Table 1. List of Faraday rotation events that Levy *et al.* associated with previous radio emission. Optical flares associated with these radio events are also shown.

Date (1968)	Distance from sun to Pioneer 6–earth line of sight (solar radii)	Faraday rotation (U.T.)		Type III dekametric noise burst (U.T.)	Flares associated with noise bursts				
		Maximum	Start		McMath plage No. associated with flare	Location (heliographic coordinates)	Importance No. and flare type	Corrected area (square degrees)	Degrees from west limb
4 Nov.	10.9	1700	1550	1244	9749	S15 W28	–N	0.70	62
				1305					
				1457					
				1502					
				1522					
8 Nov.	8.6	1730	1640	1631	9760	N18 E42	– –F	1.8	132
12 Nov.	6.2	1900	1750	1643	9760	N18 W9	– –F	0.31	81
				1647	9768	N10 E46	–N	1.2	136
				1726	9760	N17 W14	–N	1.5	76
				1746					

Table 2. List of Faraday rotation events and more recent flare identifications.

Date (1968)	Distance from sun to Pioneer 6–earth line of sight (solar radii)	Flare associated with Faraday rotation event					ΔT (hr : min)	$\bar{V}$ (km/sec)	Corrected area (square degrees)	Degrees from west limb
		Start (U.T.)	Maximum (U.T.)	McMath plage No.	Location (heliographic coordinates)	Importance No. and flare type				
4 Nov	10.9	0520	0614	9740	S15 W90	1B	10:30	200	4.8	0
		0933	0938	9740	S18 W90	–N	6:17	330	2.3	0
8 Nov.	8.6	2005*	2018*	9747	N7 W79	1F	20:35	80	1.44	11
		2017*	2032*	9747	N10 W76	–F	20:23	80	0.41	14
12 Nov.	6.2	1421	1452	9754	N5 W72	1B	3:29	340	14	18

* Flare on 7 November.

1 lists those dekametric bursts Levy *et al.* associated with the Faraday rotation events and information concerning the flare or flares that began a few minutes prior to the radio emission (*2*).

Table 2 lists the flares that I find to be more likely causes of the Faraday rotation events observed in the passage of the Pioneer 6 radio signal through the solar corona. These flares did not produce any observed type III radio emission but it would appear that the particle-producing ability necessary for the type III radio bursts (occurring within a few tenths of a solar radius above the photosphere) need not be related to the ability of that flare to cause coronal disturbances of the type observed by Levy *et al.* These coronal disturbances occur at about ten solar radii and are effects more likely associated with the ambient plasma at these distances.

The flares listed in Table 2 are located within 20° of the west limb of the sun. The west limb is the most favored position for producing the effects observed. All the flares listed in Table 1 are more than 60° away from the west limb and in one case the flare is 132° away. The flares listed in Table 2 are substantially larger in importance number and area. In addition, the transit times ΔT calculated for these events (on the basis of the starting time of the event rather than the time of the maximum) result in average coronal velocities $\bar{V}$ of a few hundred kilometers per second, in agreement with Parker's model of the solar wind (*3*) rather than with values several times larger. This agreement, however, is a product of the identification rather than a necessary condition, as these may be unusual events.

The correct identification of solar-associated events observed on earth with particular flares and active regions on the sun is a difficult task near the solar maximum as there are many active centers and many are flaring. It is, however, my opinion, and Levy *et al.* concur, that the flares listed in Table 2 are more likely the causal agents responsible for the Faraday rotation events than those flares listed in Table 1.

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3 September 1969

Ice Survey by the U.S. Coast Guard

The greatest mass of ice in the Northern Hemisphere is the Greenland ice sheet. Since the first crossing by F. Nansen in 1888, it has been the subject of recurrent exploration and investigation. As a result of detailed studies within the last two decades, it has become the earth's best known continental glacier. We now have extremely valuable information about the thickness of ice, the configuration of the subglacial floor, and the relationship of these elements to surface form. Seismic data (*1*, p. 242) indicate that the subglacial floor is like a great saucer with a portion resting below sea level.

Recently developed measurement of ice depths by airborne radio sounding is providing additional data on the thickness of the Greenland Ice Cap (2). The highest point on the crest of the ice cap in the north is near the center of the continent but is much closer to the eastern margin in the southern two-thirds. A broad depression extends transversely across Greenland near the Arctic Circle (*1*, p. 21). This depression terminates at both ends at some of the largest, most active outlet glaciers in Greenland. The outlet glaciers on the west coast in the Northeast Bay and Disko Bay areas were the subject of study by the U.S. Coast Guard in the summer of 1968. The area provided a fine display of huge tidal outlet glaciers, most of which are afloat. These glaciers are the principal sources of icebergs, many of which find their way into the North Atlantic shipping lanes.

Between 1928 and 1935 the Coast Guard expeditions to Greenland identified 21 major iceberg-producing glaciers. The last time they had been studied by Coast Guard Ice Patrol oceanographers was in 1940, and this effort was curtailed owing to the outbreak of World War II. Glaciologists and other scientists who have studied Greenland glaciers more recently have concluded that the general decline of glaciers typical of the first half of the century is now moderating (*1*, p. 280). Thus a systematic effort to determine the fronts of glaciers on the west coast of Greenland and the iceberg productivity of these glaciers was in order. In 1968 nine of the glacier fronts were charted and bench marks were established for future surveys. Observations included an inventory of iceberg size, type, distribution, and movement.

The variation in the length of Greenland glaciers and their movements attracted the attention of scientists at an early period. In various places accurate determinations of the position of the glacier fronts were undertaken, thus making it possible to establish the extent of changes that have taken place. Umanak Fjord on the west coast of Greenland has been the location of several measurements over a period of 62 years, 1850–1912, and these measurements demonstrate erratic advances and retreats. In 1851 Rink found that the Umiatorfik Glacier had its terminus 372 m from the sea. In 1875 it was 322 m from the sea, and in 1879 Steenstrup found that it was 535 m from the sea (*3*).

The margin of the Jacobshavn Glacier has shown the most impressive variations. The position of the front was measured several times between Rink's visit in 1850 and Engell's visit in 1902 (*4*). Although there were short periods of advance, they were exceeded by a retirement, which totaled 11 km by 1902. The Coast Guard party in 1968 was able to make a count of the huge quantity of bergs in the fjord.

Fig. 1. Principal iceberg-producing glaciers of west Greenland.

The output of icebergs is really the most impressive phenomenon of the glaciers in the Disko Bay and the Northeast Bay areas. The estimate of annual iceberg production in all of Greenland glaciers varies between 150 and 215 km^3 of water. West Greenland produces 87 km^3 of icebergs annually. From the movement of Jacobshavn Glacier alone it is estimated that its annual iceberg production is 20 km^3 of ice (*1*, p. 272).

The 1969 party, following the pattern established in 1968, surveyed the area between Upernivik and Kap York. The major iceberg-producing glaciers visited in this area included Upernivik, Gade, King Oscar, Hayes, Steenstrup, Nansen, and Dietrichson. Secondary glaciers in the area also surveyed included Cornell, Giesecke, and Ussing. The base of operations was the U.S. Coast Guard icebreaker *Southwind*. Field parties were transported from the vessel to the vicinity of the survey sites by helicopters. Helicopters were also used to obtain oblique and vertical photographs of the glacier fronts. A camera-equipped plane photographed the major glacier fronts along the west coast of Greenland from 68°N to the Humboldt Glacier. Preliminary data indicate that there has been dramatic retirement of some of the glaciers and particularly of Upernivik.

As a member of the University of Michigan expedition in 1931, I found that the Upernivik Glacier had receded an average of 914 m from its reported position in 1887, and in some parts of its front it had receded as much as 1524 m. The Giesecke Glacier in the same region on the west coast had retreated 610 m in its active portion by comparison with Ryder's 1886 measurements.

Between my own studies in 1931 and 1947, the Upernivik Glacier retired approximately 5 km. This determination was made from aerial maps prepared by the Danish Geodetic Survey (*5*). From preliminary information brought back by the 1969 survey party, it is apparent that there has been a substantial retirement since the 1947 survey.

Giesecke Glacier, farther north, also shows signs of losses, but they are less dramatic than those at Upernivik.

There is a wealth of material about the Greenland ice sheet that will give other evidence about the advances and retreats. The Coast Guard should give serious consideration to comparing its aerial photographs, the large-scale and fairly detailed aeronautical charts published by the Army Map Service, and the charts and maps available through the Danish Geodetic Institute. On the west Greenland coast the institute over a period of several decades has completed a continuous triangulation from Cape Farewell to Thule. In addition to numerous base lines, there are 15 astronomic stations and over a hundred major stations. A study of available maps and of aerial photographs taken for use in map-making would doubtless yield additional valuable information about the extent of iceberg production of the glaciers under study. The bench marks that have been established will be useful in the continuation of this important work.

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