressed the following view in regard to the relationship between the two countries: "Any union in which the one people is restrained in exercising its freedom is and will remain a danger."[2] Nansen was appointed Norway's first minister to England (from 1906 to 1908), following the establishment of the Norwegian monarchy.

In 1920, the League of Nations appointed Fridtjof Nansen as the high commissioner responsible for the repatriation from Russia of almost a half-million prisoners of war from the former German and Austro-Hungarian armies. The new Soviet government would not recognize the League of Nations, but negotiated directly with Nansen. Special identity papers, referred to as "Nansen passports," were carried by such distinguished people as the composer Rachmaninoff and ballerina Anna Pavlova. Vidkun Quisling, Nansen's chief assistant at that time (later to become the infamous traitor of World War II), said that "one has to go back to the age of Caesar or Augustus to see similar world problems laid in the hands of a single individual."[9]

Nansen continued his humanitarian work, organizing relief efforts for millions of people in the U.S.S.R. during a terrible famine following the Bolshevik revolution. In 1923, he organized the exchange of hundreds of thousands of Greek and Turkish prisoners after the 1921–22 war in Asia Minor.

In a letter written by Sigmund Freud in September 1932 to Albert Einstein, the causes of war and the role of scientists in preventing war were discussed. In that context, Freud referred to Fridtjof Nansen as a "lover of his fellow men, who responded to the call of the League of Nations" and who "took on himself the task of succoring homeless and starving victims of the World War."[10] In 1922, Nansen was awarded the Nobel Peace Prize; he used the prize money to support his international relief work.

In 1929, at the age of 68, Fridtjof Nansen prepared for a flight to the North Pole in the *Graf Zeppelin*. Airplanes did not interest him because they could not land on the ice, but the *Zeppelin* could hover and conduct scientific measurements. He signed a contract with the German government for a flight in the spring of 1930, but he died on 13 May of that year.

Baron Ferdinand von Richthofen, an eminent geographer of the time, provided the following description of Nansen after hearing him lecture in 1890:

> The peculiar magic of Nansen's personality, which never fails to affect those who stand face to face with him, was strongly felt during the delivery of this lecture. He took us all captive by the strength of his immovable will. We saw in him a strong man marching towards a clearly realized goal, and clinging with tenacious energy to a well weighed and carefully projected plan. In him were found, in happy combination, unusual enterprise and scientific sense—qualities so often found divorced. Especially in our age of sport, it may almost be said to be the rule that the most daring feats of strength, such as the conquest of our high mountains, are carried out solely for their own sake and merely to satisfy the lust for adventure. All the more worthy of recognition is it, then, when the greatest physical difficulties are overcome in the service of a higher goal. He has shown both perception and understanding of the problems connected with arctic research.[9]

Figure 10. The *Fram* photographed at the ice barrier in the Antarctic during Amundsen's expedition, 1910–12. (Courtesy of the Norwegian Polar Research Institute and Mittet & Co., Oslo, Norway.)

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