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Catalogue of Persistent Trains II: Images of Leonid Meteor Trains during the METRO Campaign 1998–2002

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Abstract

As a result of the meteor train observation (METRO) campaign in 1998–2002, statistically sufficient numbers of persistent meteor train images of the Leonids were obtained by Japanese amateur observers. The image archive now contains images of 439 sequences for 176 persistent meteor trains, including 53 multiple-site simultaneous observations. During the first systematic observation campaign for the imaging of persistent meteor trains, many amateur observers were able to capture images of persistent train structures with sufficient accuracy through the use of a photographic/video observation technique established at the onset of the METRO campaign. Promotion of the campaign to collaborators resulted in the multiple detection of these extremely rare phenomena during the Leonid storms in the East Asia region in 2001. The high temporal and spatial resolution of the archived images makes the catalogue invaluable for statistical studies of persistent train morphology, event studies of meteor train plasma and upper atmospheric science.

Key words: Persistent meteor train, Imaging, Triangulation observation, Amateur observers, METRO campaign

1. Introduction

Statistically sufficient numbers of images of persistent meteor trains have proved difficult to obtain due to the extreme rarity of these phenomena. Although many researchers have reported observations of persistent trains over the last century (e.g. Trowbridge 1907, Liller and Whipple 1954, Baggaley 1977, Shigeno et al. 1998, Jenniskens et al. 2000, Abe et al. 2003, Borovička and Koten 2003, Suzuki 2003), the investigation of even basic morphologies has yet to be performed in any detail. In the period of 1998–2002, many persistent trains were observed during Leonid meteor storms due to the establishment of the meteor train observation (METRO) campaign in Japan as a well-integrated observation campaign targeting persistent meteor trains. Through the successful cooperation of skilled amateur observers and recent advancements in imaging instrumentation, the first statistically adequate number of images of persistent meteor trains were obtained. As an archive of valuable data for future studies, an image catalogue of Leonid meteor trains has been created and is presented in this paper.

Leonids activity was elevated in 1998–2002 due to the return of the parent comet 55P/Tempel-Tuttle to perihelion in 1998. Corresponding to the encounter with multiple dust trails, Japan and East Asia encountered a Leonid meteor storm of ZHR = 4520 at 18:10 UT on Nov. 18 (3:10 JST on Nov. 19), 2001 (Ogawa and Uchiyama 2001). As the Leonids have a high incidence velocity of 71 kms^{-1}, the appearance of persistent meteor trains of Leonids occurs much more often during Leonids events than during other meteor showers. Although Leonid meteor storms have been reported historically, the rate of Leonid persistent train appearance was unknown due to the lack of a concerted observation campaign aimed at meteor train imaging. The perihelion passage of the parent comet of the Leonids thus provided an important opportunity for meteor train imaging. The METRO campaign was initiated in 1998 with the objective of obtaining multiple-site observations of meteor trains with high spatial and temporal resolution in order to allow the height, three-dimensional structure and motion of persistent meteor trains to be resolved. The meteor train images were also expected to be useful for study of the upper atmospheric wind system.

The METRO campaign was aimed at amateur observers, raising awareness as to the importance of highly integrated observations of persistent meteor trains through high-resolution imaging. The campaign resulted in the collection of much useful information regarding meteor train morphology. Observation of persistent train events and rapid, repeated photography or video imaging of the luminescence through manual techniques proved to be effective for capturing the intrinsic motion of the meteor trains and the diffusion speed in the upper atmosphere. For events that were observed and captured at multiple sites, precise heights and three-dimensional structures can be determined for the moving persistent trains.

In the past, observations of meteor trains by Japanese amateur observers (Toda et al. 2004) have demonstrated the good observation skills of amateur observers, and these skills were put to good use during the 1998–2002 period when the frequency of these extremely rare phenomena increased. As a result, the METRO campaign recorded many

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scientifically useful results, again demonstrating the good skills of the collaborators. During the campaign period in 1998–2002, more than 439 image sequences including 53 multiple-site observations and 123 single-site observations were submitted to the METRO campaign. Prior to the METRO campaign, precision investigations of the heights and structures of persistent trains were limited in number. The image catalogue of persistent meteor trains created during the METRO campaign therefore provides a new opportunity to determine these features statistically. In this paper, the observations are listed and examples of the images are presented. The complete set of image sequences and video observations will soon be available via the internet (Yamamoto et al. 2005).

2. Observation methods

Meteor trains were photographed by still imaging using film and digital cameras and by video imaging. The most common technique for capturing meteor train images involved 1) manually targeting and photographing the meteor train upon appearance, 2) precise recording of the appearance time of parent fireballs and the timing of each snapshot, 3) recording of the magnitude of the fireballs and the background constellations, and 4) recording of the local coordinates of the observation site. This method was carefully reviewed before the METRO campaign on the basis of past observation examples. The largest numbers of observations were recorded in 2001 when Japan and East Asia encountered the largest meteor storm of this period.

2-1. Still imaging (film and digital cameras)

As persistent meteor trains in the upper atmosphere undergo rapid diffusion, short exposures of imaging are important for obtaining high-quality detailed images of persistent train structures. The use of lenses with long focal length is also important for high-resolution imaging of the events, and wide-aperture lenses and high-sensitivity film are necessary for high-quality imaging of the faint luminescence. As repeated short-exposure photographs or video imaging allow the complex motion of persistent trains to be resolved, image sequences were obtained by the following technique during the METRO campaign: 1) Use of a telephoto lens with focal length of over 200 mm, 2) use of a wide-aperture lens of F = 2.8 or brighter, 3) taking short exposures of less than 4 s, and 4) using film with a total sensitivity of ISO = 12,800 for monochrome film and ISO = 6400 for color film, after the quadruple intensifying treatment. Digital devices, such as charge-coupled device (CCD) and complementary metal oxide semiconductor (CMOS) cameras, although undergoing rapid development in terms of sensitivity and resolution in those years, were also used to capture the faint luminescence of meteor trains. However, the resolution of digital devices was lesser than that of 35 mm film at that time.

These observation techniques were evaluated during the METRO campaign and were adjusted during the observation period. For example, in 1998, a 4 s exposure using a 200 mm lens was deemed acceptable, but in 2001 the use of a 1 s exposure time and 400 mm telephoto lens was suggested. Figure 1 shows an example of the photographic instrumenta-

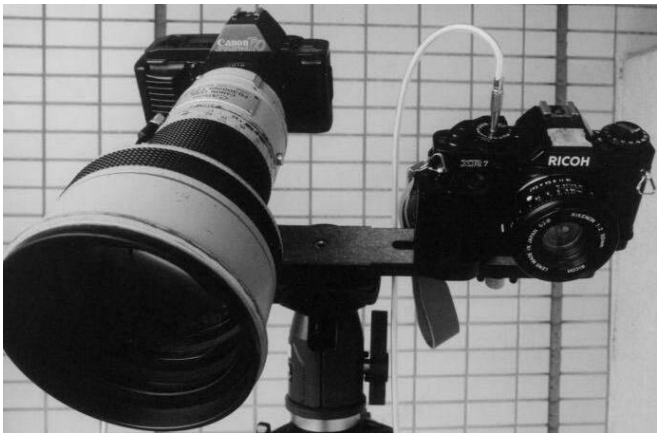

Fig. 1. An example of photographic camera with a 300 mm telephoto lens for meteor train imaging. A camera with a 300 mm F=2.8 telephoto lens was equipped with another camera with a 50 mm lens. The 300 mm telephoto lens was used for fine imaging, whereas, the 50 mm one was available in determining the whole structures of meteor trains as well as the background constellation field. Synchronous timings of exposures should be applied for the two-cameras system.

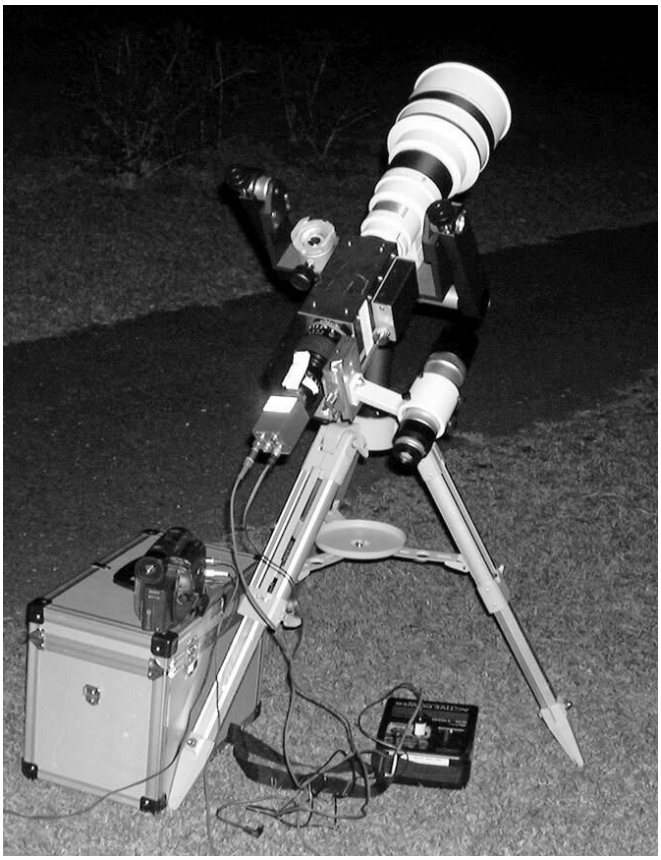

Fig. 2. An example of the video observation system for meteor train imaging. It consisted of a 400 mm telephoto lens for 35 mm film camera, a 1-inch I.I. (whose gain is 50,000 times), a pair of relay lenses, and a 1/2-inch monochrome CCD video camera. The I.I. was equipped at the focal plane of the 400 mm lens and output light was guided to the video CCD using the relay lens system. The combined focal length was about 550 mm. Recording media was a "Hi8" type analog videotape. A fork type platform for vertical and horizontal motions with free-stop capabilities was used.

tion used. Time keeping within 1 s error was realized through the use of time signals transmitted by short-wave radio or determined using a global positioning system (GPS) receiver.

2-2. Video imaging

Digital video imaging, while limited in spatial resolution, is effective for detecting the rapid motion of persistent meteor trains. Compared with photographic imaging, digital video imaging has the advantage that sequences of highly fixed snapshots can be obtained easily at high temporal resolution of 1/30 of a second per frame, as well as allowing for extended recording times. Film imaging is limited in terms of film length, which may be of particular concern when taking repeated images at short exposure times. Digital video is also limited in terms of color sensitivity, which is lower than for film except for highly integrated video cameras for professional broadcasting (Tanioka et al. 2003). For example, while bright meteor trains can be detected by a CCD video camera, a video camera with an image intensifier (I.I.) is able to detect the fine structure of faint train luminescence more clearly. An example of a video system is shown in figure 2. A video monitor is typically used for quick and secure aiming at the faint luminescence. Video recorders were suggested to be in constant operation during observation in order to detect the "flash" timing of fireball appearances and thereby allow accurate times of observations to be successfully recorded. Time keeping for video imaging followed the same procedure as for still imaging.

3. Results

The METRO campaign was widely announced to amateur observers in Japan through astronomical news for the general public, scientific workshops and meetings, and the campaign website itself (Yamamoto et al. 1998). During the 5-year period of the METRO campaign for Leonids observation, a nationwide network of observers was successfully established (Toda et al. 2003). The accuracy of meteor storm prediction was also improved during this period by accounting for encounters with multiple dust trails (McNaught and Asher 1999), making it possible to specify in detail the date and time of observation.

The image sequences reported in the 1998–2002 period are listed in Table 1. In 1998, 5 trains were observed by 20 observers, including one bright and long-lasting persistent train generated by a –8 magnitude fireball. In 1999, 7 trains were reported by 7 observers, and in 2000, 2 trains were photographed by 17 collaborators. In 2001, as predicted by several researchers (e.g. Asher and McNaught 2000, Lyytinen and Van Flandern 2000), a vigorous Leonid meteor storm was observed over Japan (and also in East Asia), resulting in the successful recording of 154 persistent trains throughout Japan under the clear sky condition. In 2002, according to the storm predictions in European and American region (e.g. McNaught and Asher 2002, Vaubaillon 2002), 10 observers including earnest observers who visited Spain and the USA obtained 8 train results.

Examples of high-quality image sequences are displayed in figures 3 to 5. Figure 3 shows sequences of fine color images, figure 4 shows examples of sequences of grayscale and middle-level color images, and examples of video sequences are shown in figure 5.

The 439 observations of Leonid persistent trains obtained between 1998 and 2002 in Japan are listed in Table 1, showing the observation date and time, the observer, the number of obtained images, the focal length f and F-number of the lens used, the observation site (city or town, prefecture), and the image sequence code. The example images presented in this paper are only a small fraction of the vast data set collected during the METRO campaign. The full set

Table 1. List of archived persistent trains. All cases (439 sequences for 176 trains) were observed in Japan during 1998–2002, except for No. 463–469 observed in Spain and No. 470–474 in U.S.A. The results include 53 groups of simultaneous observation from multiple sites (indicated by 'bold' train numbers). Images archived in figures 3 to 5 are numbered by 'No.' and 'Images' of this table. Code of each image sequence is labelled by the rule described as the text of subsection 3.1. Though the number listed in the column of 'Images' means whole obtained samples, not every image was archived in figures 3 to 5.

No.	Train	Observation date	Time with error	Observer	Device	Images	f	F	Observation site	Code of image sequences	Figure
38				M.Toda		36	200	2.0	Gotemba, Shizuoka	L 199811180413_todamasa1CF01	3-01
39				J. Komoriya		8	105	2.0	Misato, Gunma	L 199811180413_komoriya1CF01	3-01
40				A. Ohbayashi		7	100	2.0	Ogasa, Shizuoka	L 199811180413_ohbayash1CF01	3-01
41				NHK	I.I. color HDTV	video	-	-	Gotemba, Shizuoka	L 199811180413_nipponho1CV01	3-02
42				J. Aizawa		19	200	2.8	Miwa, Ibaraki	L 199811180413_aizawajo1CF01	3-02
43				S. Uchiyama		37	85	1.4	Awano, Tochigi	L 199811180413_uchiyama1CF01	3-02
44				H.Yamanaka		8	85	1.8	Amagi-yugashima, Shizuoka	L 199811180413_yamanaka1CF02	4-01
45				N. Shitara		15	50	1.7	Miwa, Ibaraki	L 199811180413_shitaran1CF01	4-01
46				Y. Shigeno		5	300	2.8	Miyagi, Gunma	L 199811180413_shigenoy1CF01	4-01
47	**30**	Nov. 18, 1998	4:13:55 ±2s	M. Oba		3	24	2.8	Amagi-yugashima, Shizuoka	L 199811180413_obamasah1CF01	4-01
48				Y.Takeda		21	50	2.0	Asahi, Ibaraki	L 199811180413_takedaya1CF01	4-01
49				Ma. Kobayashi		13	85	1.4	Oizumi, Yamanashi	L 199811180413_kobayash1CF01	4-02
50				N. Kurita		10	50	1.4	Oizumi, Yamanashi	L 199811180413_kuritana1CF01	4-02
51				B. Suzuki	CCD (CV-04)	20	50	1.4	Otaki, Saitama	L 199811180413_suzukibu1MD01	4-02
52				S. Takemoto	I.I. + video	video	28	-	Narusawa, Yamanashi	L 199811180413_takemoto1MV01	5-01
53				K. Karasaki	I.I. + video	video	135	3.5	Miura, Kanagawa	L 199811180413_karasaki1MV01	5-01
54				M. Fujita		1	50	1.4	Miwa, Ibaraki	L 199811180413_fujitami1CF01	-
55				M.-Y. Yamamoto		5	105	1.8	Bato, Tochigi	L 199811180413_yamamoto1CF01	-
56				C. Tanaka		6	50	1.4	Shimonita, Gunma	L 199811180413_tanakach1CF01	-
57				H. Minegishi		1	50	-	Mishima, Shizuoka	L 199811180413_minegish1CF01	-
58	31	Nov. 18, 1998	about 04:30	N. Shitara		3	50	1.7	Miwa, Ibaraki	L 199811180430_shitaran1CF01	-
59				N. Shitara		15	50	1.7	Miwa, Ibaraki	L 199811180444_shitaran1CF01	4-02
60	**32**	Nov. 18, 1998	4:44:00 ±30s	J. Aizawa		14	200	2.8	Miwa, Ibaraki	L 199811180444_aizawajo1CF01	4-02
61				M.-Y. Yamamoto		5	105	1.8	Bato, Tochigi	L 199811180444_yamamoto1CF01	-
62				K. Karasaki	I.I. + video	video	135	3.5	Miura, Kanagawa	L 199811180444_karasaki1MV01	5-01
63	33	Nov. 18, 1998	4:59:30 ±30s	J. Aizawa		1	200	2.8	Miwa, Ibaraki	L 199811180459_aizawajo1CF01	-
64	34	Nov. 18, 1998	5:06:30 ±30s	J. Aizawa		5	200	2.8	Miwa, Ibaraki	L 199811180506_aizawajo1CF01	-
65				N. Shitara		4	50	1.7	Miwa, Ibaraki	L 199811180506_shitaran1CF01	-
66				S. Suzuki		12	85	1.2	Kobuchizawa, Yamanashi	L 199911190136_suzukisa1CF01	4-03
67	**35**	Nov. 19, 1999	1:36:22 ±2s	K. Kobayashi		3	50	2.8	Seki, Mie	L 199911190136_kobayask1CF01	4-03
68				K. Nagashima		3	85	1.4	Kasagi, Kyoto	L 199911190136_nagashim1CF01	4-03
69	36	Nov. 19, 1999	2:00:30 ±30s	T. Kuroda		1	85	1.2	Minamimaki, Nagano	L 199911190200_kurodato1MF01	-

Table 1. (continued)

No.	Train	Observation date	Time with error	Observer	Device	Images	f	F	Observation site	Code of image sequences	Figure
70				S. Suzuki		12	85	1.2	Kobuchisawa, Yamanashi	L 199911190231_suzukisa1CF01	4-03
71	**37**	Nov. 19, 1999	2:31:00 ±2s	T. Kuroda		1	85	1.2	Minamimaki, Nagano	L 199911190231_kurodato1MF01	4-03
72						4	85	1.2	Minamimaki, Nagano	L 199911190231_kurodato2CF01	-
73	38	Nov. 19, 1999	3:32:24 ±2s	M. Toda		18	200	2.0	Oyama, Shizuoka	L 199911190332_todamasa1CF01	4-04
74	39	Nov. 19, 1999	4:04:32 ±2s	T. Kuroda		2	85	1.2	Minamimaki, Nagano	L 199911190404_kurodato2CF01	-
75	**40**	Nov. 19, 1999	4:26:24 ±2s	T. Ichikawa		1	50	1.4	Yasuura, Hirosima	L 199911190426_ichikawa1CF01	4-04
76				K. Maruoka		12	50	1.4	Kainan, Tokushima	L 199911190426_maruokak1CF01	4-04
77	41	Nov. 20, 1999	5:00:33 ±2s	T. Kuroda		12	50	1.4	Minamimaki, Nagano	L 199911200500_kurodato2CF01	-
78				Y. Higa		37	50	2.0	Yamamoto, Miyagi	L 200011190335_higayosh2CF01	3-03
79						17	300	2.8	Yamamoto, Miyagi	L 200011190335_higayosh1MF01	4-05
80				M.-Y. Yamamoto		24	105	1.8	Yamamoto, Miyagi	L 200011190335_yamamoto1CF02	3-03
81				T. Ozaki		6	50	1.4	Miwa, Ibaraki	L 200011190335_ozakitoy1CF01	3-03
82				M. Nakamura		10	105	2.8	Ogawa, Tochigi	L 200011190335_nakamura1CF01	3-03
83				H. Okayasu		18	50	2.0	Shiraoka, Saitama	L 200011190335_okayasuh1CF01	4-04
84				S. Uchiyama		3	50	2.0	Makabe, Ibaraki	L 200011190335_uchiyama1CF01	4-04
85				M. Uehara		10	50	1.4	Yamamoto, Miyagi	L 200011190335_ueharami1CF01	4-05
86	**42**	Nov. 19, 2000	3:35:31 ±2s	F. Kanno		18	180	2.8	Oshika, Miyagi	L 200011190335_kannofum1CF01	4-05
87				A. Yoshida		4	50	1.8	Yamamoto, Miyagi	L 200011190335_yoshidaa1CF01	4-05
88				Y. Sato		4	28	2.5	Ogoe, Fukushima	L 200011190335_satoyosh1CF01	4-05
89				M. Saito		17	50	1.4	Yamamoto, Miyagi	L 200011190335_saitomas1CF02	4-06
90				R. Ikeshita		12	50	1.4	Yamamoto, Miyagi	L 200011190335_ikeshita1CF01	4-06
91				Ma. Sato		1	135	2.0	Kitakami, Miyagi	L 200011190335_satomako1CF01	4-06
92				F. Futaba		2	50	1.4	Misaki, Chiba	L 200011190335_futabafu1CF01	4-06
93				H. Saeki		1	-	-	Namie, Fukushima	L 200011190335_saekihir1CF01	4-06
94				S. Shibuya		2	50	1.2	Kamikawa, Saitama	L 200011190335_shibuyas1CF01	4-06
95	**43**	Nov. 19, 2000	5:08:15 ±2s	M.-Y. Yamamoto		3	105	1.8	Yamamoto, Miyagi	L 200011190508_yamamoto1CF01	4-07
96				Mi. Sato		2	28	2.8	Narusawa, Yamanashi	L 200011190508_satomiki1CF01	4-07
97	44	Nov. 16, 2001	2:02:30 ±30s	M. Koishikawa		25	-	-	Sendai, Miyagi	L 200111160202_koishika1CF01	-
98	45	Nov. 18, 2001	23:54:05 ±2s	S. Suzuki	CMOS (D-30)	2	100	2.0	Yachiho, Nagano	L 200111182354_suzukisa1CD01	4-07
99						2	100	2.0	Yachiho, Nagano	L 200111182354_suzukisa2CF01	-
100				R. Ikeshita		11	135	2.8	Yamamoto, Miyagi	L 200111190050_ikeshita1CF01	4-07
101	**46**	Nov. 19, 2001	0:50:31 ±2s	N. Ogura		17	100	2.0	Samegawa, Fukushima	L 200111190050_oguranob1CF01	4-07
102				S. Sugimoto	I.I. + video	video	85	1.2	Nasu, Tochigi	L 200111190050_sugimoto1MV01	5-02
103	47	Nov. 19, 2001	0:56:17 ±2s	S. Suzuki	CMOS (D-30)	8	100	2.0	Yachiho, Nagano	L 200111190056_suzukisa1CD01	4-08
104						8	100	2.0	Yachiho, Nagano	L 200111190056_suzukisa2CF01	-

Table 1. (continued)

No.	Train	Observation date	Time with error	Observer	Device	Images	f	F	Observation site	Code of image sequences	Figure
105				S. Suzuki	CMOS (D-30)	11	100	2.0	Yachiho, Nagano	L 200111190106_suzukisa1CD01	4-08
106	**48**	Nov. 19, 2001	1:06:28 ±2s			9	100	2.0	Yachiho, Nagano	L 200111180106_suzukisa2CF01	-
107				M. Toda		12	58	1.2	Oizumi, Yamanashi	L 200111190106_todamasa2CF01	4-08
108				H. Okayasu		10	50	1.4	Shobu, Saitama	L 200111190106_okayasuh1CF01	-
109	49	Nov. 19, 2001	1:07:39 ±2s	N. Ogura		18	100	2.0	Samegawa, Fukushima	L 200111190107_oguranob1CF01	4-08
110				K. Maeda	I.I. + video	video	400	2.8	Tsuno, Miyazaki	L 200111190116Amaedakou1MV01	5-02
111	**50**	Nov. 19, 2001	1:16:18 ±5s	N. Tanaka		3	50	1.4	Tsuno, Miyazaki	L 200111190116Atanakana1CF01	-
112				Misato Obs.	Color CCD (BJ-32c)	8	3.5	1.4	Misato, Wakayama	L 200111190116Amisatoob1CD01	-
113				M. Owada		5	85	1.4	Haruno, Shizuoka	L 200111190116Bowadamin1MF01	4-09
114				Y. Yoshino		11	135	2.0	Otaki, Saitama	L 200111190116Byoshinoy1CF01	4-09
115				M. Toda		37	58	1.2	Oizumi, Yamanashi	L 200111190116Btodamasa2CF01	4-09
116	**51**	Nov. 19, 2001	1:16:54 ±2s	S. Suzuki	CMOS (D-30)	8	100	2.0	Yachiho, Nagano	L 200111190116Bsuzukisa1CD01	4-09
117						3	100	2.0	Yachiho, Nagano	L 200111180116Bsuzukisa2CF01	-
118				N. Kurita		5	180	2.5	Oizumi, Yamanashi	L 200111190116Bkuritana1CF01	4-09
119				S. Amikura		5	200	4.0	Gozenyama, Ibaraki	L 200111190116Bamikuras1CF01	-
120	52	Nov. 19, 2001	1:22:16 ±2s	S. Suzuki	CMOS (D-30)	3	100	2.0	Yachiho, Nagano	L 200111190122_suzukisa1CD01	4-10
121				N. Kurita		4	180	2.5	Oizumi, Yamanashi	L 200111190136_kuritana1CF01	4-10
122				Ma. Kobayashi		7	85	1.4	Oizumi, Yamanashi	L 200111190136_kobayash1CF01	4-10
123				M. Toda		16	200	4.0	Oizumi, Yamanashi	L 200111190136_todamasa1CF01	4-10
124						30	58	1.2	Oizumi, Yamanashi	L 200111190136_todamasa2CF01	4-10
125	**53**	Nov. 19, 2001	1:36:33 ±2s	Y. Natsume		8	135	2.8	Shitara, Aichi	L 200111190136_natsumey1CF01	4-11
126				S. Suzuki	CMOS (D-30)	3	100	2.0	Yachiho, Nagano	L 200111190136_suzukisa1CD01	4-11
127						5	100	2.0	Yachiho, Nagano	L 200111190136_suzukisa2CF01	-
128				Y. Yoshino		11	135	2.0	Otaki, Saitama	L 200111190136_yoshinoy1CF01	4-11
129				N. Koshiyama		37	85	2.0	Haruno, Shizuoka	L 200111190136_koshiyam1CF01	4-11
130				M. Owada		17	85	1.4	Haruno, Shizuoka	L 200111190136_owadamin1MF01	4-11
131	54	Nov. 19, 2001	1:41:32 ±9s	Misato Obs.	Color CCD (BJ-32c)	8	3.5	1.4	Misato, Wakayama	L 200111190141_misatoob1CD01	-
132	55	Nov. 19, 2001	1:43:48 ±2s	Y. Natsume		3	135	2.8	Shitara, Aichi	L 200111190143_natsumey1CF01	-
133	56	Nov. 19, 2001	1:44:29 ±2s	M. Toda		3	58	1.2	Oizumi, Yamanashi	L 200111190144Atodamasa2CF01	-
134	57	Nov. 19, 2001	1:44:29 ±5s	K. Maeda	I.I. + video	video	400	2.8	Tsuno, Miyazaki	L 200111190144Bmaedakou1MV01	5-02
135				N. Tanaka		3	50	1.4	Tsuno, Miyazaki	L 200111190144Btanakana1CF01	-

Table 1. (continued)

No.	Train	Observation date	Time with error	Observer	Device	Images	f	F	Observation site	Code of image sequences	Figure
136				Y. Ishiduka		22	85	1.7	Takayama, Gunma	L 200111190147_ishiduka2CF02	3-04
137						4	400	3.5	Takayama, Gunma	L 200111190147_ishiduka1MF01	4-12
138				Y. Watanabe		11	50	2.0	Niiharu, Gunma	L 200111190147_watanabe1CF01	3-04
139				S. Suzuki	CMOS (D-30)	12	100	2.0	Yachiho, Nagano	L 200111190147_suzukisa1CD01	3-05
140						14	100	2.0	Yachiho, Nagano	L 200111190147_suzukisa2CF01	-
141				N. Ogura		18	100	2.0	Samegawa, Fukushima	L 200111190147_oguranob1CF01	3-05
142				Y.Takeda		15	85	1.8	Daigo, Ibaraki	L 200111190147_takedaya1CF01	3-06
143				N. Kurita		14	180	2.5	Oizumi, Yamanashi	L 200111190147_kuritana1CF01	3-06
144				S. Amikura		9	200	4.0	Gozenyama, Ibaraki	L 200111190147_amikuras1CF01	3-06
145				Ma. Kobayashi		6	85	1.4	Oizumi, Yamanashi	L 200111190147_kobayash1CF01	3-06
146				M. Owada		14	85	1.4	Haruno, Shizuoka	L 200111190147_owadamin1MF01	4-12
147				H. Okayasu		8	50	1.4	Shobu, Saitama	L 200111190147_okayasuh1CF01	4-12
148				J. Komoriya		6	50	1.4	Shimonita, Gunma	L 200111190147_komoriya1CF01	4-12
149				M. Toda		7	58	1.2	Oizumi, Yamanashi	L 200111190147_todamasa2CF01	4-12
150	**58**	Nov. 19, 2001	1:47:26 ±2s	N. Koshiyama		37	50	1.4	Haruno, Shizuoka	L 200111190147_koshiyam1CF01	4-13
151				S. Nomoto		6	50	1.8	Kounosu, Saitama	L 200111190147_nomotosa1CF01	4-13
152				Y. Yamada		4	50	1.8	Asahi, Aichi	L 200111190147_yamadayo1CF01	4-13
153				Y. Natsume		7	135	2.8	Shitara, Aichi	L 200111190147_natsumey1CF01	4-13
154				M. Saito		7	300	2.8	Satomi, Ibaraki	L 200111190147_saitomas1MF01	4-13
155				K. Tomaru		3	50	-	Shimonita, Gunma	L 200111190147_tomaruku1CF01	4-14
156						2	35	-	Shimonita, Gunma	L 200111190147_tomaruku2CF01	-
157				T. Konishi		12	28	2.8	Urugi, Nagano	L 200111190147_konishit1CF01	4-14
158				T. Sekiguchi		1	50	1.7	Kawagoe, Saitama	L 200111190147_sekiguch1CF01	4-14
159				Mi. Kobayashi		8	40	2.4	Seto, Aichi	L 200111190147_kobayami1CF01	4-14
160				Y. Okamoto	8 s/fr time lapse video	video	3.5	1.4	Oizumi, Yamanashi	L 200111190147_okamotoy1MV01	5-03
161				S. Sugimoto	I.I. + video	video	85	1.2	Nasu, Tochigi	L 200111190147_sugimoto1MV01	5-03
162				A. Kawamura		36	300	2.8	Ontake, Nagano	L 200111190147_kawamura1MF01	-
163				C. Tanaka		1	50	1.7	Gotemba, Shizuoka	L 200111190147_tanakach1MF01	-
164				S. Onuki		1	-	-	Nasu, Tochigi	L 200111190147_ohnukish1CF01	-
165				S. Suzuki	CMOS (D-30)	2	100	2.0	Yachiho, Nagano	L 200111190148_suzukisa1CD01	4-14
166						6	100	2.0	Yachiho, Nagano	L 200111190148_suzukisa2CF01	-
167				Ma. Kobayashi		5	85	1.4	Oizumi, Yamanashi	L 200111190148_kobayash1CF01	4-14
168	**59**	Nov. 19, 2001	1:48:32 ±2s	N. Koshiyama		18	50	1.4	Haruno, Shizuoka	L 200111190148_koshiyam1CF01	-
169				Y. Natsume		7	135	2.8	Shitara, Aichi	L 200111190148_natsumey1CF01	-
170				N. Ogura		18	100	2.0	Samegawa, Fukushima	L 200111190148_oguranob1CF01	-
171				J. Komoriya		2	50	1.4	Shimonita, Gunma	L 200111190148_komoriya1CF01	-
172				Y. Okamoto	8 s/fr time lapse video	video	3.5	1.4	Oizumi, Yamanashi	L 200111190148_okamotoy1MV01	-
173	60	Nov. 19, 2001	1:58:22 ±2s	Y. Natsume		4	135	2.8	Shitara, Aichi	L 200111190158Anatsumey1CF01	4-15

Table 1. (continued)

No.	Train	Observation date	Time with error	Observer	Device	Images	f	F	Observation site	Code of image sequences	Figure
174				S. Suzuki	CMOS (D-30)	1	100	2.0	Yachiho, Nagano	L 200111190158Bsuzukisa1CD01	-
175	**61**	Nov. 19, 2001	1:58:31 ±2s			2	100	2.0	Yachiho, Nagano	L 200111190158Bsuzukisa2CF01	-
176				J. Komoriya		1	50	1.4	Shimonita, Gunma	L 200111190158Bkomoriya1CF01	-
177	62	Nov. 19, 2001	about 02:00	A. Okazaki		8	28	2.8	Rikubetsu, Hokkaido	L 200111190200_okazakia1CF01	4-15
178				S. Suzuki	CMOS (D-30)	2	100	2.0	Yachiho, Nagano	L 200111190201_suzukisa1CD01	4-15
179						2	100	2.0	Yachiho, Nagano	L 200111190201_suzukisa2CF01	-
180	**63**	Nov. 19, 2001	2:01:26 ±2s	J. Komoriya		1	50	1.4	Shimonita, Gunma	L 200111190201_komoriya1CF01	4-15
181				N. Ogura		12	100	2.0	Samegawa, Fukushima	L 200111190201_oguranob1CF01	4-15
182				S. Amikura		6	50	1.7	Gozenyama, Ibaraki	L 200111190201_amikuras1CF01	-
183	64	Nov. 19, 2001	2:02:37 ±2s	K. Maeda	I.I. + video	video	400	2.8	Tsuno, Miyazaki	L 200111190202_maedakou1MV01	5-03
184				N. Tanaka		1	50	1.4	Tsuno, Miyazaki	L 200111190202_tanakana1CF01	-
185	65	Nov. 19, 2001	2:03:36 ±2s	S. Suzuki	CMOS (D-30)	1	100	2.0	Yachiho, Nagano	L 200111190203Asuzukisa1CD01	-
186						2	100	2.0	Yachiho, Nagano	L 200111190203Asuzukisa2CF01	-
187	66	Nov. 19, 2001	2:03:50 ±2s	K. Kato		30	135	1.8	Kitaibaraki, Ibaraki	L 200111190203Bkatokenj1CF01	4-16
188	67	Nov. 19, 2001	2:05:05 ±2s	N. Ogura		4	100	2.0	Samegawa, Fukushima	L 200111190205Aoguranob1CF01	4-16
189	68	Nov. 19, 2001	2:05:13 ±2s	S. Suzuki	CMOS (D-30)	1	100	2.0	Yachiho, Nagano	L 200111190205Bsuzukisa1CD01	-
190						2	100	2.0	Yachiho, Nagano	L 200111190205Bsuzukisa2CF01	-
191	69	Nov. 19, 2001	2:05:53 ±2s	S. Suzuki	CMOS (D-30)	1	100	2.0	Yachiho, Nagano	L 200111190205Csuzukisa1CD01	-
192						2	100	2.0	Yachiho, Nagano	L 200111190205Csuzukisa2CF01	-
193	70	Nov. 19, 2001	2:06:29 ±2s	S. Suzuki	CMOS (D-30)	1	100	2.0	Yachiho, Nagano	L 200111190206_suzukisa1CD01	-
194						2	100	2.0	Yachiho, Nagano	L 200111190206_suzukisa2CF01	-
195	71	Nov. 19, 2001	2:08:47 ±5s	K. Maeda	I.I. + video	video	400	2.8	Tsuno, Miyazaki	L 200111190208_maedakou1MV01	5-04
196	72	Nov. 19, 2001	2:15:12 ±1s	M. Owada		31	85	1.4	Haruno, Shizuoka	L 200111190215Aowadamin1MF01	4-16
197	73	Nov. 19, 2001	2:15:30 ±30s	J. Aizawa		4	200	2.8	Utatsu, Miyagi	L 200111190215Baizawajo1CF01	4-16
198	74	Nov. 19, 2001	2:16:30 ±30s	N. Tanaka		3	50	1.4	Tsuno, Miyazaki	L 200111190216_tanakana1CF01	-
199				J. Aizawa		28	200	2.8	Utatsu, Miyagi	L 200111190217_aizawajo1CF01	3-07
200				N. Ogura		19	100	2.0	Samegawa, Fukushima	L 200111190217_oguranob1CF01	3-07
201				Y.Takeda		17	85	1.8	Daigo, Ibaraki	L 200111190217_takedaya1CF01	3-07
202				Ma. Kobayashi		2	85	1.4	Oizumi, Yamanashi	L 200111190217_kobayash1CF01	4-17
203	**75**	Nov. 19, 2001	2:17:28 ±2s	J. Komoriya		3	50	1.4	Shimonita, Gunma	L 200111190217_komoriya1CF01	4-17
204				N. Koshiyama		3	85	1.4	Haruno, Shizuoka	L 200111190217_koshiyam1MF01	4-17
205				Y. Higa		5	300	2.8	Naraha, Fukushima	L 200111190217_higayosh1MF01	4-17
206						26	85	2.0	Naraha, Fukushima	L 200111190217_higayosh2CF01	4-17
207				T. Watanabe	CCD video (WAT-100N)	video	6	0.8	Tanagura, Fukushima	L 200111190217_watanate1MV01	5-04
208				S. Sugimoto	I.I. + video	video	85	1.4	Nasu, Tochigi	L 200111190217_sugimoto1MV01	5-04
209	76	Nov. 19, 2001	2:19:30 ±30s	N. Tanaka		1	50	1.4	Tsuno, Miyazaki	L 200111190219_tanakana1CF01	-
210				K. Nakatsu		9	28	2.8	Tosashimizu, Kochi	L 200111190238_nakatsuk1CF01	4-18
211	**77**	Nov. 19, 2001	2:38:23 ±2s	S. Kawazu		1	50	4.0	Tosayamada, Kochi	L 200111190238_kawazusa1CF01	4-18
212				T. Saito	I.I. + video	video	28	2.0	Miki, Hyogo	L 200111190238_saitotos1MV01	5-05
213				T. Katsume		2	-	-	Kozuki, Hyogo	L 200111190238_katsumet1CF01	-

Table 1. (continued)

No.	Train	Observation date	Time with error	Observer	Device	Images	f	F	Observation site	Code of image sequences	Figure
214				J. Aizawa		28	200	2.8	Utatsu, Miyagi	L 200111190242Aaizawajo1CF01	4-18
215	**78**	Nov. 19, 2001	2:42:19 ±2s	N. Ogura		17	100	2.0	Samegawa, Fukushima	L 200111190242Aoguranob1CF01	4-18
216				S. Suzuki	CMOS (D-30)	2	100	2.0	Yachiho, Nagano	L 200111190242Asuzukisa1CD01	-
217						2	100	2.0	Yachiho, Nagano	L 200111190242Asuzukisa2CF01	-
218				K. Kato		29	135	1.8	Kitaibaraki, Ibaraki	L 200111190242Bkatokenj1MF02	4-19
219				M. Fujita		15	100	2.8	Naraha, Fukushima	L 200111190242Bfujitami1CF01	4-19
220	**79**	Nov. 19, 2001	2:42:28 ±2s	Y. Higa		8	300	2.8	Naraha, Fukushima	L 200111190242Bhigayosh1MF01	4-19
221						19	85	2.0	Naraha, Fukushima	L 200111190242Bhigayosh2CF01	-
222				S. Sugimoto	I.I. + video	video	85	1.2	Nasu, Tochigi	L 200111190242Bsugimoto1MV01	5-05
223	80	Nov. 19, 2001	2:47:30 ±30s	N. Tanaka		8	50	1.4	Tsuno, Miyazaki	L 200111190247_tanakana1CF01	4-19
224	81	Nov. 19, 2001	2:50:12 ±30s	N. Tanaka		14	50	1.4	Tsuno, Miyazaki	L 200111190250_tanakana1CF01	4-19
225	82	Nov. 19, 2001	2:52:03 ±2s	S. Suzuki	CMOS (D-30)	2	100	2.0	Yachiho, Nagano	L 200111190252Asuzukisa1CD01	-
226						2	100	2.0	Yachiho, Nagano	L 200111190252Asuzukisa2CF01	-
227	83	Nov. 19, 2001	2:52:35 ±2s	J. Aizawa		11	200	2.8	Utatsu, Miyagi	L 200111190252Baizawajo1CF01	4-20
228				S. Suzuki	CMOS (D-30)	3	100	2.0	Yachiho, Nagano	L 200111190252Csuzukisa1CD01	4-20
229	**84**	Nov. 19, 2001	2:52:48 ±2s			4	100	2.0	Yachiho, Nagano	L 200111190252Csuzukisa2CF01	-
230				M. Toda		3	58	1.2	Oizumi, Yamanashi	L 200111190252Ctodamasa2CF01	4-20
231	85	Nov. 19, 2001	2:52:47 ±1s	N. Koshiyama		32	85	1.4	Haruno, Shizuoka	L 200111190252Dkoshiyam1MF01	4-20
232				M. Owada		5	50	1.4	Haruno, Shizuoka	L 200111190252Dowadamin1MF01	4-20
233	86	Nov. 19, 2001	2:53:13 ±2s	J. Aizawa		14	200	2.8	Utatsu, Miyagi	L 200111190253_aizawajo1CF01	4-21
234	87	Nov. 19, 2001	2:55:30 ±30s	N. Tanaka		1	50	1.4	Tsuno, Miyazaki	L 200111190255_tanakana1CF01	-
235	88	Nov. 19, 2001	2:58:23 ±2s	S. Okamoto	I.I. + video	video	50	1.4	Asahi, Aichi	L 200111190258Aokamotos1MV01	5-05
236	89	Nov. 19, 2001	2:58:53 ±2s	S. Suzuki	CMOS (D-30)	1	100	2.0	Yachiho, Nagano	L 200111190258Bsuzukisa1CD01	-
237						1	100	2.0	Yachiho, Nagano	L 200111190258Bsuzukisa2CF01	-
238	90	Nov. 19, 2001	3:01:04 ±2s	J. Aizawa		14	200	2.8	Utatsu, Miyagi	L 200111190301_aizawajo1CF01	4-22
239				Y. Natsume		1	135	2.8	Shitara, Aichi	L 200111190302_natsumey1CF01	4-21
240				S. Suzuki	CMOS (D-30)	4	100	2.0	Yachiho, Nagano	L 200111190302_suzukisa1CD01	4-21
241						5	100	2.0	Yachiho, Nagano	L 200111190302_suzukisa2CF01	-
242	**91**	Nov. 19, 2001	3:02:18 ±2s	N. Koshiyama		7	85	1.4	Haruno, Shizuoka	L 200111190302_koshiyam1CF01	4-21
243				M. Toda		8	200	4.0	Oizumi, Yamanashi	L 200111190302_todamasa1CF01	-
244						12	58	1.2	Oizumi, Yamanashi	L 200111190302_todamasa2CF01	4-21
245				M. Owada		3	85	1.4	Haruno, Shizuoka	L 200111190302_owadamin1CF01	-
246				M, Owada		3	85	1.4	Haruno, Shizuoka	L 200111190303_owadamin1CF01	4-22
247	**92**	Nov. 19, 2001	3:03:53 ±2s	S. Suzuki	CMOS (D-30)	8	100	2.0	Yachiho, Nagano	L 200111190303_suzukisa1CD01	4-22
248						9	100	2.0	Yachiho, Nagano	L 200111190303_suzukisa2CF01	-
249				N. Kurita		4	105	2.4	Oizumi, Yamanashi	L 200111190303_kuritana1CF01	4-22
250	93	Nov. 19, 2001	3:07:11 ±2s	K. Maeda	I.I. + video	video	400	2.8	Tsuno, Miyazaki	L 200111190307Amaedakou1MV01	5-05
251	94	Nov. 19, 2001	3:07:48 ±2s	J. Aizawa		23	200	2.8	Utatsu, Miyagi	L 200111190307Baizawajo1CF01	4-22
252	95	Nov. 19, 2001	3:09:21 ±2s	S. Suzuki	CMOS (D-30)	3	100	2.0	Yachiho, Nagano	L 200111190309Asuzukisa1CD01	-
253						2	100	2.0	Yachiho, Nagano	L 200111190309Asuzukisa2CF01	-
254	96	Nov. 19, 2001	3:09:30 ±30s	A. Okazaki		7	28	2.8	Rikubetsu, Hokkaido	L 200111190309Bokazakia1CF01	4-23

Table 1. (continued)

No.	Train	Observation date	Time with error	Observer	Device	Images	f	F	Observation site	Code of image sequences	Figure
255	97	Nov. 19, 2001	3:09:52 ±2s	S. Suzuki	CMOS (D-30)	1	100	2.0	Yachiho, Nagano	L 200111190309Csuzukisa1CD01	-
256	98	Nov. 19, 2001	3:12:50 ±5s	N. Tanaka		6	50	1.4	Tsuno, Miyazaki	L 200111190312_tanakana1CF01	4-23
257				M. Owada		2	85	1.4	Haruno, Shizuoka	L 200111190319_owadamin1CF01	4-23
258	**99**	Nov. 19, 2001	3:19:32 ±2s	S. Suzuki	CMOS (D-30)	4	100	2.0	Yachiho, Nagano	L 200111190319_suzukisa1CD01	4-23
259						4	100	2.0	Yachiho, Nagano	L 200111190319_suzukisa2CF01	-
260	100	Nov. 19, 2001	3:21:18 ±2s	S. Suzuki	CMOS (D-30)	2	100	2.0	Yachiho, Nagano	L 200111190321Asuzukisa1CD01	-
261						4	100	2.0	Yachiho, Nagano	L 200111190321Asuzukisa2CF01	-
262	101	Nov. 19, 2001	3:21:58 ±2s	N. Tanaka		4	50	1.4	Tsuno, Miyazaki	L 200111190321Btanakana1CF01	4-23
263				K. Maeda	I.I. + video	video	400	2.8	Tsuno, Miyazaki	L 200111190321Bmaedakou1MV01	5-06
264	102	Nov. 19, 2001	3:24:50 ±30s	N. Tanaka		4	50	1.4	Tsuno, Miyazaki	L 200111190324_tanakana1CF01	4-23
265	**103**	Nov. 19, 2001	3:25:08 ±2s	K. Kato		37	135	1.8	Kitaibaraki, Ibaraki	L 200111190325Akatokenj1MF01	4-24
266				M. Toda		3	58	1.2	Oizumi, Yamanashi	L 200111190325Atodamasa1CF01	-
267				N. Kurita		5	180	2.5	Oizumi, Yamanashi	L 200111190325Bkuritana1CF01	4-24
268	**104**	Nov. 19, 2001	3:25:10 ±2s	S. Suzuki	CMOS (D-30)	4	100	2.0	Yachiho, Nagano	L 200111190325Bsuzukisa1CD01	4-24
269						4	100	2.0	Yachiho, Nagano	L 200111190325Bsuzukisa2CF01	-
270				M. Toda		11	58	1.2	Oizumi, Yamanashi	L 200111190325Btodamasa1CF01	4-24
271	105	Nov. 19, 2001	3:25:17 ±2s	Y. Okamoto	8 s/fr time lapse video	video	3.5	1.4	Oizumi, Yamanashi	L 200111190325Cokamotoy1MV01	-
272	106	Nov. 19, 2001	3:25:53 ±2s	K. Kato		8	135	1.8	Kitaibaraki, Ibaraki	L 200111190325Dkatokenj1MF01	-
273				S. Suzuki	CMOS (D-30)	4	100	2.0	Yachiho, Nagano	L 200111190326_suzukisa1CD01	4-25
274	**107**	Nov. 19, 2001	3:26:10 ±2s			5	100	2.0	Yachiho, Nagano	L 200111190326_suzukisa2CF01	-
275				N. Kurita		4	180	2.5	Oizumi, Yamanashi	L 200111190326_kuritana1CF01	4-25
276	**108**	Nov. 19, 2001	3:28:37 ±2s	Y. Okamoto	8 s/fr time lapse video	video	3.5	1.4	Oizumi, Yamanashi	L 200111190328Aokamotoy1MV01	5-06
277				S. Sugimoto	I.I. + video	video	85	1.2	Nasu, Tochigi	L 200111190328Asugimoto1MV01	-
278				S. Suzuki	CMOS (D-30)	4	100	2.0	Yachiho, Nagano	L 200111190328Bsuzukisa1CD01	4-25
279						4	100	2.0	Yachiho, Nagano	L 200111190328Bsuzukisa2CF01	-
280	**109**	Nov. 19, 2001	3:28:56 ±2s	Y. Higa		7	300	2.8	Naraha, Fukushima	L 200111190328Bhigayosh1MF01	4-25
281						7	85	2.0	Naraha, Fukushima	L 200111190328Bhigayosh2CF01	-
282				S. Sugimoto	I.I. + video	video	85	1.2	Nasu, Tochigi	L 200111190328Bsugimoto1MV01	-
283	110	Nov. 19, 2001	3:30:10 ±30s	N. Tanaka		7	50	1.4	Tsuno, Miyazaki	L 200111190330_tanakana1CF01	4-25
284	111	Nov. 19, 2001	3:32:03 ±2s	S. Sugimoto	I.I. + video	video	85	1.2	Nasu, Tochigi	L 200111190332Asugimoto1MV01	-
285	112	Nov. 19, 2001	3:32:26 ±2s	S. Suzuki	CMOS (D-30)	3	100	2.0	Yachiho, Nagano	L 200111190332Bsuzukisa1CD01	-
286						3	100	2.0	Yachiho, Nagano	L 200111190332Bsuzukisa2CF01	-
287	113	Nov. 19, 2001	3:33:30 ±30s	A. Okazaki		5	28	2.8	Rikubetsu, Hokkaido	L 200111190333_okazakia1CF01	4-25
288	114	Nov. 19, 2001	3:34:03 ±5s	K. Maeda	I.I. + video	video	400	2.8	Tsuno, Miyazaki	L 200111190334Amaedakou1MV01	5-06
289				N. Tanaka		1	50	1.4	Tsuno, Miyazaki	L 200111190334Atanakana1CF01	-
290	115	Nov. 19, 2001	3:34:50 ±20s	N. Tanaka		1	50	1.4	Tsuno, Miyazaki	L 200111190334Btanakana1CF01	-
291	116	Nov. 19, 2001	3:34:58 ±2s	T. Saito	I.I. + video	video	28	2.0	Miki, Hyogo	L 200111190334Csaitotos1MV01	-
292	117	Nov. 19, 2001	3:35:00 ±2s	S. Suzuki	CMOS (D-30)	3	100	2.0	Yachiho, Nagano	L 200111190335Asuzukisa1CD01	-
293						3	100	2.0	Yachiho, Nagano	L 200111190335Asuzukisa2CF01	-

Table 1. (continued)

No.	Train	Observation date	Time with error	Observer	Device	Images	f	F	Observation site	Code of image sequences	Figure
294	118	Nov. 19, 2001	3:35:22 ±2s	K. Maeda	I.I. + video	video	400	2.8	Tsuno, Miyazaki	L 200111190335Bmaedakou1MV01	5-07
295	119	Nov. 19, 2001	3:39:12 ±2s	S. Suzuki	CMOS (D-30)	1	100	2.0	Yachiho, Nagano	L 200111190339Asuzukisa1CD01	-
296						1	100	2.0	Yachiho, Nagano	L 200111190339Asuzukisa2CF01	-
297	120	Nov. 19, 2001	3:39:59 ±8s	S. Suzuki	CMOS (D-30)	1	100	2.0	Yachiho, Nagano	L 200111190339Bsuzukisa1CD01	-
298	121	Nov. 19, 2001	3:43:00 ±8s	S. Suzuki	CMOS (D-30)	1	100	2.0	Yachiho, Nagano	L 200111190343Asuzukisa1CD01	-
299						2	100	2.0	Yachiho, Nagano	L 200111190343Asuzukisa2CF01	-
300	122	Nov. 19, 2001	3:43:11 ±3s	S. Suzuki	CMOS (D-30)	1	100	2.0	Yachiho, Nagano	L 200111190343Bsuzukisa1CD01	-
301						2	100	2.0	Yachiho, Nagano	L 200111190343Bsuzukisa2CF01	-
302	**123**	Nov. 19, 2001	3:43:59 ±2s	Misato Obs.	Color CCD (BJ-32c)	16	3.5	1.4	Misato, Wakayama	L 200111190343Cmisatoob1CD01	4-26
303				K. Maeda	I.I. + video	video	400	2.8	Tsuno, Miyazaki	L 200111190343Cmaedakou1MV01	5-07
304	**124**	Nov. 19, 2001	3:44:50 ±2s	Y. Natsume	CMOS (D-30)	1	135	2.8	Shitara, Aichi	L 200111190344_natsumey1CF01	4-26
305				Y. Uyama		4	85	1.4	Suzuka, Mie	L 200111190344_uyamayos1CF01	4-26
306				S. Suzuki		1	100	2.0	Yachiho, Nagano	L 200111190344_suzukisa1CD01	-
307						1	100	2.0	Yachiho, Nagano	L 200111190344_suzukisa2CF01	-
308	125	Nov. 19, 2001	3:47:08 ±2s	Y. Higa		10	85	2.0	Naraha, Fukushima	L 200111190347Ahigayosh2CF01	-
309	126	Nov. 19, 2001	3:47:42 ±2s	M. Toda		4	200	2.0	Oizumi, Yamanashi	L 200111190347Btodamasa1CF01	-
310	127	Nov. 19, 2001	3:47:56 ±2s	S. Sugimoto	I.I. + video	video	85	1.2	Nasu, Tochigi	L 200111190347Csugimoto1MV01	-
311	128	Nov. 19, 2001	3:48:05 ±2s	O. Miikeda		4	50	1.4	Kuroiso, Tochigi	L 200111190348_miikedas1CF01	4-26
312	129	Nov. 19, 2001	3:54:21 ±8s	S. Suzuki	CMOS (D-30)	1	100	2.0	Yachiho, Nagano	L 200111190354Asuzukisa1CD01	-
313						2	100	2.0	Yachiho, Nagano	L 200111190354Asuzukisa2CF01	-
314	**130**	Nov. 19, 2001	3:54:26 ±2s	S. Amikura		8	200	4.0	Gozenyama, Ibaraki	L 200111190354Bamikuras1CF01	4-26
315				Y. Maekawa		11	50	1.4	Hitachi, Ibaraki	L 200111190354Bmaekaway1CF01	4-26
316				Y. Higa		5	300	2.8	Naraha, Fukushima	L 200111190354Bhigayosh1MF01	4-27
317						9	85	2.0	Naraha, Fukushima	L 200111190354Bhigayosh2CF01	-
318				K. Kato		32	200	2.8	Kitaibaraki, Ibaraki	L 200111190354Bkatokenj1CF01	4-27
319				K. Koretsune		32	180	2.8	Kitaibaraki, Ibaraki	L 200111190354Bkoretsun1CF01	4-27
320	131	Nov. 19, 2001	3:55:26 ±8s	S. Suzuki	CMOS (D-30)	1	100	2.0	Yachiho, Nagano	L 200111190355_suzukisa1CD01	-
321						2	100	2.0	Yachiho, Nagano	L 200111190355_suzukisa2CF01	-
322	132	Nov. 19, 2001	4:00:25 ±35s	S. Suzuki		2	100	2.0	Yachiho, Nagano	L 200111190400Asuzukisa2CF01	-
323	133	Nov. 19, 2001	4:00:35 ±35s	S. Suzuki		2	100	2.0	Yachiho, Nagano	L 200111190400Bsuzukisa2CF01	-
324	**134**	Nov. 19, 2001	4:01:32 ±2s	Y. Natsume		1	135	2.8	Shitara, Aichi	L 200111190401_natsumey1CF01	-
325				M. Owada		2	85	1.4	Haruno, Shizuoka	L 200111190401_owadamin1CF01	-
326				S. Suzuki		6	100	2.0	Yachiho, Nagano	L 200111190401_suzukisa2CF01	-
327	135	Nov. 19, 2001	4:03:30 ±30s	S. Suzuki		2	100	2.0	Yachiho, Nagano	L 200111190403_suzukisa2CF01	-
328	136	Nov. 19, 2001	4:04:00 ±2s	N. Kurita		3	180	2.5	Oizumi, Yamanashi	L 200111190404_kuritana1CF01	-
329	137	Nov. 19, 2001	4:05:26 ±2s	N. Tanaka		5	50	1.4	Tsuno, Miyazaki	L 200111190405_tanakana1CF01	4-27
330				K. Maeda	I.I. + video	video	400	2.8	Tsuno, Miyazaki	L 200111190405_maedakou1MV01	5-07

Table 1. (continued)

No.	Train	Observation date	Time with error	Observer	Device	Images	f	F	Observation site	Code of image sequences	Figure
331	**138**	Nov. 19, 2001	4:06:44 ±2s	Ma. Kobayashi		3	85	1.4	Oizumi, Yamanashi	L 200111190406_kobayash1CF01	4-27
332				N. Kurita		3	180	2.5	Oizumi, Yamanashi	L 200111190406_kuritana1CF01	4-27
333				Y. Natsume		8	135	2.8	Shitara, Aichi	L 200111190406_natsumey1CF01	4-28
334				M, Owada		10	85	1.4	Haruno, Shizuoka	L 200111190406_owadamin1CF01	4-28
335				N. Koshiyama		30	85	1.4	Haruno, Shizuoka	L 200111190406_koshiyam1MF01	4-28
336	**139**	Nov. 19, 2001	4:07:30 ±30s	Y. Yamada		1	50	1.8	Asahi, Aichi	L 200111190407Ayamadayo1CF01	-
337				Y. Aoki		1	-	-	Kawaue, Gifu	L 200111190407Aaokiyosh1MV01	-
338				S. Suzuki		3	100	2.0	Yachiho, Nagano	L 200111190407Asuzukisa2CF01	-
339	140	Nov. 19, 2001	4:07:30 ±30s	N. Tanaka		8	50	1.4	Tsuno, Miyazaki	L 200111190407Btanakana1CF01	4-28
340	**141**	Nov. 19, 2001	4:09:08 ±1s	Y. Natsume		2	135	2.8	Shitara, Aichi	L 200111190409_natsumey1CF01	4-29
341				Y. Yamada		1	50	1.8	Asahi, Aichi	L 200111190409_yamadayo1CF01	4-29
342				S. Okamoto		19	50	1.4	Asahi, Aichi	L 200111190409_okamotos1MV01	5-08
343				S. Suzuki		3	100	2.0	Yachiho, Nagano	L 200111190409_suzukisa2CF01	-
344	142	Nov. 19, 2001	4:10:30 ±30s	A. Okazaki		10	28	2.8	Rikubetsu, Hokkaido	L 200111190410_okazakia1CF01	4-29
345	143	Nov. 19, 2001	4:11:30 ±30s	N. Tanaka		1	50	1.4	Tsuno, Miyazaki	L 200111190411_tanakana1CF01	-
346	144	Nov. 19, 2001	4:13:01 ±2s	Y. Higa		8	300	2.8	Naraha, Fukushima	L 200111190413Ahigayosh1MF01	4-29
347						10	85	2.0	Naraha, Fukushima	L 200111190413Ahigayosh2CF01	-
348	145	Nov. 19, 2001	4:13:48 ±1s	M. Owada		3	85	1.4	Haruno, Shizuoka	L 200111190413Bowadamin1CF01	4-29
349	146	Nov. 19, 2001	4:14:01 ±5s	N. Tanaka		14	50	1.4	Tsuno, Miyazaki	L 200111190414Atanakana1CF01	4-29
350				K. Maeda	I.I. + video	video	400	2.8	Tsuno, Miyazaki	L 200111190414Amaedakou1MV01	5-08
351	147	Nov. 19, 2001	4:15:55 ±10s	N. Tanaka		5	50	1.4	Tsuno, Miyazaki	L 200111190414Btanakana1CF01	-
352	148	Nov. 19, 2001	4:19:00 ±8s	S. Suzuki	CMOS (D-30)	4	100	2.0	Yachiho, Nagano	L 200111190419_suzukisa1CD01	-
353						5	100	2.0	Yachiho, Nagano	L 200111190419_suzukisa2CF01	-
354	149	Nov. 19, 2001	4:22:56 ±2s	K. Maeda	I.I. + video	video	400	2.8	Tsuno, Miyazaki	L 200111190422_maedakou1MV01	5-08
355	150	Nov. 19, 2001	4:25:34 ±8s	S. Suzuki	CMOS (D-30)	1	100	2.0	Yachiho, Nagano	L 200111190425_suzukisa1CD01	-
356						2	100	2.0	Yachiho, Nagano	L 200111190425_suzukisa2CF01	-
357	151	Nov. 19, 2001	4:26:23 ±8s	S. Suzuki	CMOS (D-30)	1	100	2.0	Yachiho, Nagano	L 200111190426_suzukisa1CD01	-
358						1	100	2.0	Yachiho, Nagano	L 200111190426_suzukisa2CF01	-
359	152	Nov. 19, 2001	4:27:00 ±2s	M. Toda		1	200	2.0	Oizumi, Yamanashi	L 200111190427Atodamasa1CF01	-
360	**153**	Nov. 19, 2001	4:27:12 ±1s	S. Suzuki	CMOS (D-30)	4	100	2.0	Yachiho, Nagano	L 200111190427Bsuzukisa1CD01	4-30
361						3	100	2.0	Yachiho, Nagano	L 200111190427Bsuzukisa2CF01	-
362				N. Kurita		3	180	2.5	Oizumi, Yamanashi	L 200111190427Bkuritana1CF01	4-30
363				Y. Natsume		2	135	2.8	Shitara, Aichi	L 200111190427Bnatsumey1CF01	4-30
364				M. Toda		7	200	2.0	Oizumi, Yamanashi	L 200111190427Btodamasa1CF01	4-30
365				Ma. Kobayashi		3	85	1.4	Oizumi, Yamanashi	L 200111190427Bkobayash1CF01	4-30
366				M. Owada		4	85	1.4	Haruno, Shizuoka	L 200111190427Bowadamin1CF01	4-30
367				N. Koshiyama		10	85	1.4	Haruno, Shizuoka	L 200111190427Bkoshiyam1CF01	-
368	**154**	Nov. 19, 2001	4:32:41 ±2s	S. Suzuki	CMOS (D-30)	1	100	2.0	Yachiho, Nagano	L 200111190432_suzukisa1CD01	-
369						2	100	2.0	Yachiho, Nagano	L 200111190432_suzukisa2CF01	-
370				M. Owada		2	85	1.4	Haruno, Shizuoka	L 200111190432_owadamin1CF01	-

Table 1. (continued)

No.	Train	Observation date	Time with error	Observer	Device	Images	f	F	Observation site	Code of image sequences	Figure
371	155	Nov. 19, 2001	4:33:54 ±5s	K. Maeda	I.I. + video	video	400	2.8	Tsuno, Miyazaki	L 200111190433_maedakou1MV01	5-09
372	156	Nov. 19, 2001	4:34:22 ±8s	S. Suzuki	CMOS (D-30)	1	100	2.0	Yachiho, Nagano	L 200111190434_suzukisa1CD01	-
373						2	100	2.0	Yachiho, Nagano	L 200111190434_suzukisa2CF01	-
374	157	Nov. 19, 2001	4:36:07 ±8s	S. Suzuki	CMOS (D-30)	1	100	2.0	Yachiho, Nagano	L 200111190436Asuzukisa1CD01	-
375						2	100	2.0	Yachiho, Nagano	L 200111190436Asuzukisa2CF01	-
376	158	Nov. 19, 2001	4:36:40 ±2s	M. Toda		4	200	2.0	Oizumi, Yamanashi	L 200111190436Btodamasa1CF01	-
377	**159**	Nov. 19, 2001	4:37:09 ±2s	M. Toda	CMOS (D-30)	12	200	2.0	Oizumi, Yamanashi	L 200111190437_todamasa1CF01	4-31
378				S. Suzuki		3	100	2.0	Yachiho, Nagano	L 200111190437_suzukisa1CD01	4-31
379						4	100	2.0	Yachiho, Nagano	L 200111190437_suzukisa2CF01	-
380	**160**	Nov. 19, 2001	4:38:25 ±2s	T. Sakamoto		28	85	1.2	Hashikami, Aomori	L 200111190438_sakamoto1CF01	4-31
381				Y. Higa		6	300	2.8	Naraha, Fukushima	L 200111190438_higayosh1MF01	4-31
382						1	85	2.0	Naraha, Fukushima	L 200111190438_higayosh2CF01	-
383	**161**	Nov. 19, 2001	4:39:12 ±2s	N. Ogura	CMOS (D-30)	8	100	2.0	Samegawa, Fukushima	L 200111190439_oguranob1CF01	4-32
384				M. Toda		7	200	2.0	Oizumi, Yamanashi	L 200111190439_todamasa1CF01	4-32
385				S. Suzuki		2	100	2.0	Yachiho, Nagano	L 200111190439_suzukisa1CD01	4-32
386						3	100	2.0	Yachiho, Nagano	L 200111190439_suzukisa2CF01	-
387				Y. Sato		3	85	1.4	Ogoe, Fukushima	L 200111190439_satoyosh1CF01	-
388				S. Sugimoto	I.I. + video	video	85	1.2	Nasu, Tochigi	L 200111190439_sugimoto1MV01	-
389	162	Nov. 19, 2001	4:40:39 ±2s	S. Suzuki	CMOS (D-30)	2	100	2.0	Yachiho, Nagano	L 200111190440_suzukisa1CD01	-
390						3	100	2.0	Yachiho, Nagano	L 200111190440_suzukisa2CF01	-
391	163	Nov. 19, 2001	4:42:01 ±5s	S. Suzuki	CMOS (D-30)	1	100	2.0	Yachiho, Nagano	L 200111190442Asuzukisa1CD01	-
392						1	100	2.0	Yachiho, Nagano	L 200111190442Asuzukisa2CF01	-
393	164	Nov. 19, 2001	4:42:01 ±2s	S. Suzuki	CMOS (D-30)	1	100	2.0	Yachiho, Nagano	L 200111190442Bsuzukisa1CD01	-
394						1	100	2.0	Yachiho, Nagano	L 200111190442Bsuzukisa2CF01	-
395	165	Nov. 19, 2001	4:42:25 ±2s	S. Suzuki	CMOS (D-30)	1	100	2.0	Yachiho, Nagano	L 200111190442Csuzukisa1CD01	-
396	166	Nov. 19, 2001	4:45:30 ±30s	N. Tanaka		2	50	1.4	Tsuno, Miyazaki	L 200111190445Atanakana1CF01	-
397	167	Nov. 19, 2001	4:45:40 ±2s	M. Toda		3	200	2.0	Oizumi, Yamanashi	L 200111190445Btodamasa1CF01	4-31
398	168	Nov. 19, 2001	4:49:19 ±2s	S. Suzuki	CMOS (D-30)	1	100	2.0	Yachiho, Nagano	L 200111190449Asuzukisa1CD01	-
399						2	100	2.0	Yachiho, Nagano	L 200111190449Asuzukisa2CF01	-
400	169	Nov. 19, 2001	4:49:26 ±1s	M. Toda		2	200	2.0	Oizumi, Yamanashi	L 200111190449Btodamasa1CF01	-
401	**170**	Nov. 19, 2001	4:49:31 ±2s	S. Suzuki	CMOS (D-30)	6	100	2.0	Yachiho, Nagano	L 200111190449Csuzukisa1CD01	3-07
402						7	100	2.0	Yachiho, Nagano	L 200111190449Csuzukisa2CF01	-
403				Ma. Kobayashi		3	85	1.4	Oizumi, Yamanashi	L 200111190449Ckobayash1CF01	3-07
404				M. Toda		6	200	2.0	Oizumi, Yamanashi	L 200111190449Ctodamasa1CF01	3-07
405	171	Nov. 19, 2001	4:51:03 ±2s	S. Suzuki	CMOS (D-30)	2	100	2.0	Yachiho, Nagano	L 200111190451Asuzukisa1CD01	-
406						2	100	2.0	Yachiho, Nagano	L 200111190451Asuzukisa2CF01	-
407	172	Nov. 19, 2001	4:51:22 ±2s	Y. Higa		5	300	2.8	Naraha, Fukushima	L 200111190451Bhigayosh1MF01	-
408						5	85	2.0	Naraha, Fukushima	L 200111190451Bhigayosh2CF01	-
409	173	Nov. 19, 2001	4:51:25 ±2s	S. Suzuki	CMOS (D-30)	2	100	2.0	Yachiho, Nagano	L 200111190451Csuzukisa1CD01	-
410						3	100	2.0	Yachiho, Nagano	L 200111190451Csuzukisa2CF01	-

Table 1. (continued)

No.	Train	Observation date	Time with error	Observer	Device	Images	f	F	Observation site	Code of image sequences	Figure
411	**174**	Nov. 19, 2001	4:53:51 ±2s	N. Ogura		7	100	2.0	Samegawa, Fukushima	L 200111190453_oguranob1CF01	4-32
412				Y. Maekawa		3	50	1.4	Hitachi, Ibaraki	L 200111190453_maekaway1CF01	4-32
413	**175**	Nov. 19, 2001	4:55:47 ±2s	M. Toda	CMOS (D-30)	36	200	2.0	Oizumi, Yamanashi	L 200111190455_todamasa1CF01	3-08
414				S. Suzuki		5	100	2.0	Yachiho, Nagano	L 200111190455_suzukisa1CD01	3-08
415						5	100	2.0	Yachiho, Nagano	L 200111190455_suzukisa2CF01	-
416				Y. Maekawa		8	50	1.4	Hitachi, Ibaraki	L 200111190455_maekaway1CF01	3-08
417				H. Okayasu		13	50	1.4	Shobu, Saitama	L 200111190455_okayasuh1CF01	4-32
418				S. Sugimoto	I.I. + video	video	85	1.2	Nasu, Tochigi	L 200111190455_sugimoto1MV01	5-10
419				Y. Okamoto	8 s/fr time lapse video	video	3.5	1.4	Oizumi, Yamanashi	L 200111190455_okamotoy1MV01	5-10
420				S. Shibuya		6	-	-	Kamikawa, Saitama	L 200111190455_shibuyas1CF01	-
421				Y. Sato		4	85	1.4	Ogoe, Fukushima	L 200111190455_satoyosh1CF01	-
422	176	Nov. 19, 2001	4:59:08 ±2s	S. Suzuki	CMOS (D-30)	1	100	2.0	Yachiho, Nagano	L 200111190459_suzukisa1CD01	-
423						2	100	2.0	Yachiho, Nagano	L 200111190459_suzukisa2CF01	-
424	177	Nov. 19, 2001	5:00:47 ±2s	Y. Higa		7	300	2.8	Naraha, Fukushima	L 200111190500_higayosh1MF01	-
425						3	85	2.0	Naraha, Fukushima	L 200111190500_higayosh2CF01	-
426	178	Nov. 19, 2001	5:01:33 ±5s	K. Maeda	I.I. + video	video	400	2.8	Tsuno, Miyazaki	L 200111190501Amaedakou1MV01	5-09
427	**179**	Nov. 19, 2001	5:01:47 ±2s	S. Suzuki	CMOS (D-30)	1	100	2.0	Yachiho, Nagano	L 200111190501Bsuzukisa1CD01	-
428						2	100	2.0	Yachiho, Nagano	L 200111190501Bsuzukisa2CF01	-
429				S. Tago		1	-	-	Fujimi, Nagano	L 200111190501Btagosyuu1CF01	-
430	**180**	Nov. 19, 2001	5:02:05 ±2s	Y. Higa		10	300	2.8	Naraha, Fukushima	L 200111190502Ahigayosh1MF01	4-33
431						1	85	2.0	Naraha, Fukushima	L 200111190502Ahigayosh2CF01	-
432				Y. Maekawa		3	50	1.4	Hitachi, Ibaraki	L 200111190502Amaekaway1CF01	4-33
433	181	Nov. 19, 2001	5:02:59 ±2s	S. Suzuki	CMOS (D-30)	1	100	2.0	Yachiho, Nagano	L 200111190502Bsuzukisa1CD01	-
434						2	100	2.0	Yachiho, Nagano	L 200111190502Bsuzukisa2CF01	-
435	182	Nov. 19, 2001	5:03:26 ±2s	N. Ogura		2	100	2.0	Samegawa, Fukushima	L 200111190503_oguranob1CF01	4-33
436	**183**	Nov. 19, 2001	5:04:11 ±2s	Y. Maekawa		8	50	1.4	Hitachi, Ibaraki	L 200111190504Amaekaway1CD01	4-33
437				Y. Higa		8	300	2.8	Naraha, Fukushima	L 200111190504Ahigayosh1MF01	4-33
438						1	85	2.0	Naraha, Fukushima	L 200111190504Ahigayosh2CF01	-
439	184	Nov. 19, 2001	5:04:30 ±30s	N. Tanaka		2	50	1.4	Tsuno, Miyazaki	L 200111190504Btanakana1CF01	-
440	**185**	Nov. 19, 2001	5:05:01 ±5s	S. Suzuki	CMOS (D-30)	1	100	2.0	Yachiho, Nagano	L 200111190505Asuzukisa1CD01	-
441						2	100	2.0	Yachiho, Nagano	L 200111190505Asuzukisa2CF01	-
442				S. Tago		1	-	-	Fujimi, Nagano	L 200111190505Atagosyuu1CF01	-
443	186	Nov. 19, 2001	5:05:42 ±2s	S. Suzuki	CMOS (D-30)	2	100	2.0	Yachiho, Nagano	L 200111190505Bsuzukisa1CD01	-
444						3	100	2.0	Yachiho, Nagano	L 200111190505Bsuzukisa2CF01	-
445	187	Nov. 19, 2001	5:06:40 ±2s	S. Suzuki	CMOS (D-30)	1	100	2.0	Yachiho, Nagano	L 200111190506_suzukisa1CD01	-
446	188	Nov. 19, 2001	5:07:25 ±2s	S. Suzuki	CMOS (D-30)	1	100	2.0	Yachiho, Nagano	L 200111190507_suzukisa1CD01	-
447	189	Nov. 19, 2001	5:08:01 ±2s	S. Suzuki	CMOS (D-30)	1	100	2.0	Yachiho, Nagano	L 200111190508_suzukisa1CD01	-
448	190	Nov. 19, 2001	5:09:20 ±2s	Y. Higa		11	300	2.8	Naraha, Fukushima	L 200111190509_higayosh1MF01	4-33
449						2	85	2.0	Naraha, Fukushima	L 200111190509_higayosh2CF01	-

Table 1. (continued)

No.	Train	Observation date	Time with error	Observer	Device	Images	f	F	Observation site	Code of image sequences	Figure
450	191	Nov. 19, 2001	5:11:25 ±2s	S. Suzuki	CMOS (D-30)	2	100	2.0	Yachiho, Nagano	L 200111190511Asuzukisa1CD01	-
451						2	100	2.0	Yachiho, Nagano	L 200111190511Asuzukisa2CF01	-
452	192	Nov. 19, 2001	5:11:55 ±2s	H. Okayasu		5	50	1.4	Shobu, Saitama	L 200111190511Bokayasuh1CF01	-
453	193	Nov. 19, 2001	5:12:03 ±2s	S. Suzuki	CMOS (D-30)	2	100	2.0	Yachiho, Nagano	L 200111190512_suzukisa1CD01	-
454						3	100	2.0	Yachiho, Nagano	L 200111190512_suzukisa2CF01	-
455				S. Suzuki	CMOS (D-30)	4	100	2.0	Yachiho, Nagano	L 200111190515_suzikisa1CD01	-
456	**194**	Nov. 19, 2001	5:15:51 ±2s			5	100	2.0	Yachiho, Nagano	L 200111190515_suzikisa2CF01	-
457				H. Okayasu		5	50	1.4	Shobu, Saitama	L 200111190515_okayasuh1CF01	-
458	195	Nov. 19, 2001	5:17:59 ±2s	S. Suzuki	CMOS (D-30)	1	100	2.0	Yachiho, Nagano	L 200111190517_suzukisa1CD01	-
459						4	100	2.0	Yachiho, Nagano	L 200111190517_suzukisa2CF01	-
460	196	Nov. 19, 2001	5:20:00 ±2s	Y.Hazenoki		3	-	-	Kushimoto, Wakayama	L 200111190520_hazenoki1CF01	-
461	**197**	Nov. 19, 2001	5:35:50 ±10s	Y. Aoki		1	-	-	Kawaue, Gifu	L 200111190535_aokiyosh1CF01	-
462				M. Kamiya		2	135	2.0	Kami, Nagano	L 200111190535_kamiyamo1CF01	-
463	**198**	Nov. 19, 2002	15:08:37 ±2s	M.-Y. Yamamoto		17	105	1.8	Taide, Tenerife, **SPAIN**	L 200211191508Ayamamoto1CF01	4-34
464				M. hiramatsu	I.I. + video (UV)	video	30	1.2	Taide, Tenerife, **SPAIN**	L 200211191508Ahiramats1MV01	-
465	199	Nov. 19, 2002	15:08:37 ±2s	K. Oikawa	I.I. + video (1" CCD)	video	143	1.8	Tenerife observatory, **SPAIN**	L 200211191508Boikawaki1MV01	5-10
466				M.-Y. Yamamoto		17	55	1.8	Taide, Tenerife, **SPAIN**	L 200211191520_yamamoto2MF01	4-34
467	**200**	Nov. 19, 2002	15:20:56 ±2s	K. Oikawa	2 s/fr color (1/2" CCD)	video	12.5	1.8	Tenerife observatory, **SPAIN**	L 200211191520_oikawaki1CV01	4-34
468				M. Hiramatsu	I.I. + video (UV)	video	30	1.2	Taide, Tenerife, **SPAIN**	L 200211191520_hiramats1MV01	5-10
469				Y. Ichikawa	CCD (S2pro)	8	-	-	Tenerife observatory, **SPAIN**	L 200211191520_ichikawy1CD01	-
470	201	Nov. 19, 2002	19:57:47 ±2s	S. Suzuki		13	85	1.2	Joshua tree, California, **USA**	L 200211191957_suzukisa1CD01	4-35
471				Y. Tomari		17	50	1.4	Tucson, Arizona, **USA**	L 200211192035_tomariyo1CF01	3-08
472	**202**	Nov. 19, 2002	20:35:22 ±1s	F. Kanno		3	100	2.0	Sedona, Arizona, **USA**	L 200211192035_kannofum1CF01	4-35
473				S. Hashimoto		20	85	1.2	Joshua tree, California, **USA**	L 200211192035_hashimot1CD01	4-35
474	203	Nov. 19, 2002	21:27:15 ±2s	S. Suzuki		26	85	1.2	Joshua tree, California, **USA**	L 200211192127_suzukisa1CD01	4-35
475	204	Nov. 19, 2002	2:46:41 ±1s	Y.Watanabe		4	50	2.0	Sakai, Ibaraki	L 200211190246_watanabe1CF01	4-34
476	205	Nov. 19, 2002	5:17:34 ±2s	S. Shibuya		1	50	1.2	Kamikawa, Kanagawa	L 200211190517_shibuyas1CF01	-

of image sequences will soon be available via the internet (Yamamoto et al. 2005).

3-1.Code of image sequence

The observation code for each image is based on the name of the parent meteor shower, the observation date and time, the observer, and the photographic conditions.

(examples)
`12345678901234567890123456 7` (column numbers)
`L200111190116Btodamasa2MF01`

(explanations)
column 01 : Name of the parent meteor shower ('L':Leonids)
column 02–13: Observation date and time:
02–05: Year (YYYY)
06–09: Month and day (MMDD)
10–13: Hour and minute (HHMM) as Japan Standard Time (JST=UT+9h)
column 14 : Alphabetical order if multiple trains appeared within one minute
column 15–22: Observer name code (8 characters)
column 23 : Camera number for each observer
column 24 : Type of color ('C' for color imaging, 'M' for monochrome one)
column 25 : Type of camera ('F' for film, 'D' for digital device (CCD or CMOS), and 'V' for video)
column 26–27: Image number of each sequence in 2 columns

3-2.Field of view of image

As the focal length and F-number of the objective lens differed from observer to observer, the field of view (FOV) will be different for each image. The FOV is proportional to the focal length of the lens in relation to the film/chip size of the camera. Typical focal lengths and corresponding fields of view for 35 mm film cameras are listed in table 2. However, as the field of view differs unpredictably between digital devices, and because some of the images are cropped in figures 3 to 5, the field of view for each image sequence is recorded with the image as 'FOV.'

3-3.Other parameters

The start time of each exposure is recorded with each image as 'Ts', counted from the appearance of the parent fireball. The exposure period for each snapshot is recorded as 'Exp', and the number of frames for video image integration is recorded as 'Integ' (Integ = 30 corresponds to Exp = 1). As the persistent trains diffused rapidly, images with short 'Ts' and 'Exp' are very important for morphological study. Some observers selected larger 'Exp' values near the end of their observation sequences in order to obtain clear images of faint long-lasting trains.

Table 2. Field of view of typical lens for 35 mm film camera.

Focal length (mm)	Field of view (degrees)
50	39.0 x 26.0
85	25.3 x 17.0
105	19.5 x 13.0
135	15.1 x 10.1
200	10.3 x 6.8
300	6.5 x 4.3
400	5.2 x 3.4

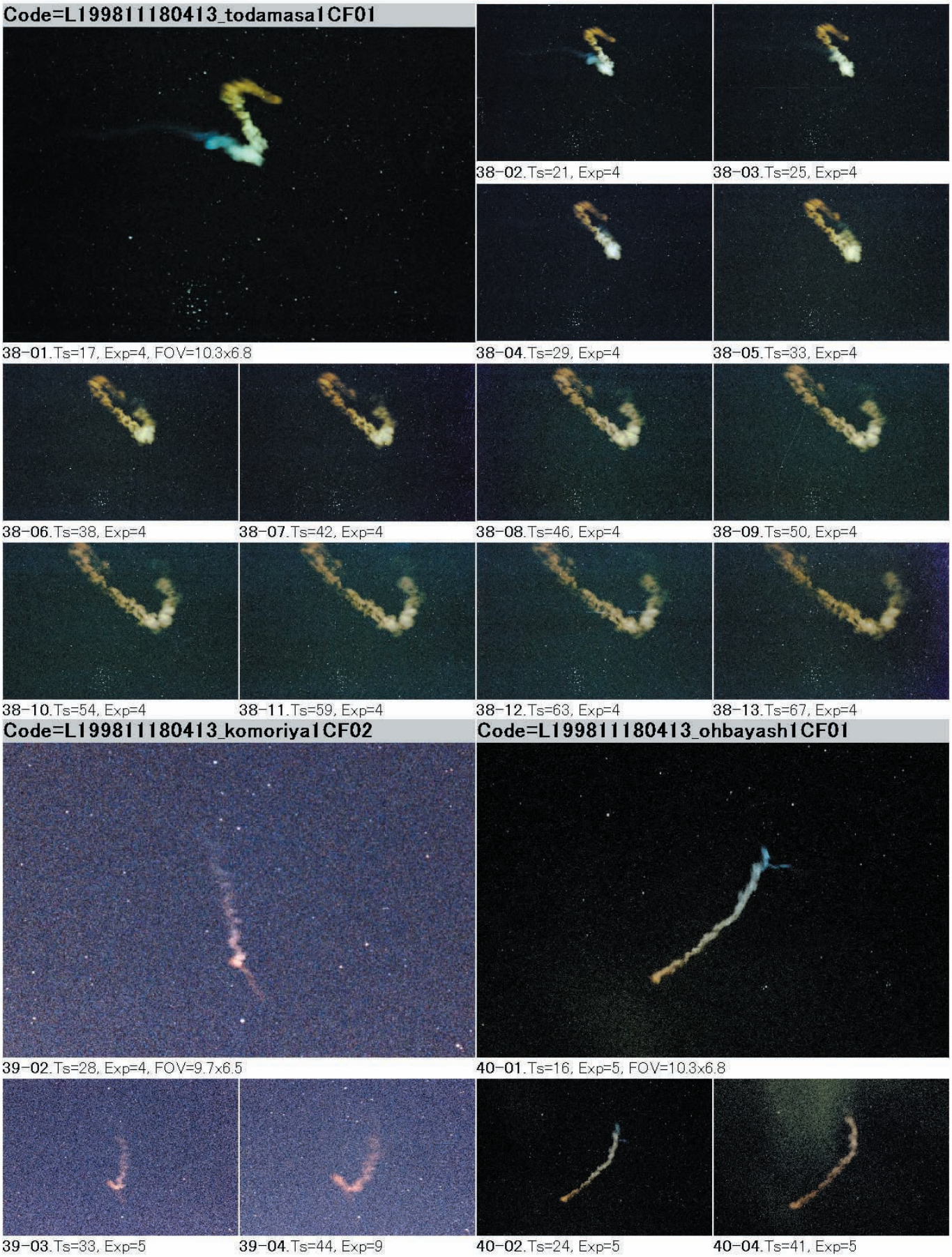

Fig. 3-01. Image sequences No. 38, 39, and 40. All of the examples were simultaneously observed with each other and with all examples from No. 38 to No. 57 (Train 30). The clear persistent meteor train was observed after a –8 magnitude fireball. Bluish color seen at upper side of the train could be imaged only in the early stage of persistent trains.

Fig. 3-02. Image sequences No. 41, 42, and 43. All of the examples were simultaneously observed with each other and with all examples from No. 38 to No. 57 (Train 30). The image sequence of No. 41 observed by color HDTV for broadcasting use was appeared by courtesy of NHK. A bright parent fireball of Train 30 was fortunately observed in the same FOV of the video file of No. 41.

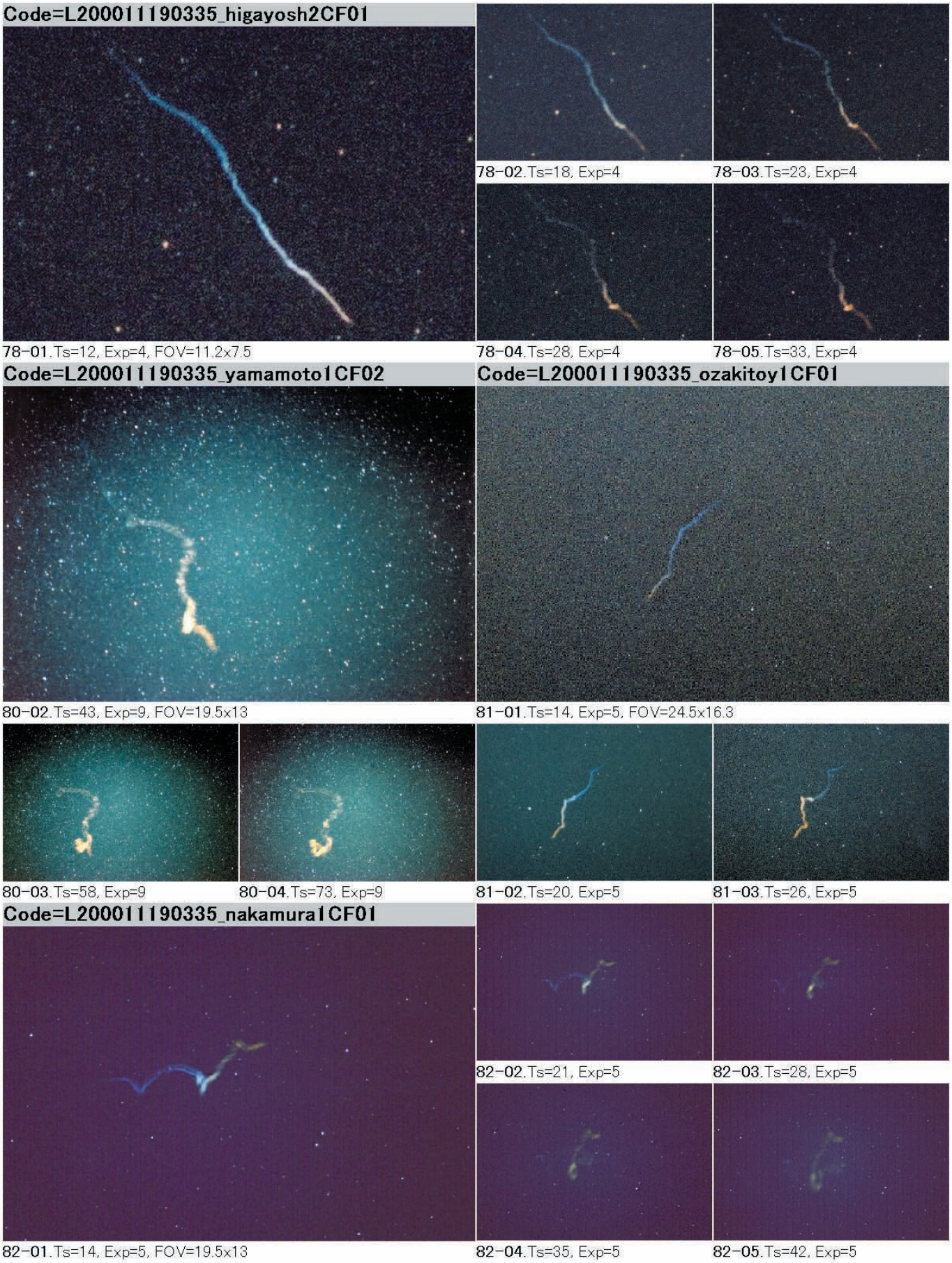

Fig. 3-03. Image sequences No. 78, 80, 81, and 82. All of the examples were simultaneously observed with each other and with all examples from No. 78 to No. 94 (Train 42).

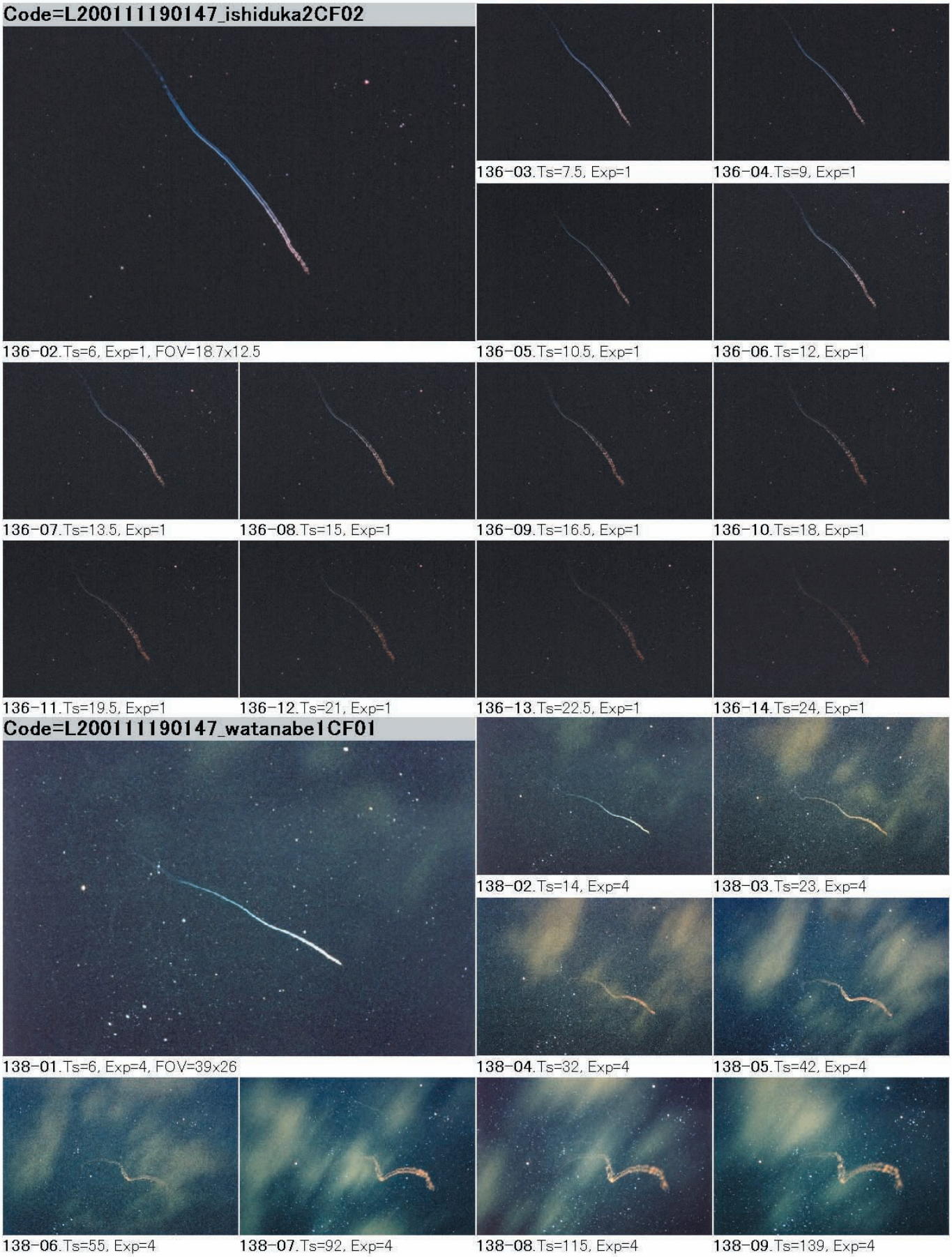

Fig. 3-04. Image sequences No. 136 and 138. Both of the examples were simultaneously observed with each other and with all examples from No. 136 to No. 164 (Train 58).

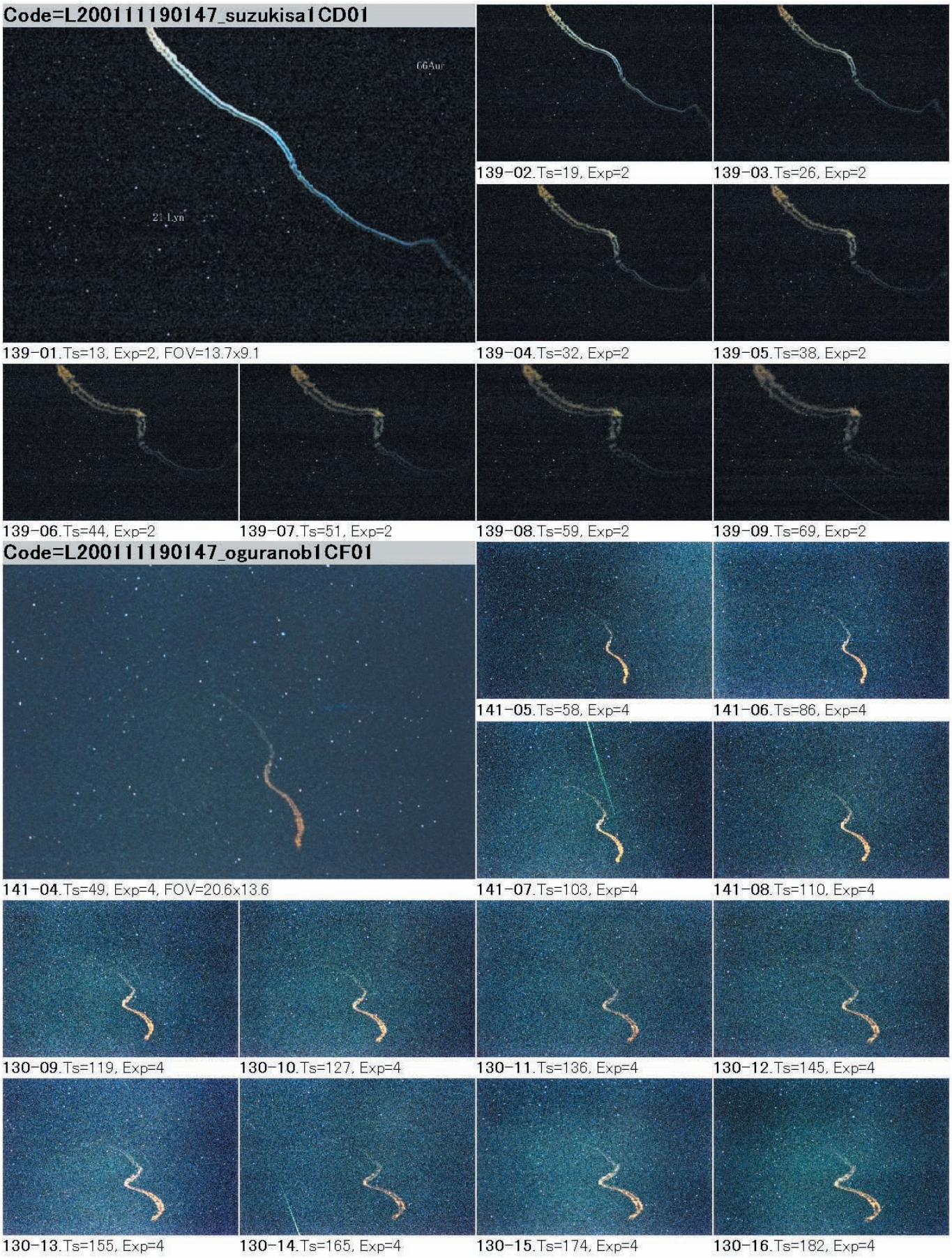

Fig. 3-05. Image sequences No. 139 and 141. Both of the examples were simultaneously observed with each other and with all examples from No. 136 to No. 164 (Train 58). Clear double-striation structure of persistent trains was clearly seen in the examples of No. 129.

Fig. 3-06. Image sequences No. 142, 143, 144, and 145. All of the examples were simultaneously observed with each other and with all examples from No. 136 to No. 164 (Train 58). Accompanied small structure seen in image No. 145-01 was another train (Train 59).

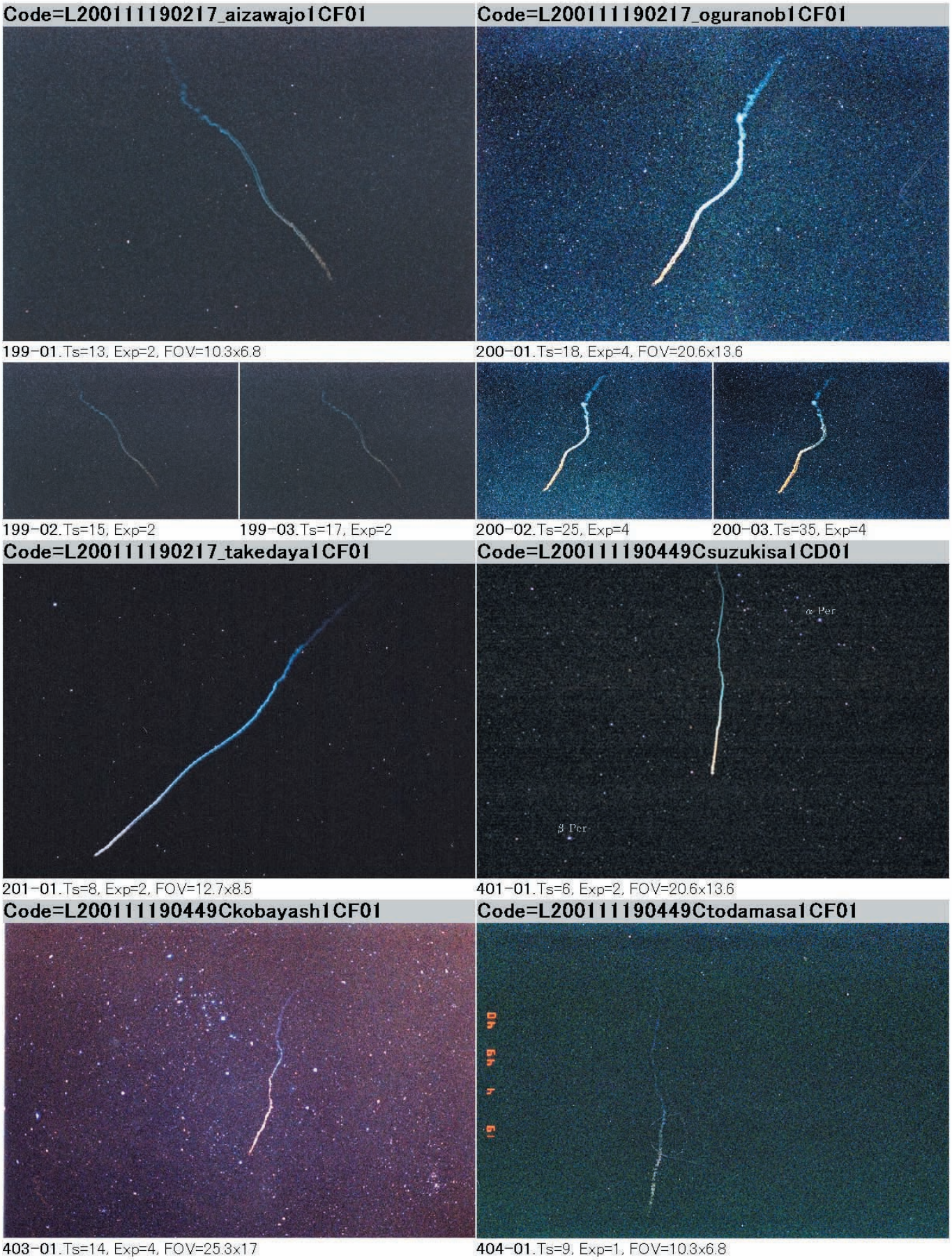

Fig. 3-07. Image sequences No. 199, 200, 201, 401, 403, and 404. The No. 199, 200, and 201 were simultaneously observed with each other and with all examples from No. 199 to No. 208 (Train 75). The No. 401, 403, and 404 were also simultaneously observed with each other and with No. 402 (Train 170).

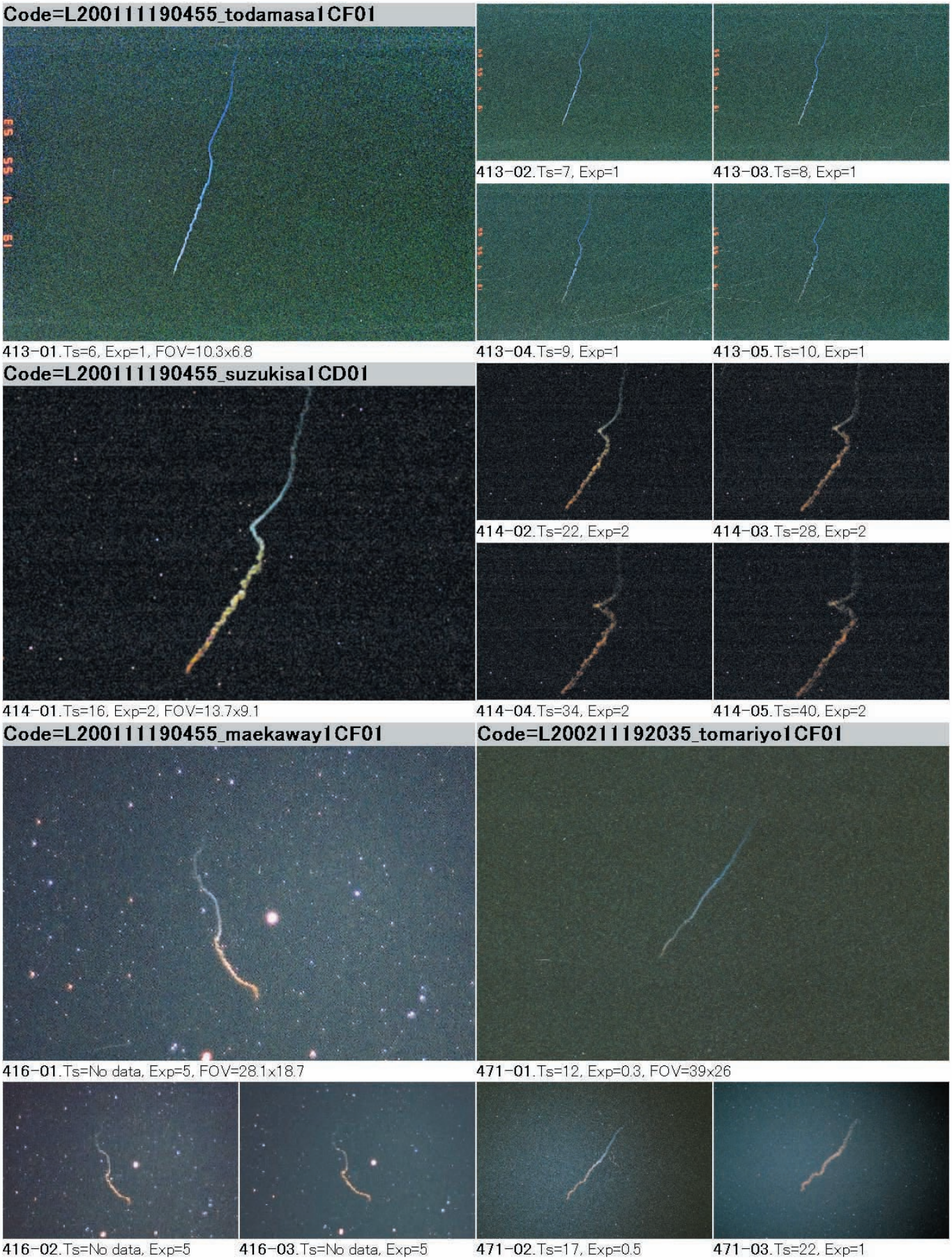

Fig. 3-08. Image sequences No. 413, 414, 416, and 471. The No. 413, 414, and 416 were simultaneously observed with each other and with all examples from No. 413 to No. 421 (Train 175). The No. 471 was simultaneously observed with No. 472 and 473. Note that the No. 471 was observed in Arizona, USA (LT=UT–7h=JST–16h).

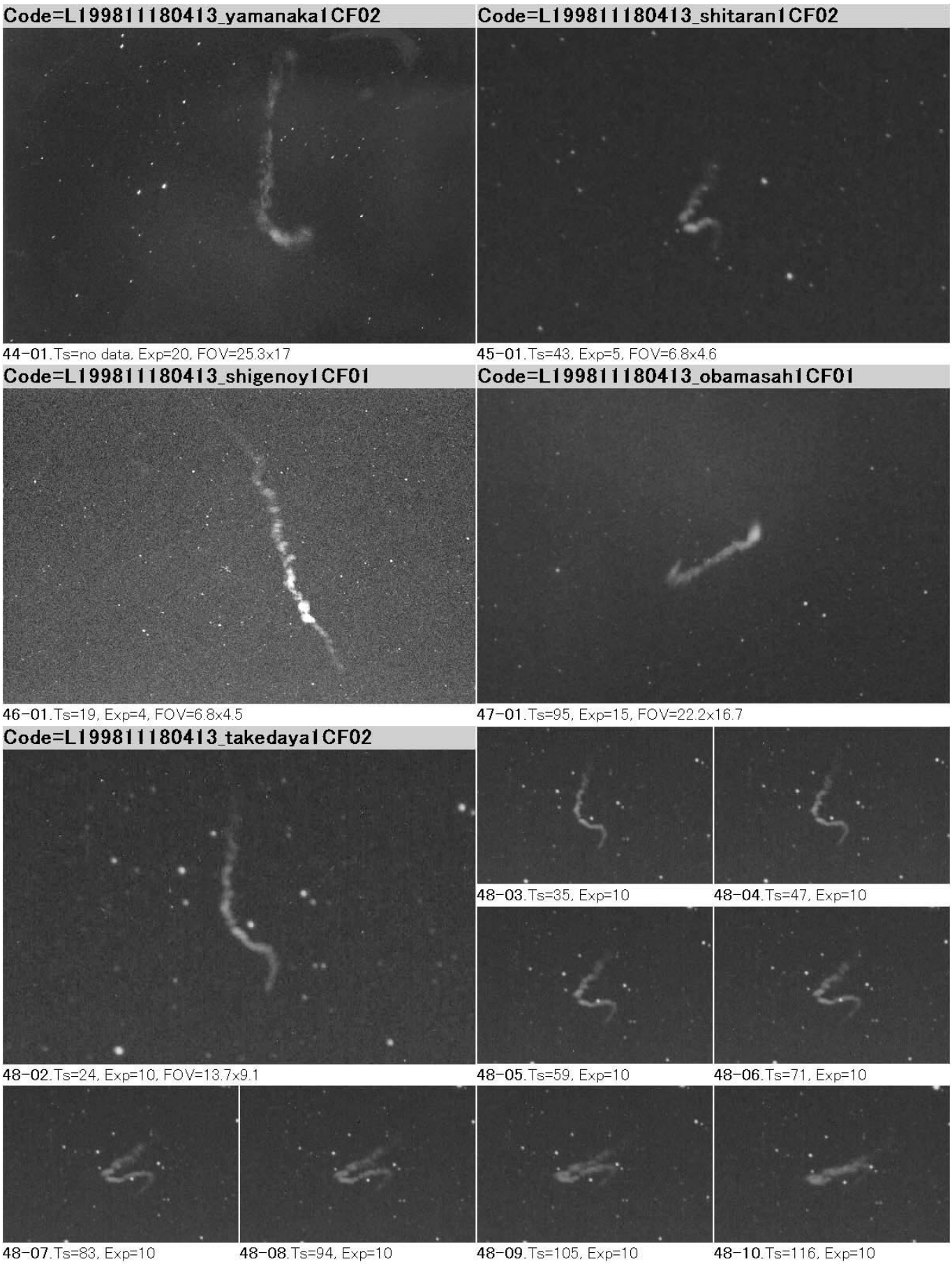

Fig. 4-01. Image sequences No. 44, 45, 46, 47, and 48. All of the examples were simultaneously observed with each other and with all examples from No. 38 to No. 57 (Train 30).

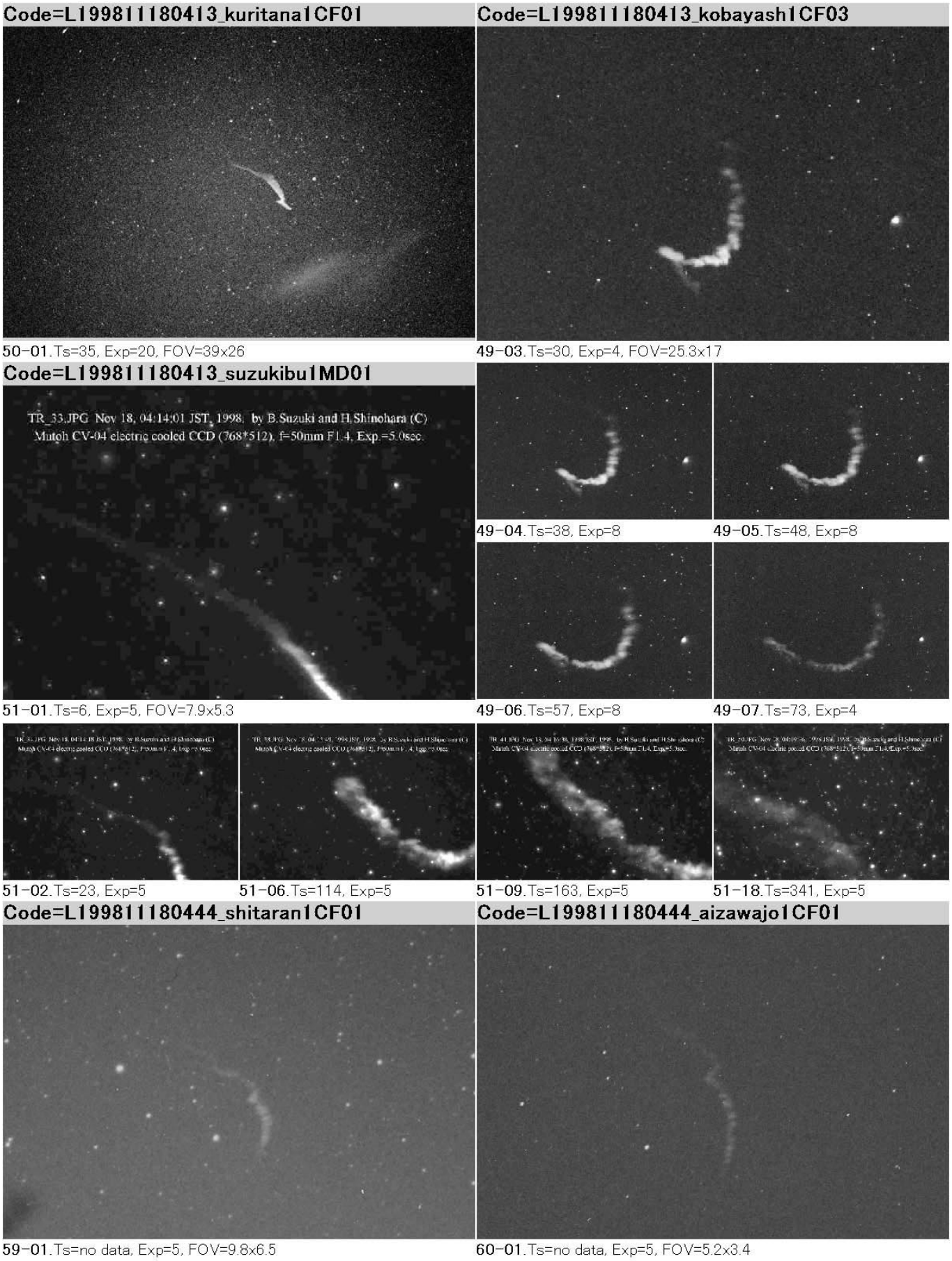

Fig. 4-02. Image sequences No. 49, 50, 51, 59, and 60. The No. 49, 50, 51 were simultaneously observed with each other and with all examples from No. 38 to No. 57 (Train 30). The No. 59 and 60 were simultaneously observed with each other and with No. 61 and 62 (Train 32).

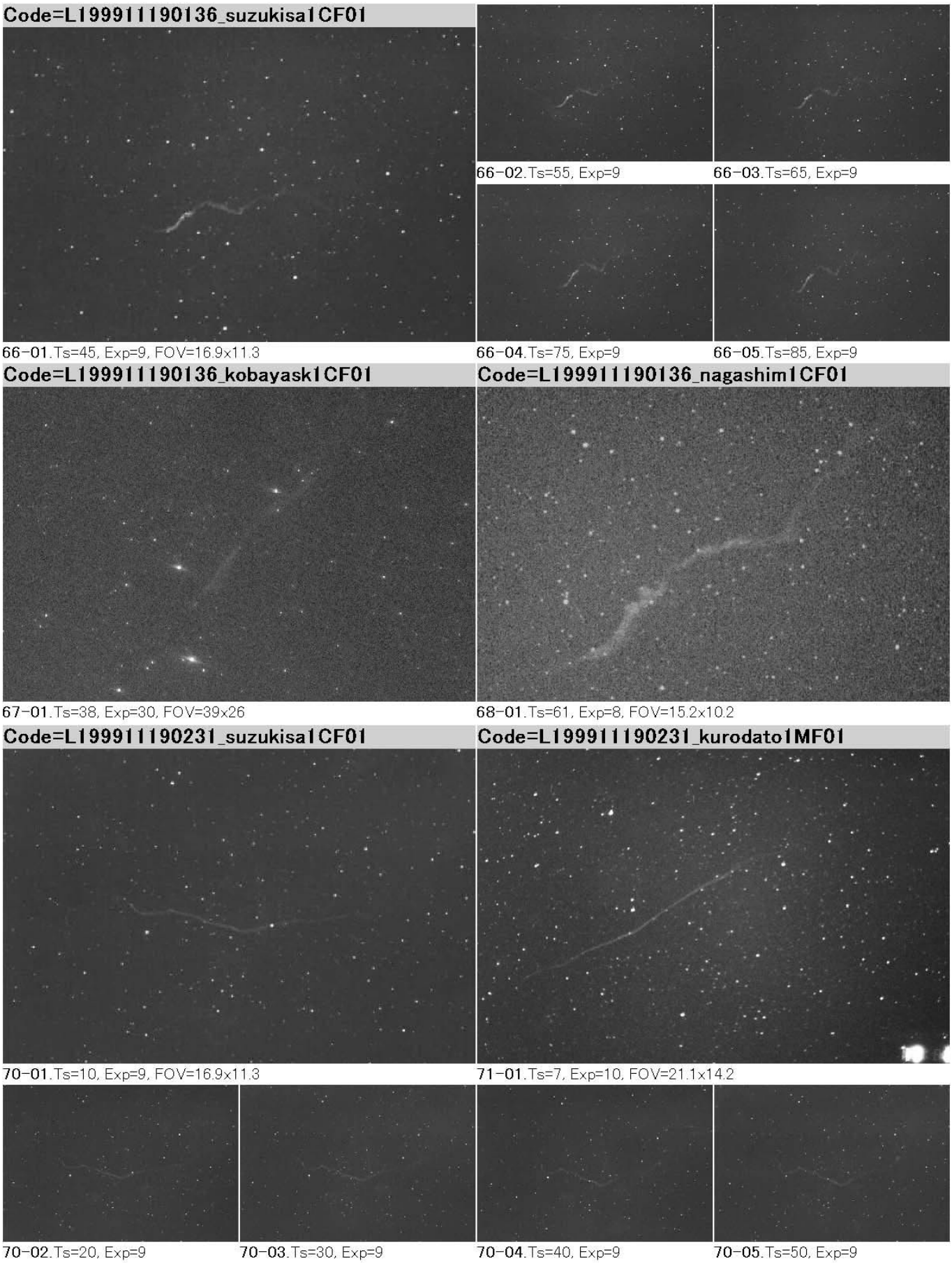

Fig. 4-03. Image sequences No. 66, 67, 68, 70, and 71. The No. 66, 67, and 68 were simultaneously observed with each other (Train 35), whereas, a simultaneous observation was established among the No.70, 71, and 72 (Train 37).

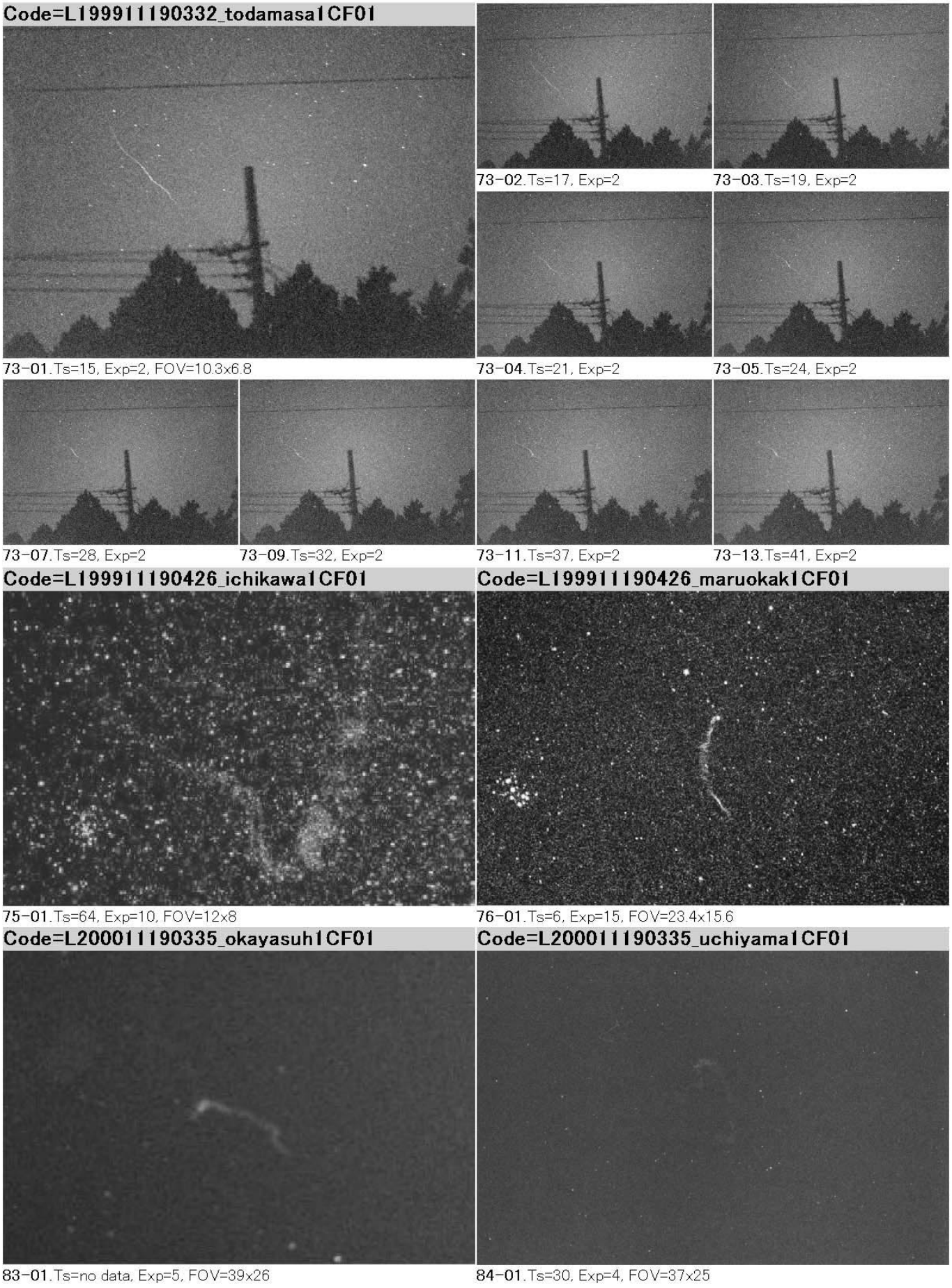

Fig. 4-04. Image sequences No. 73, 75, 76, 83, and 84. The No. 75 and 76 were simultaneously observed with each other (Train 40), whereas, a simultaneous observation was established from No. 78 to 94 including the No. 83 and 84.

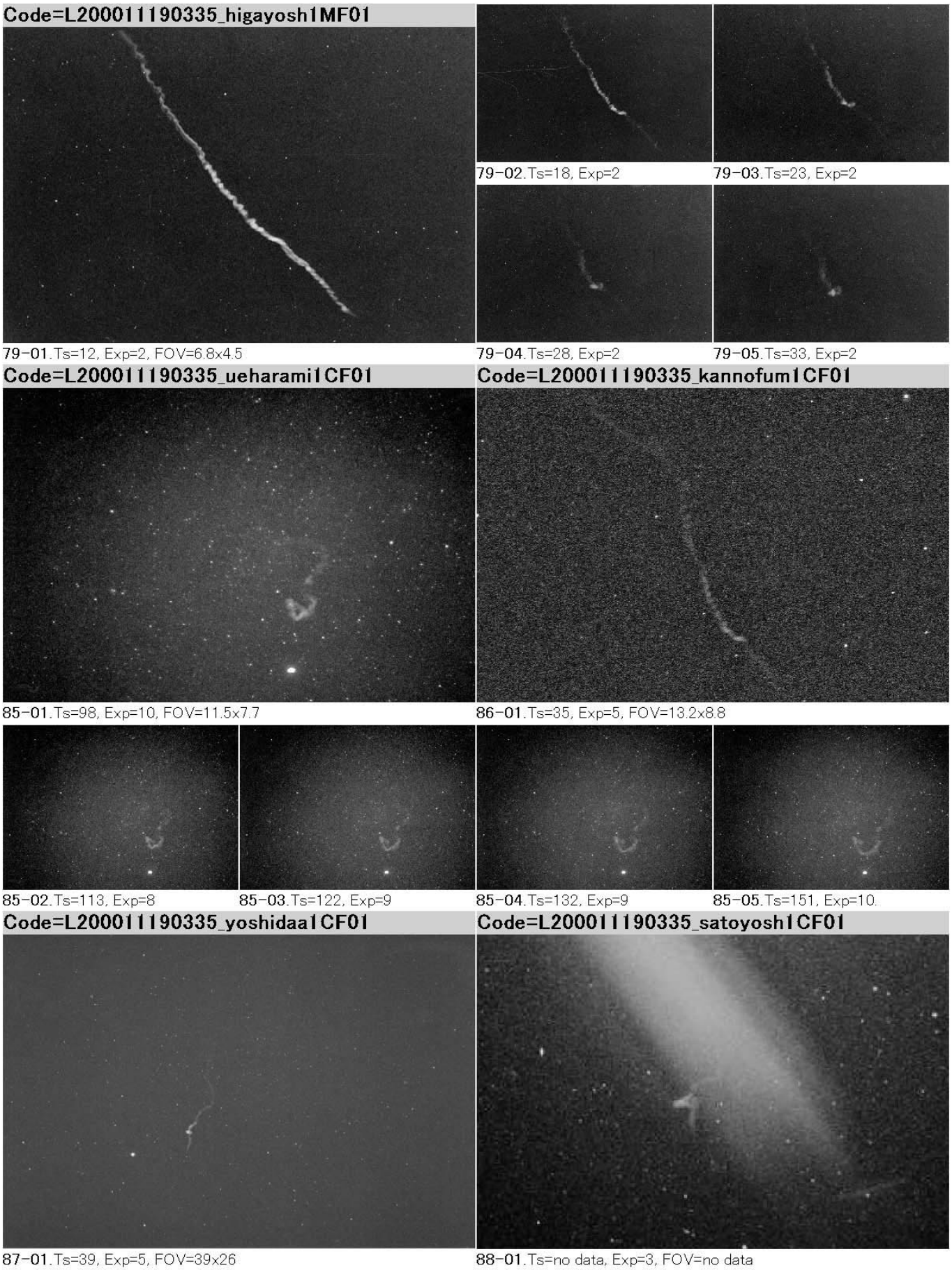

Fig. 4-05. Image sequences No. 79, 85, 86, 87, and 88. All of the examples were simultaneously observed with each other and with all examples from No. 78 to No. 94 (Train 42).

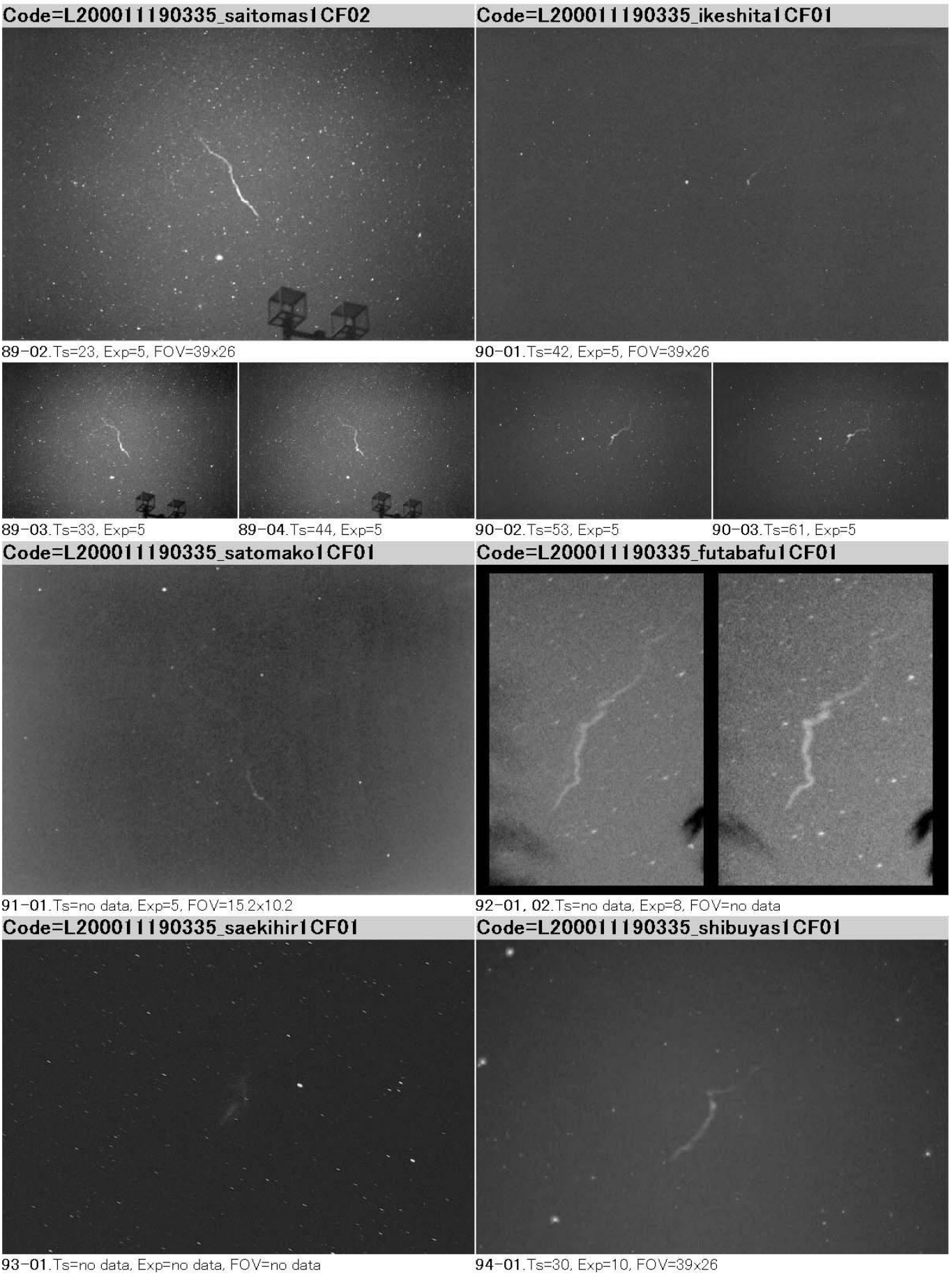

Fig. 4-06. Image sequences No.89, 90, 91, 92, 93, and 94. All of the examples were simultaneously observed with each other and with all examples from No. 78 to No. 94 (Train 42).

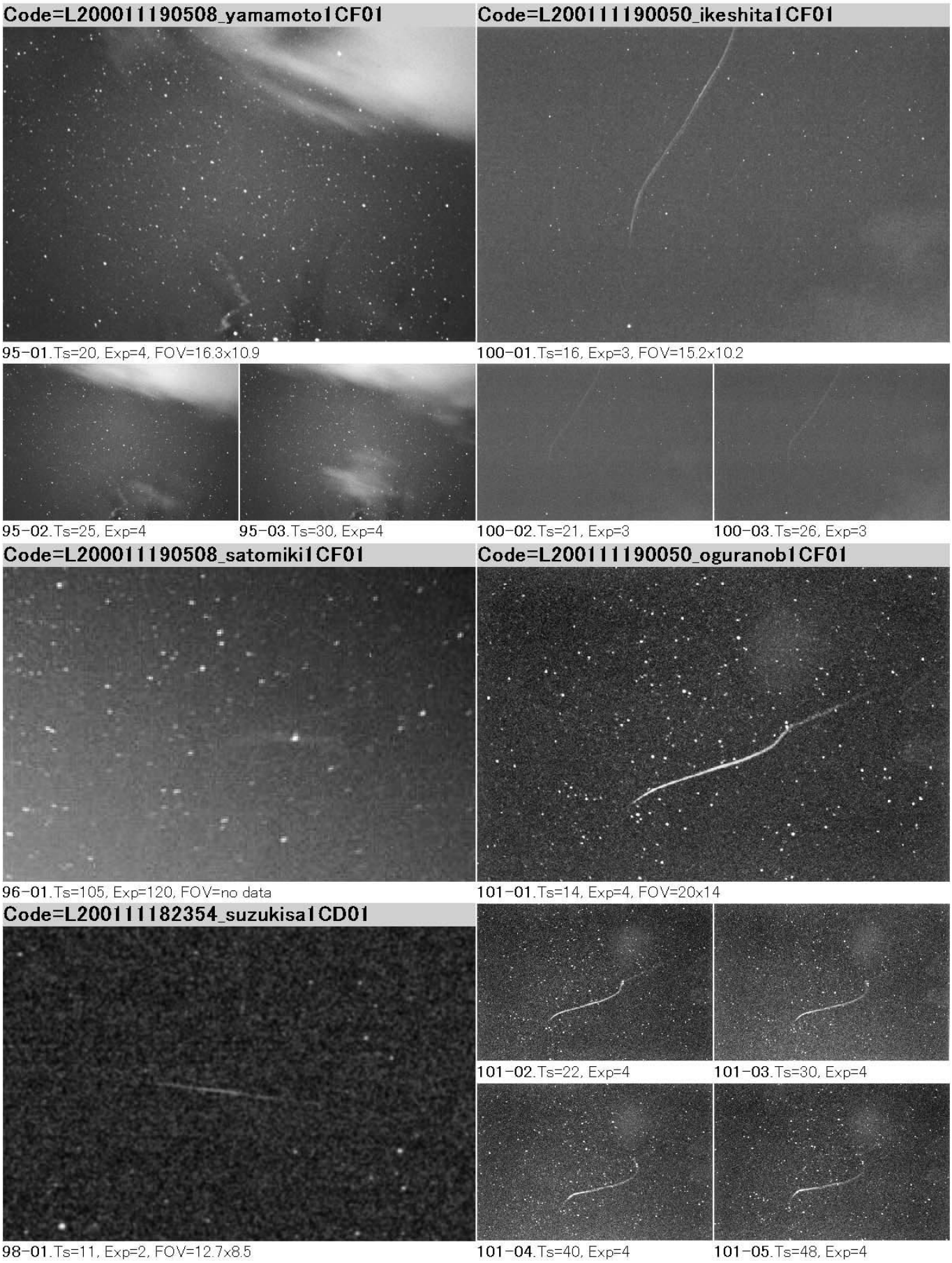

Fig. 4-07. Image sequences No. 95, 96, 98, 100, and 101. The No. 95 and 96 were simultaneously observed with each other (Train 43), whereas, a simultaneous observation was established among the No.100, 101, and 102 (Train 46).

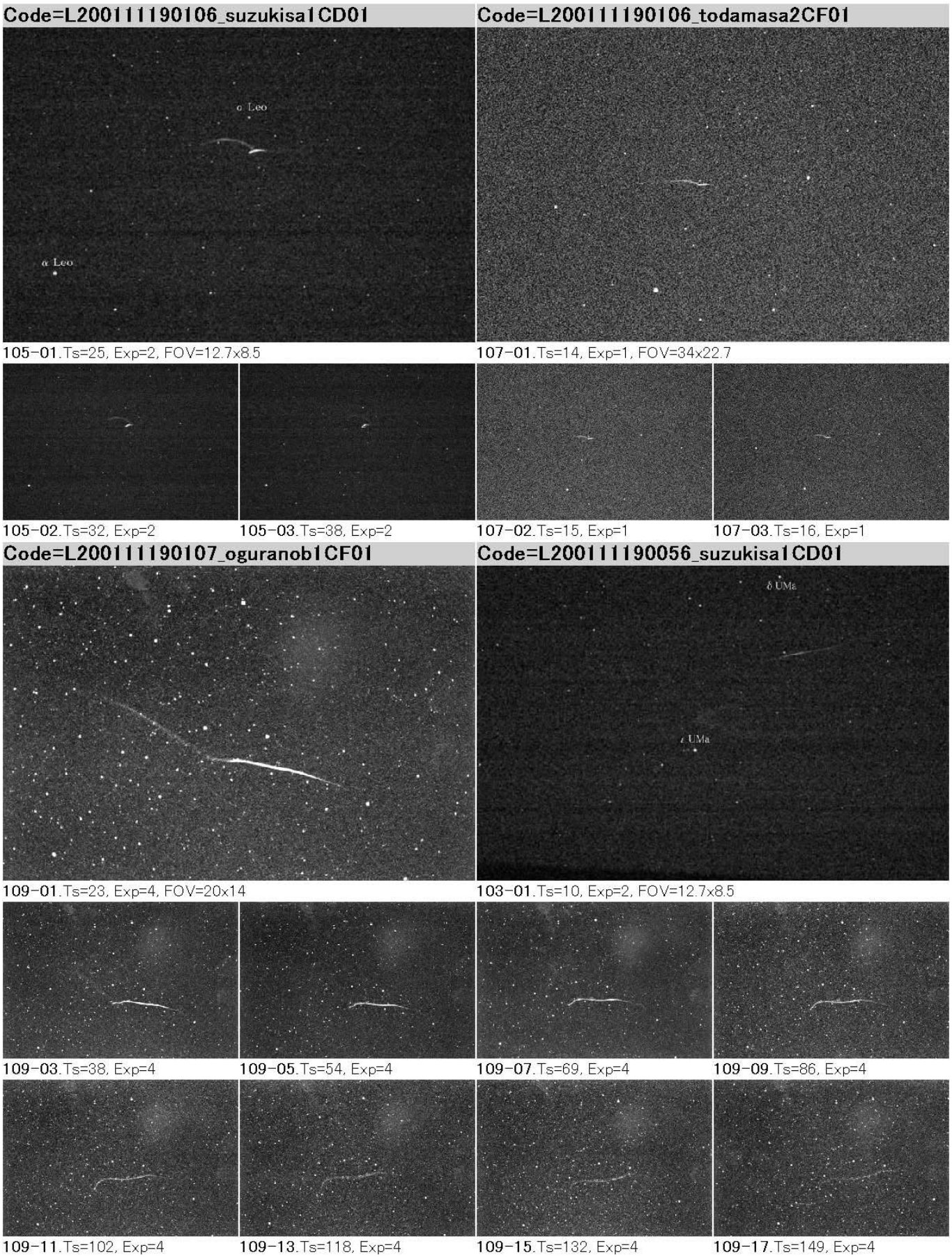

Fig. 4-08. Image sequences No. 103, 105, 107, and 109. The No. 105 and 107 were simultaneously observed with each other and with No. 106 and 108 (Train 48).

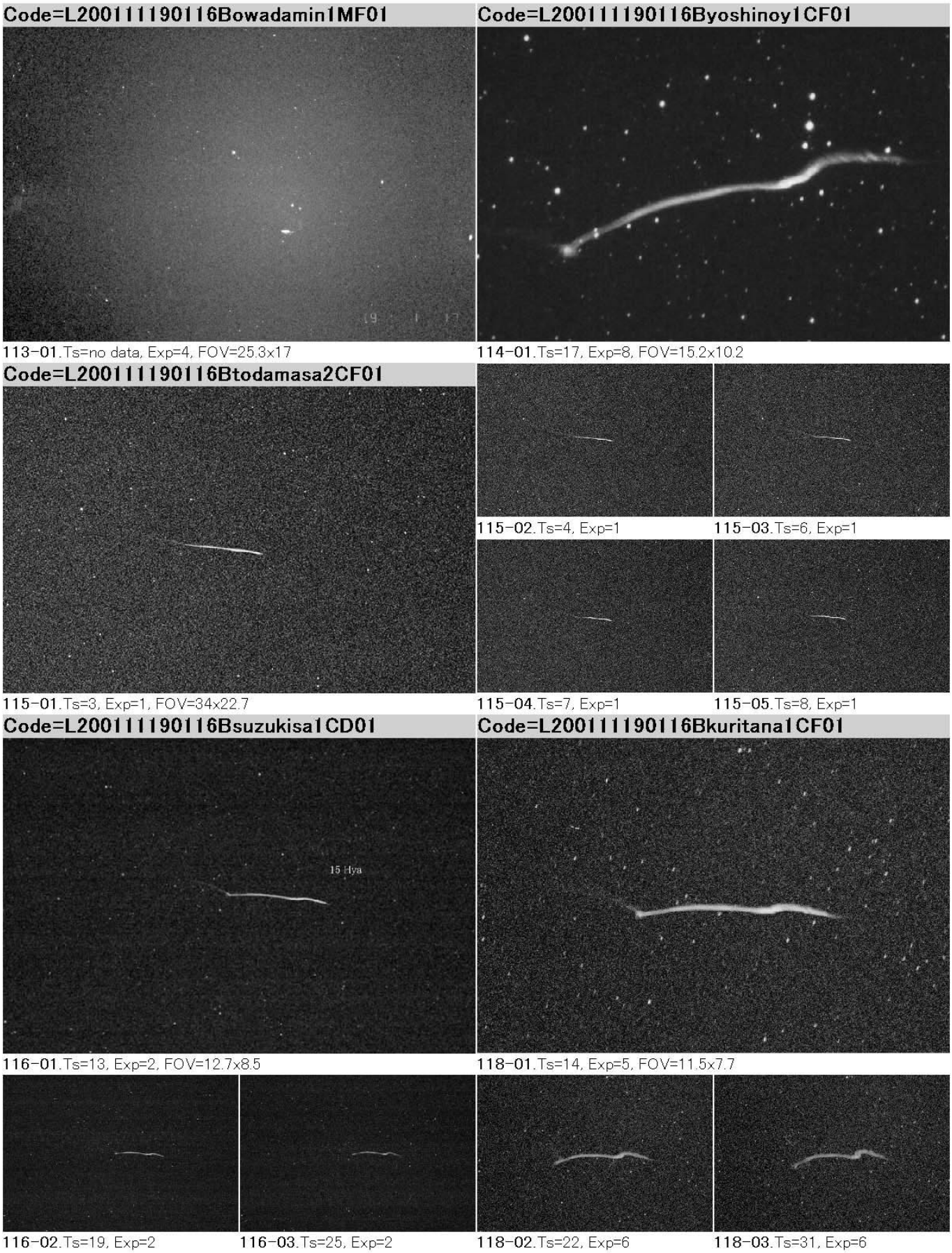

Fig. 4-09. Image sequences No.113, 114, 115, 116, and 118. All of the examples were simultaneously observed with each other and with No. 117 and 119 (Train 51).

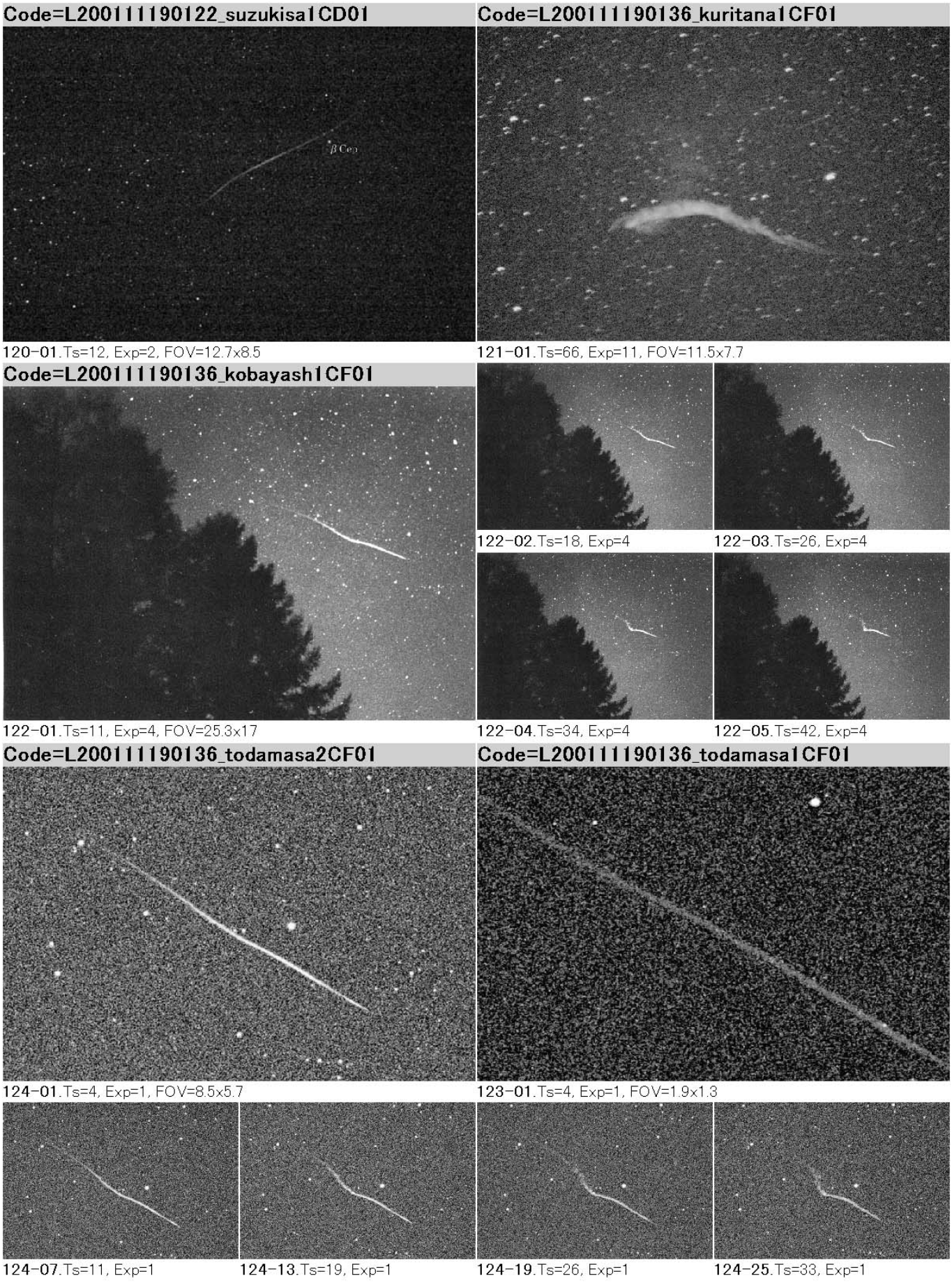

Fig. 4-10. Image sequences No. 120, 121, 122, 123, and 124. All of the examples except the No. 120 were simultaneously observed with each other and with all examples from No. 121 to No. 130 (Train 53).

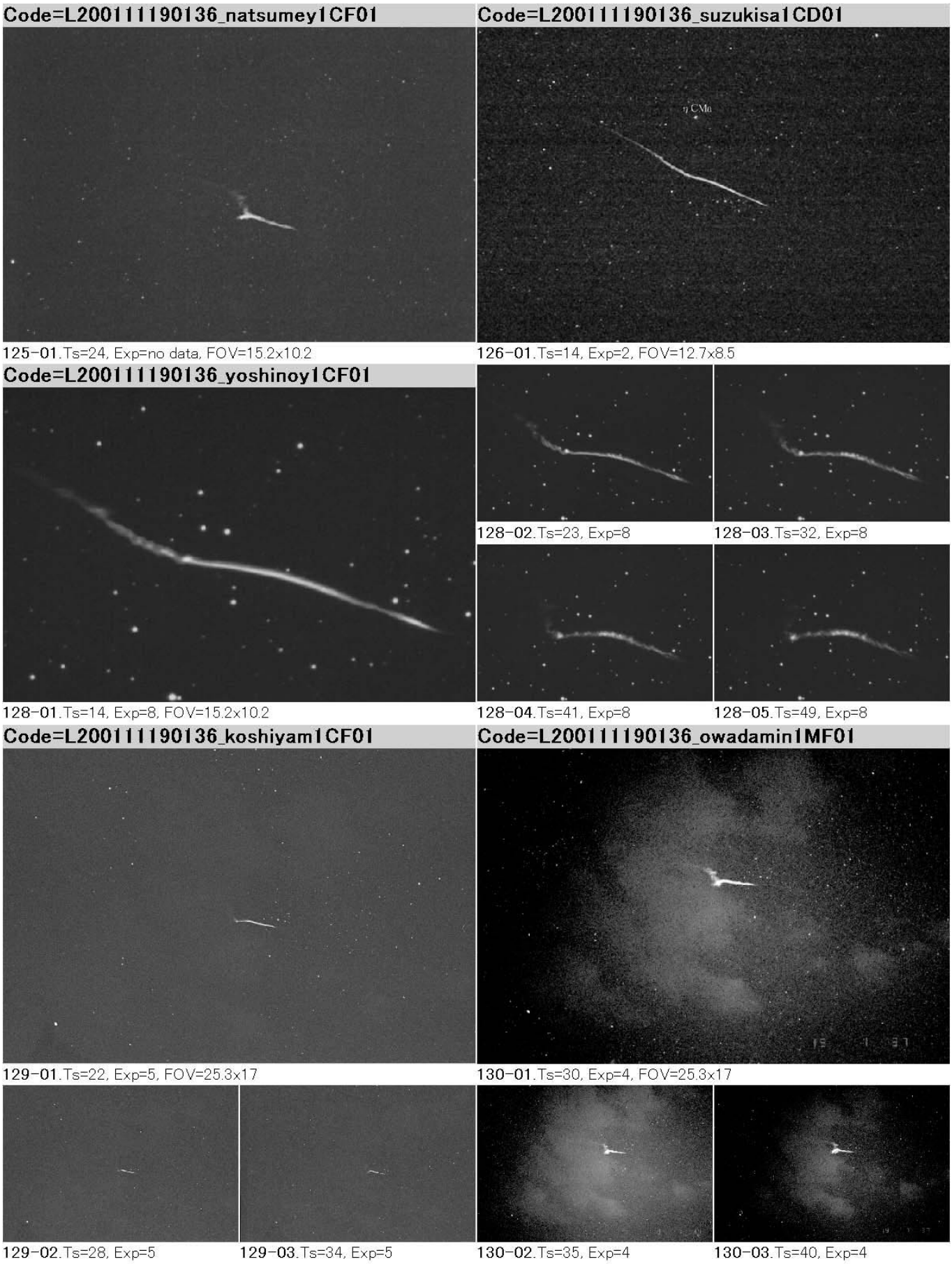

Fig. 4-11. Image sequences No. 125, 126, 128, 129, and 130. All of the examples were simultaneously observed with each other and with all examples from No. 121 to No. 130 (Train 53).

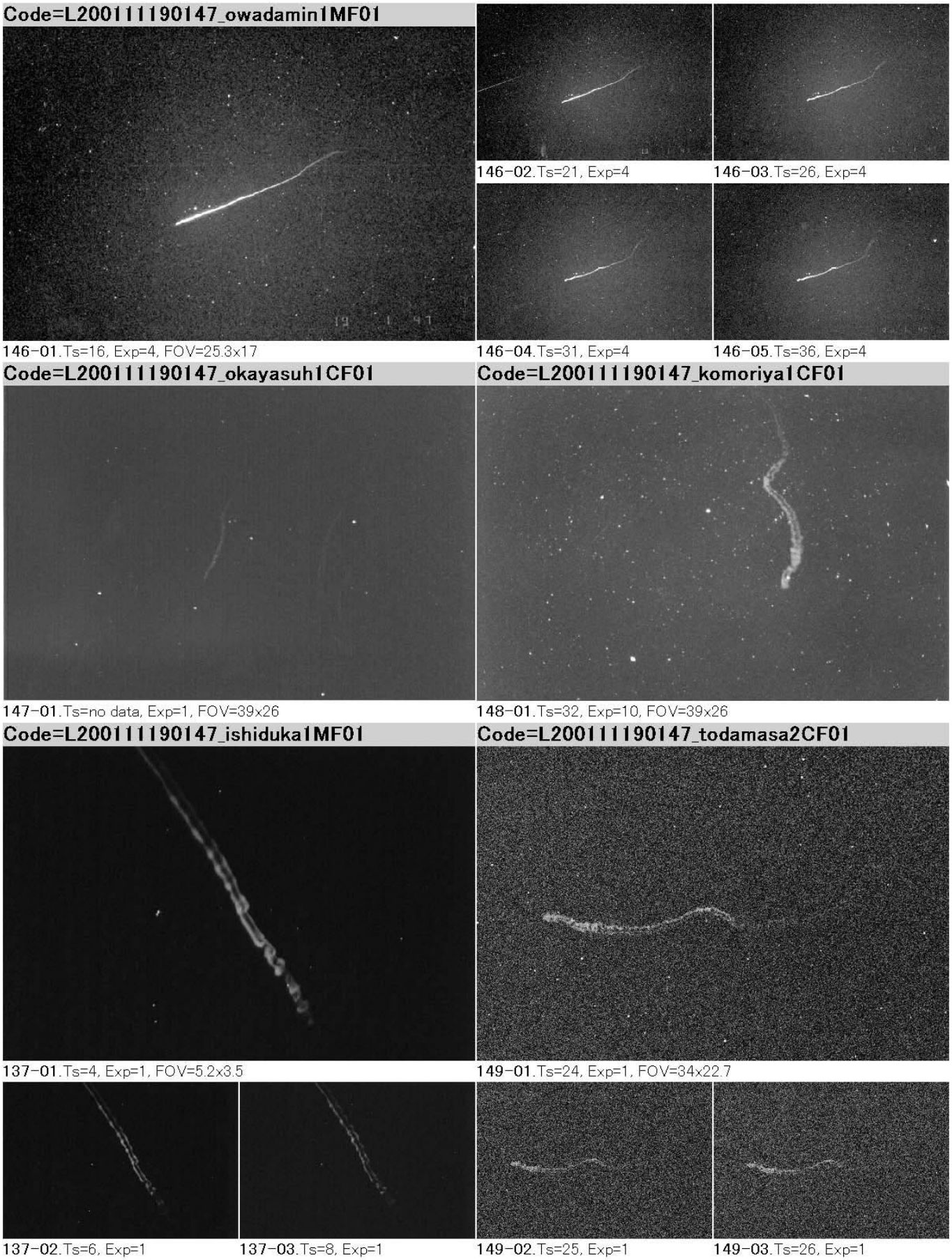

Fig. 4-12. Image sequences No. 137, 146, 147, 148, and 149. All of the examples were simultaneously observed with each other and with all examples from No. 136 to No. 164 (Train 58). The No. 137 taken by 400 mm telephoto lens was the finest image sequence during the period 1998–2002.

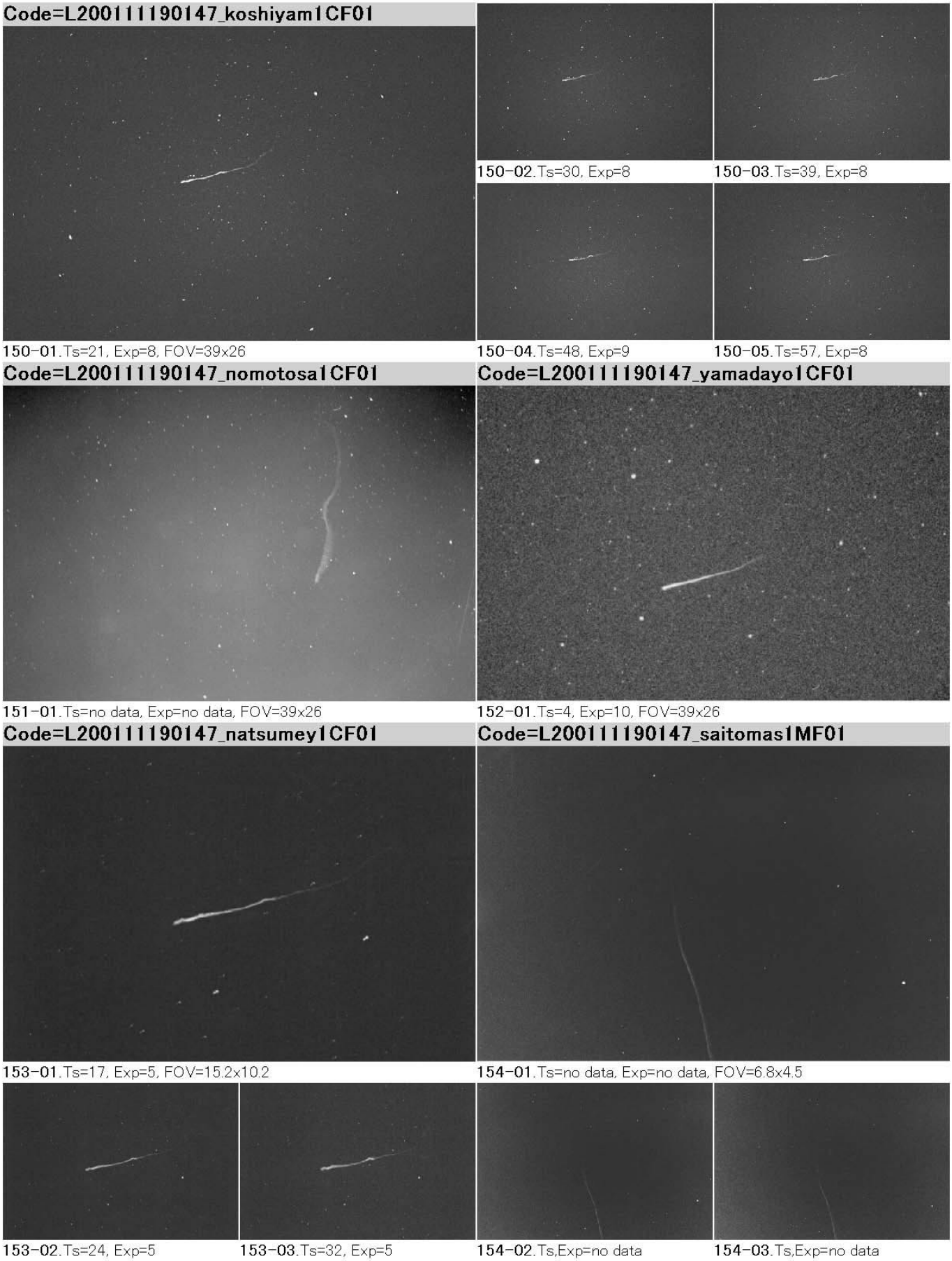

Fig. 4-13. Image sequences No. 150, 151, 152, 153, and 154. All of the examples were simultaneously observed with each other and with all examples from No. 136 to No. 164 (Train 58).

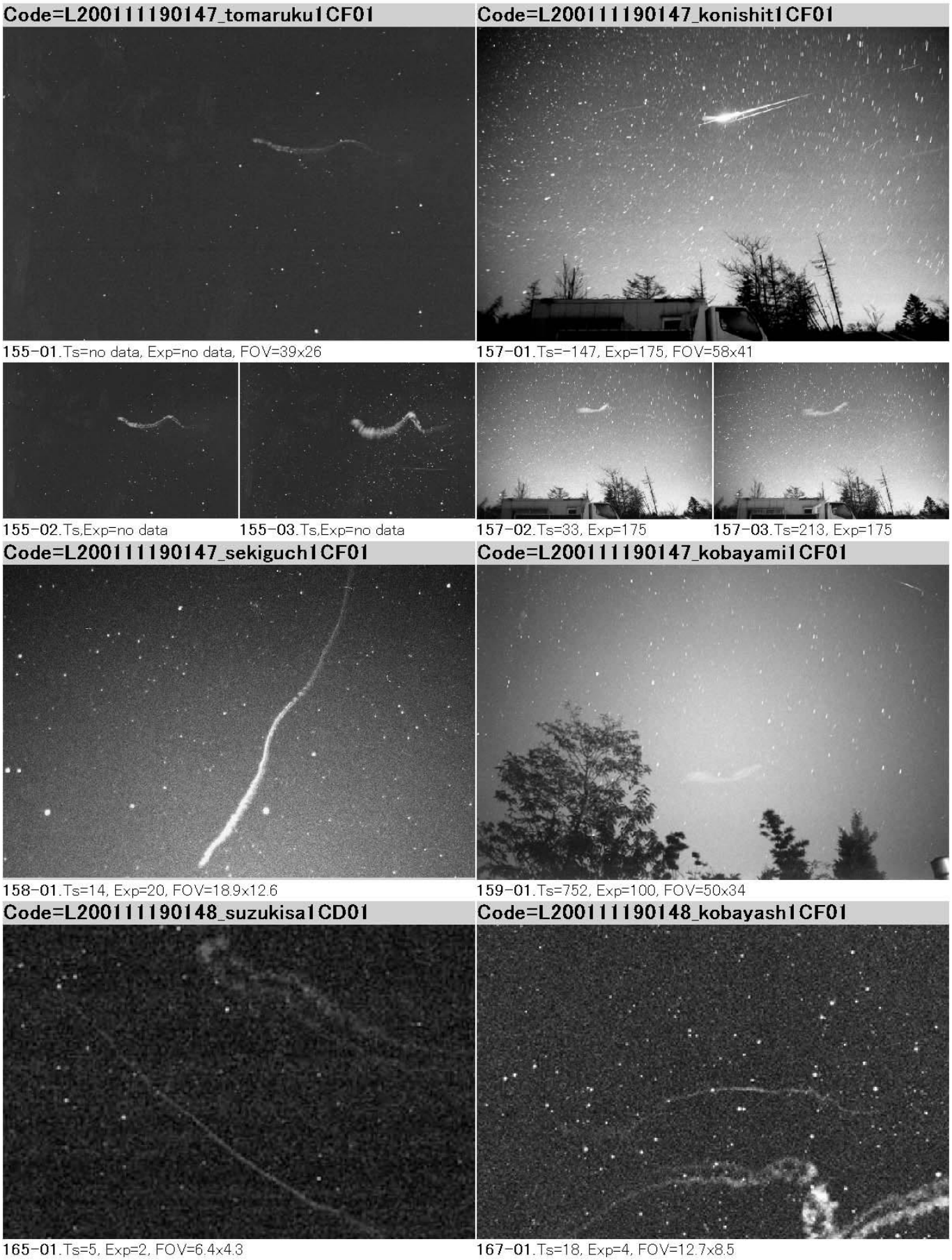

Fig. 4-14. Image sequences No. 155, 157, 158, 159, 165, and 167. The No. 155, 157, 158, and 159 were simultaneously observed with each other and with all examples from No. 136 to No. 164 (Train 58). The No. 165 and 167 were also simultaneously observed with each other and with all examples from No. 165 to No. 172 (Train 59). Train 59 was observed just after the appearance of the brightest train (Train 58) in the same FOV.

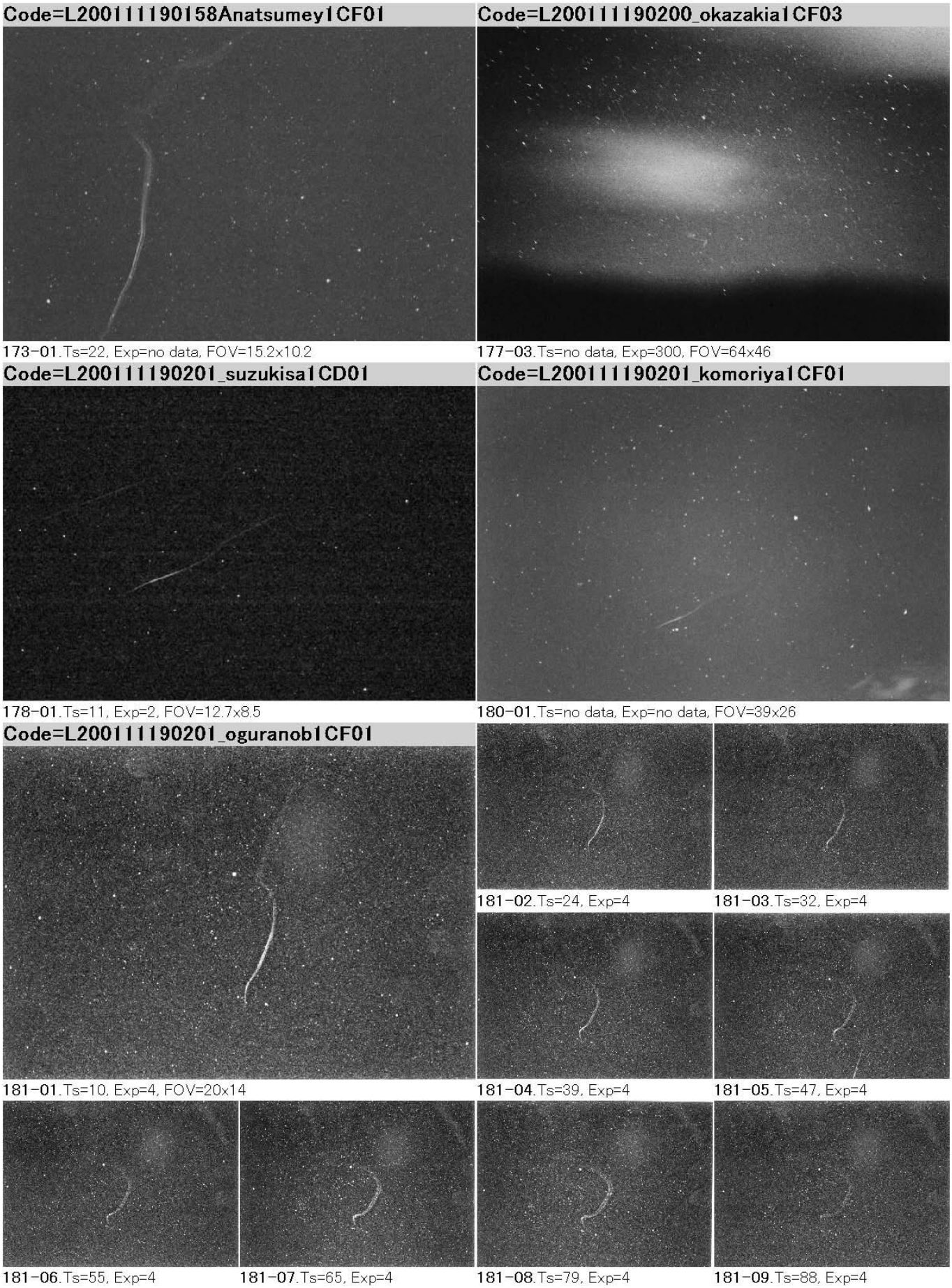

Fig. 4-15. Image sequences No. 173, 177, 178, 180, and 181. The No. 178, 180, and 181 were simultaneously observed with each other and with No. 179 and 182 (Train 63).

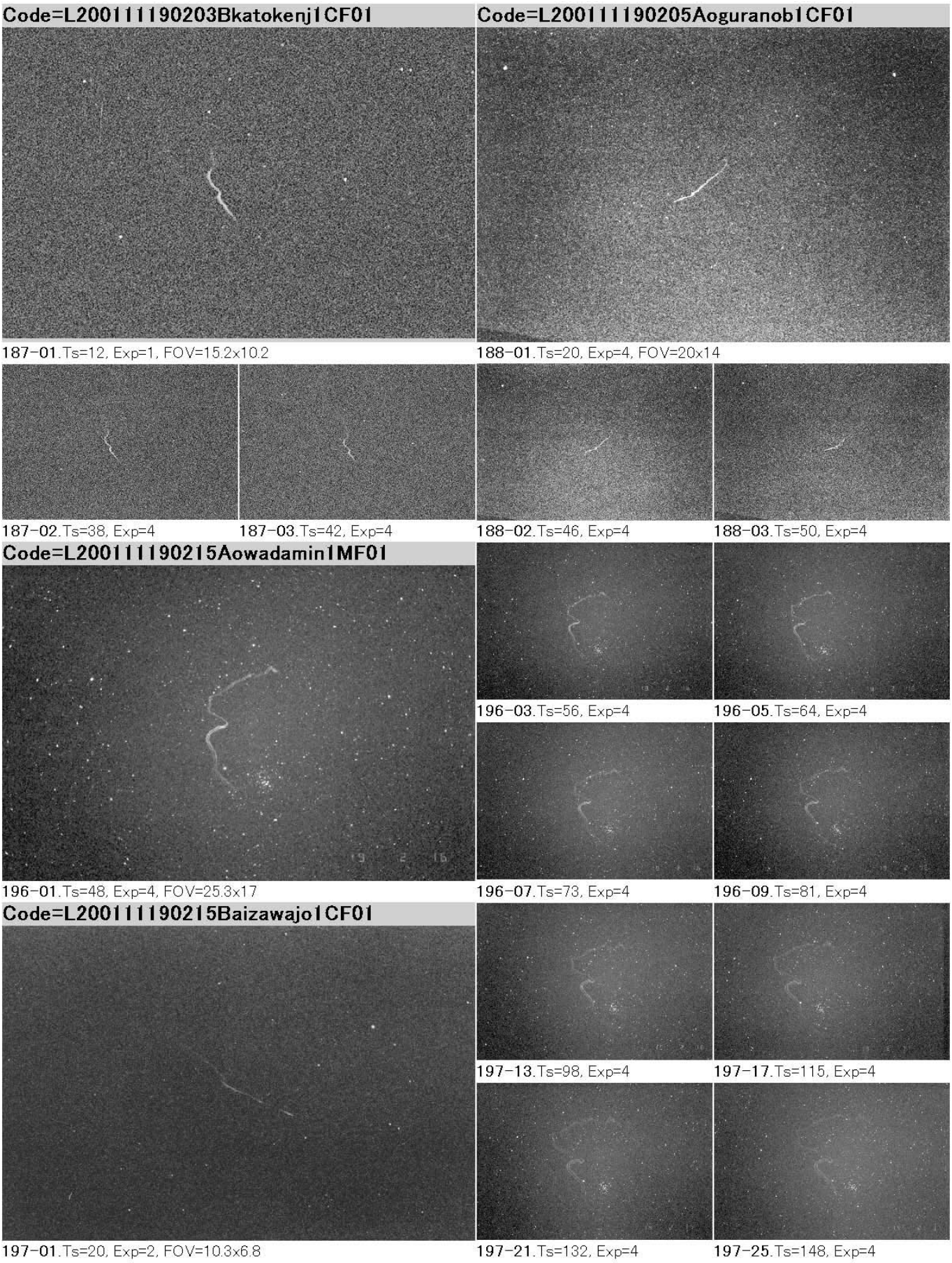

Fig. 4-16. Image sequences No. 187, 188, 196, and 197.

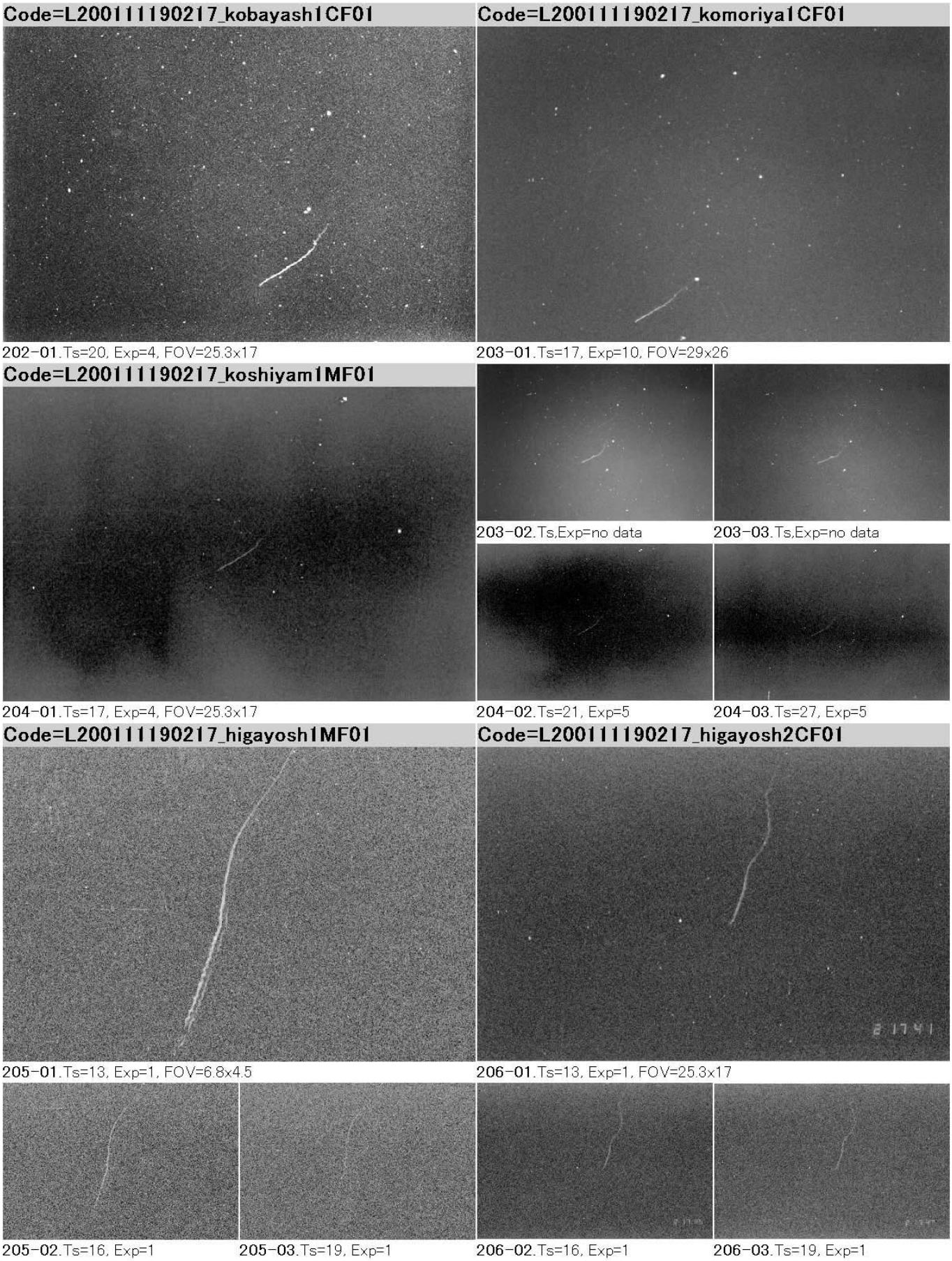

Fig. 4-17. Image sequences No. 202, 203, 204, 205, and 206. All of the examples were simultaneously observed with each other and with all examples from No. 199 to No. 208 (Train 75).

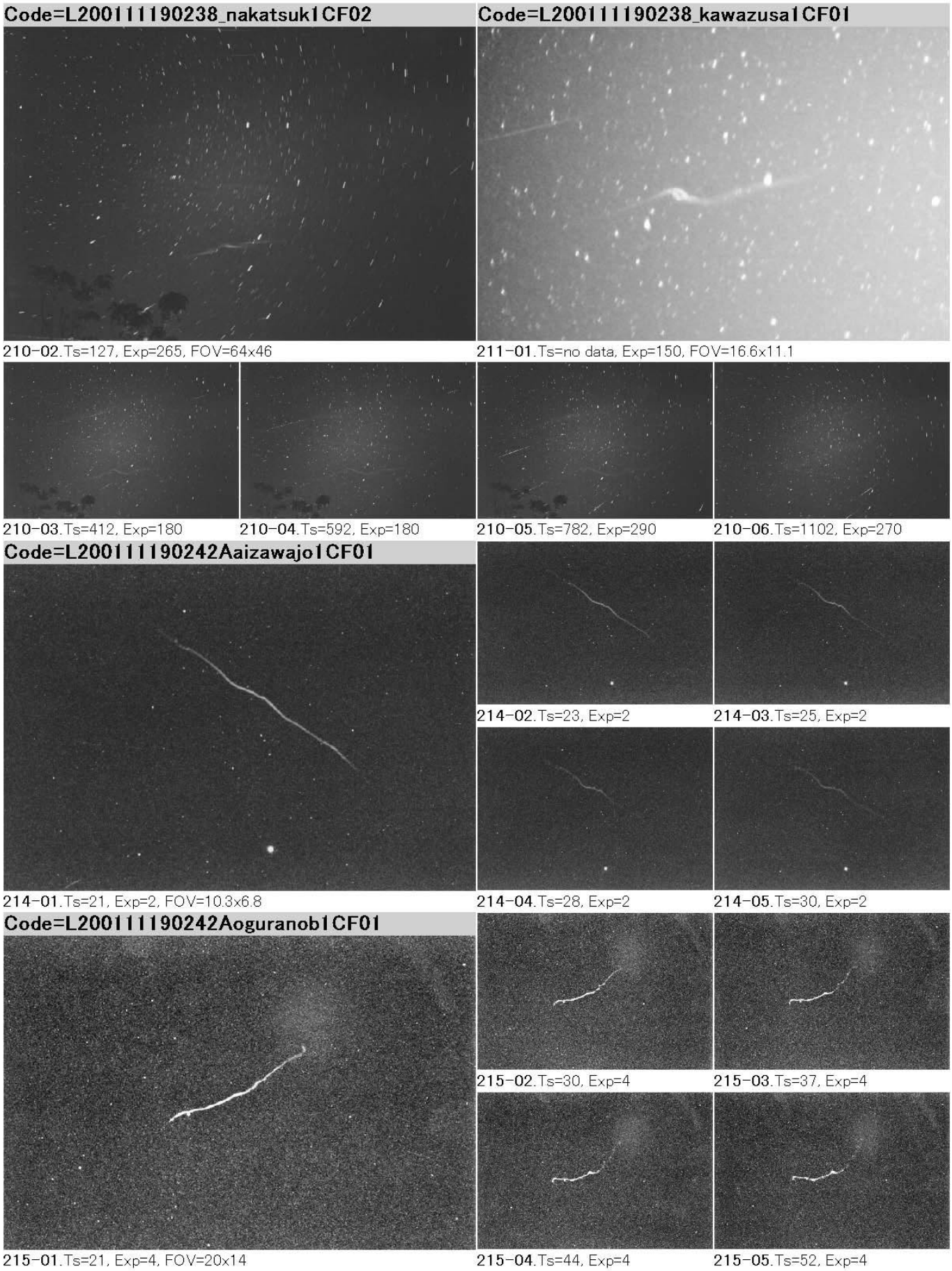

Fig. 4-18. Image sequences No. 210, 211, 214, and 215. The No. 210 and 211 were simultaneously observed with each other and with No. 212 and 213 (Train 77), whereas, a simultaneous observation was established among the No.214, 215, 216, and 217 (Train 78).

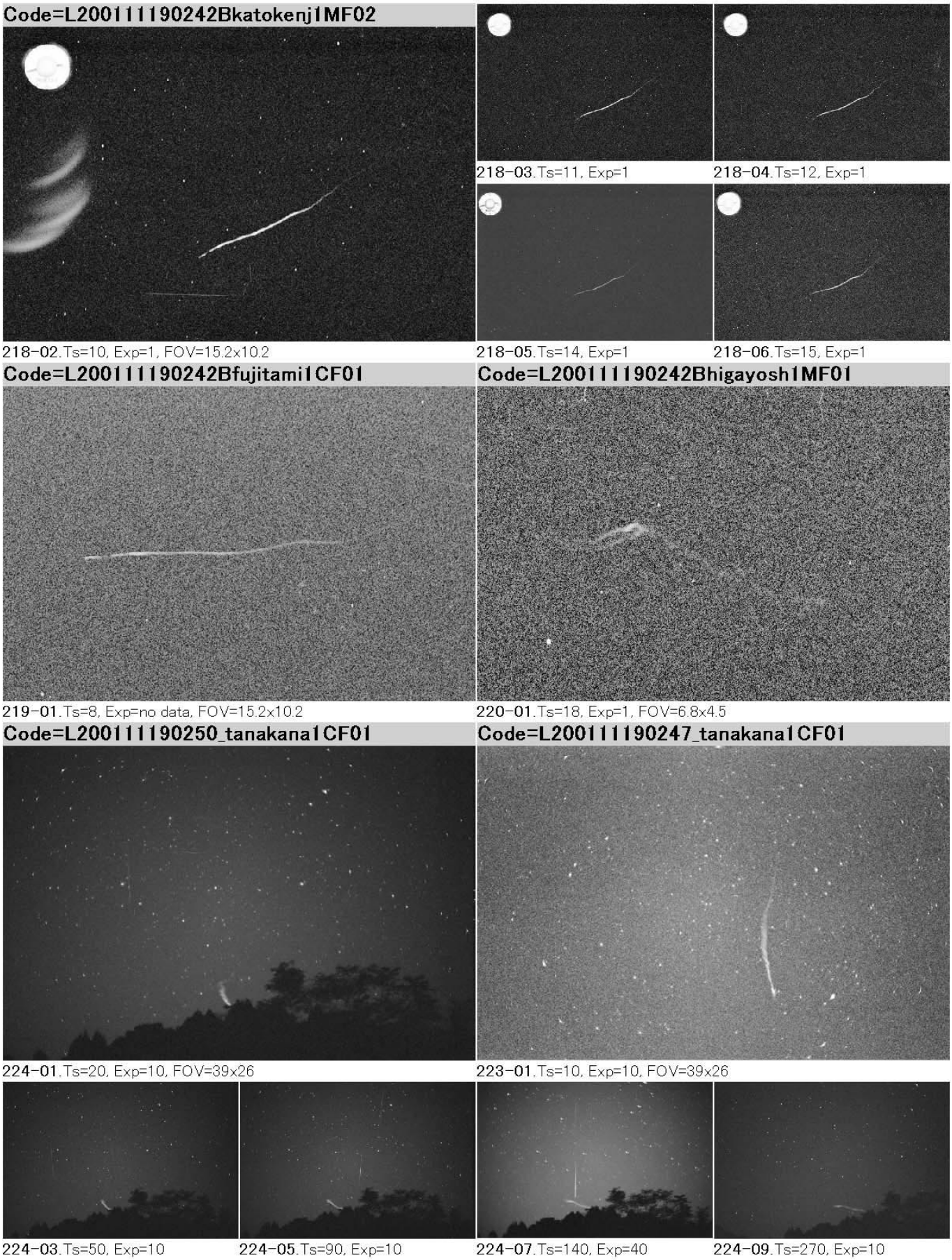

Fig. 4-19. Image sequences No. 218, 219, 220, 223, and 224. The No. 218, 219, and 220 were simultaneously observed with each other and with No. 221 and No. 222 (Train 79).

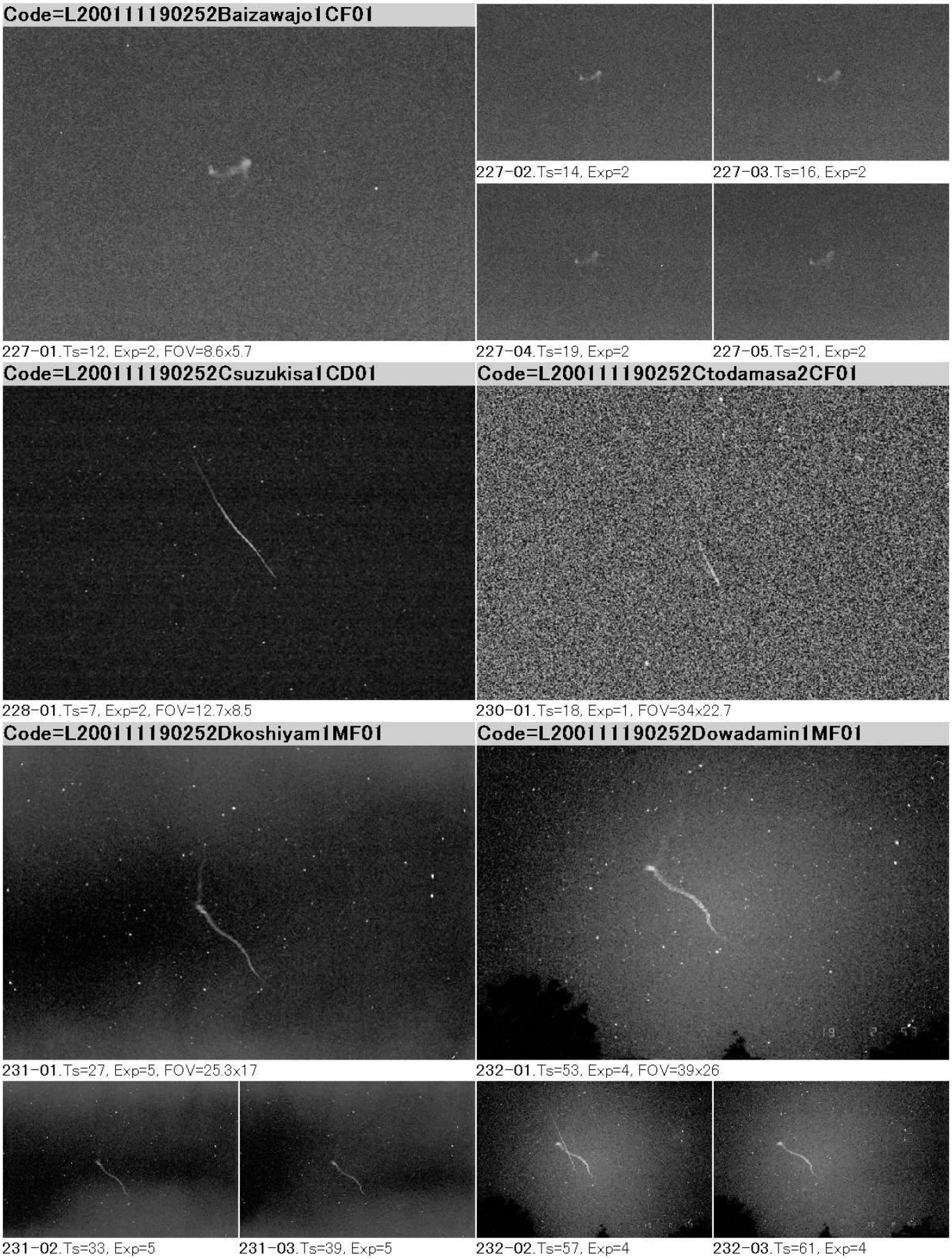

Fig. 4-20. Image sequences No. 227, 228, 230, 231, and 232. The No. 228 and 230 were simultaneously observed with each other and with No. 229 (Train 84). The No. 231 and 232 were also simultaneously observed with each other from one observational site.

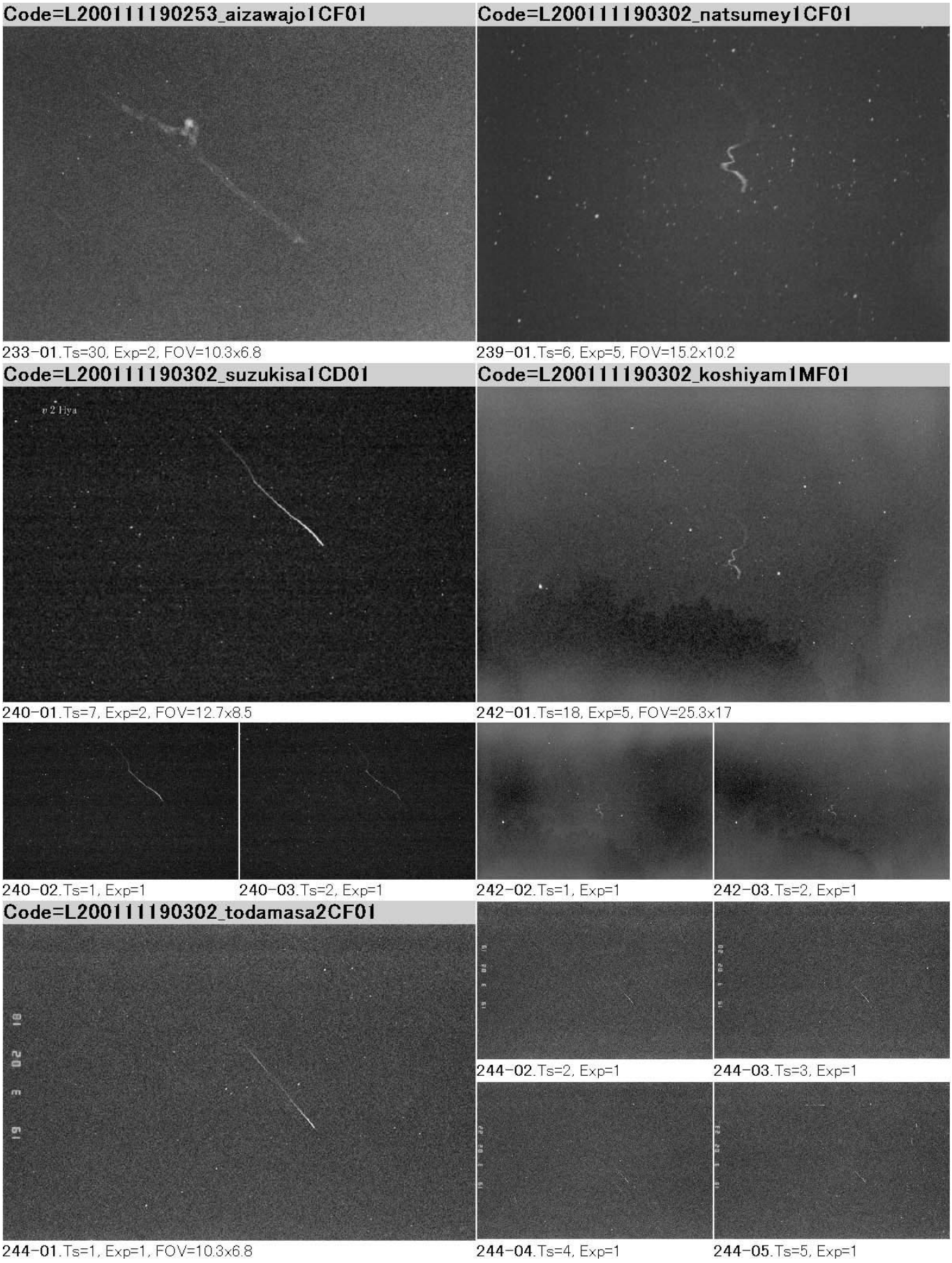

Fig. 4-21. Image sequences No. 233, 239, 240, 242, and 244. All of the examples except the No. 233 were simultaneously observed with each other and with all examples from No. 239 to No. 245 (Train 91).

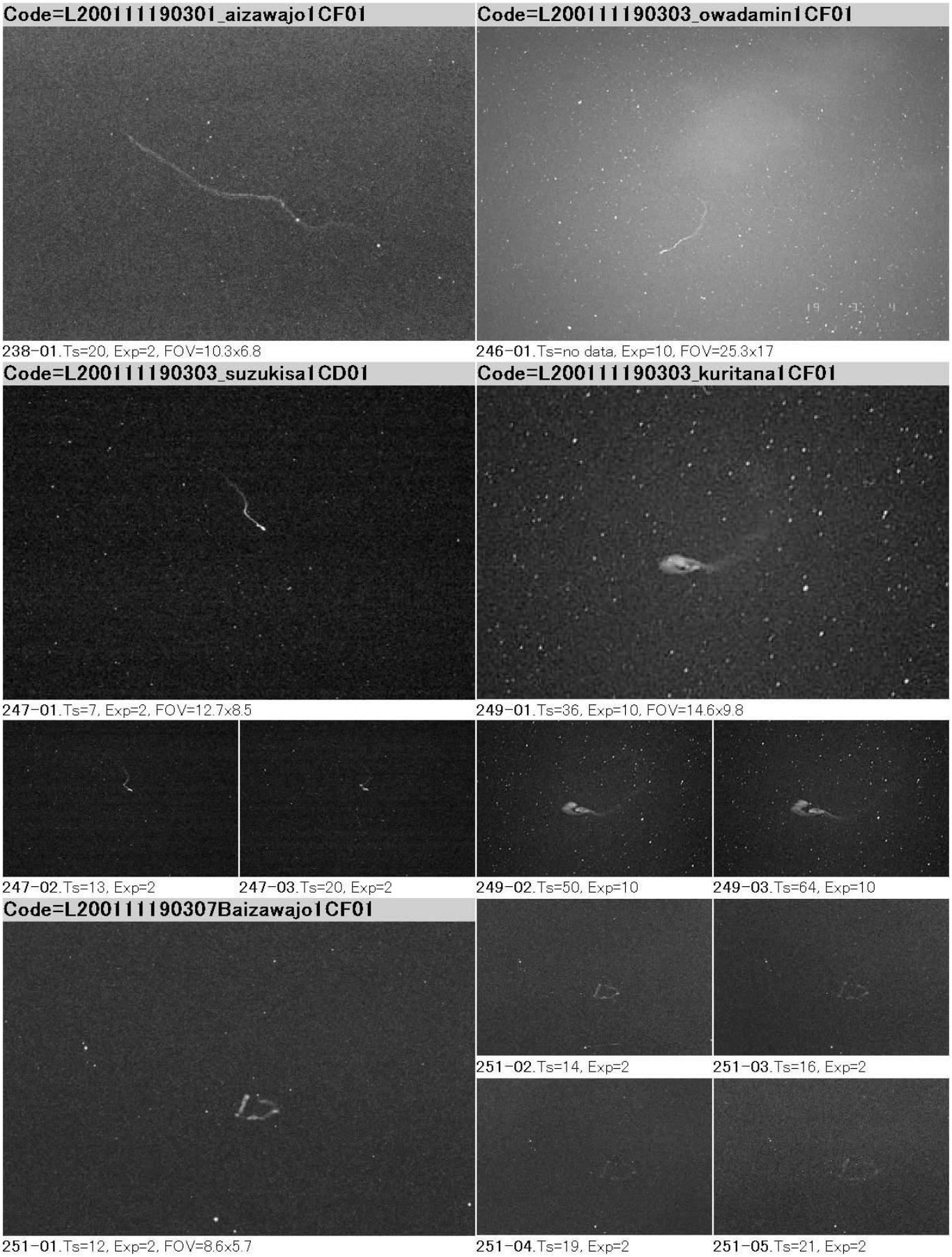

Fig. 4-22. Image sequences No. 238, 246, 247, 249, and 251. The No. 246, 247, and 249 were simultaneously observed with each other and with No. 248 (Train 92). No. 251 was observed besides the radiant of Leonids.

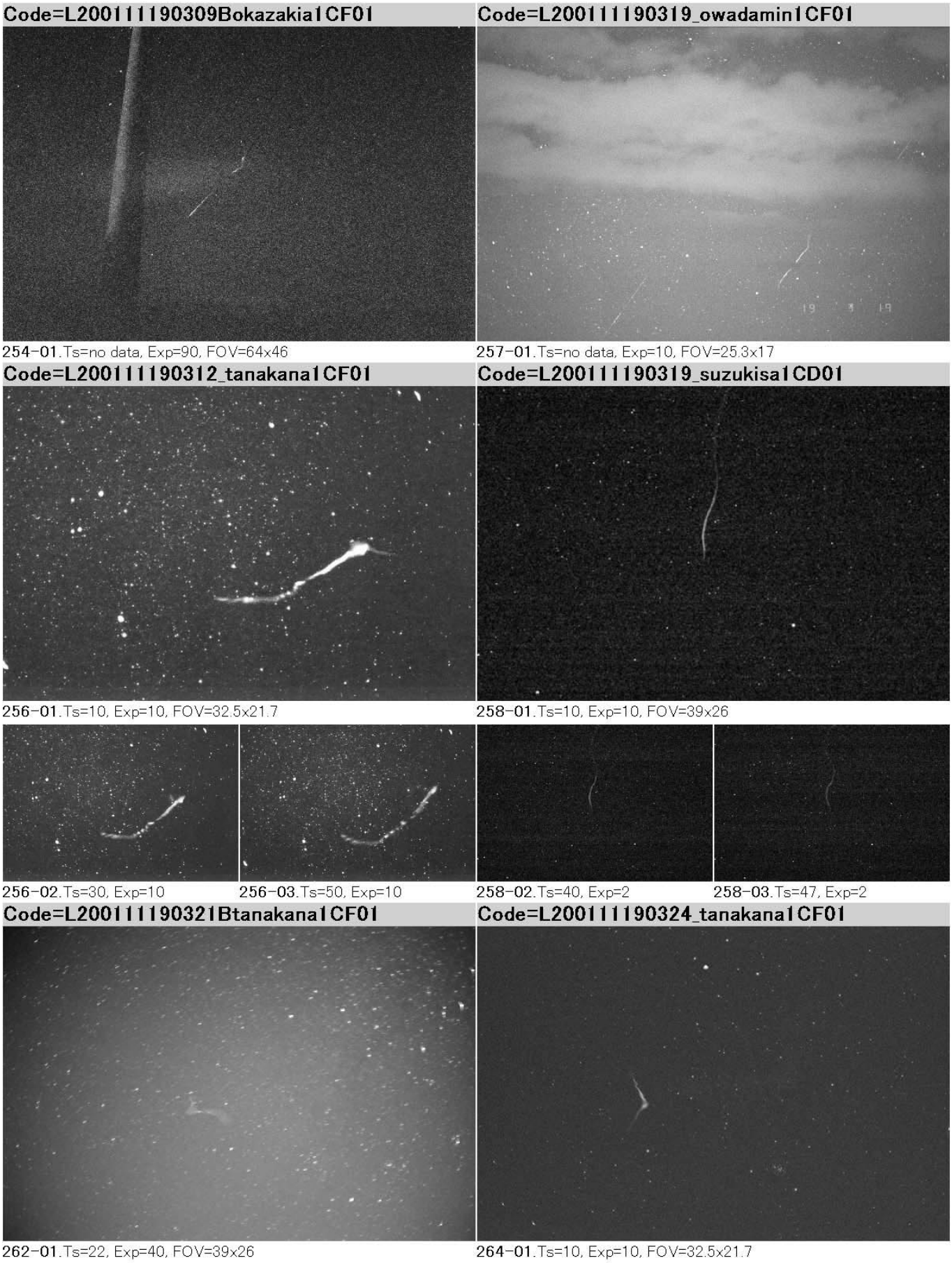

Fig. 4-23. Image sequences No. 254, 256, 257, 258, 262, and 264. The No. 257 and 258 were simultaneously observed with each other and with No. 259 (Train 99).

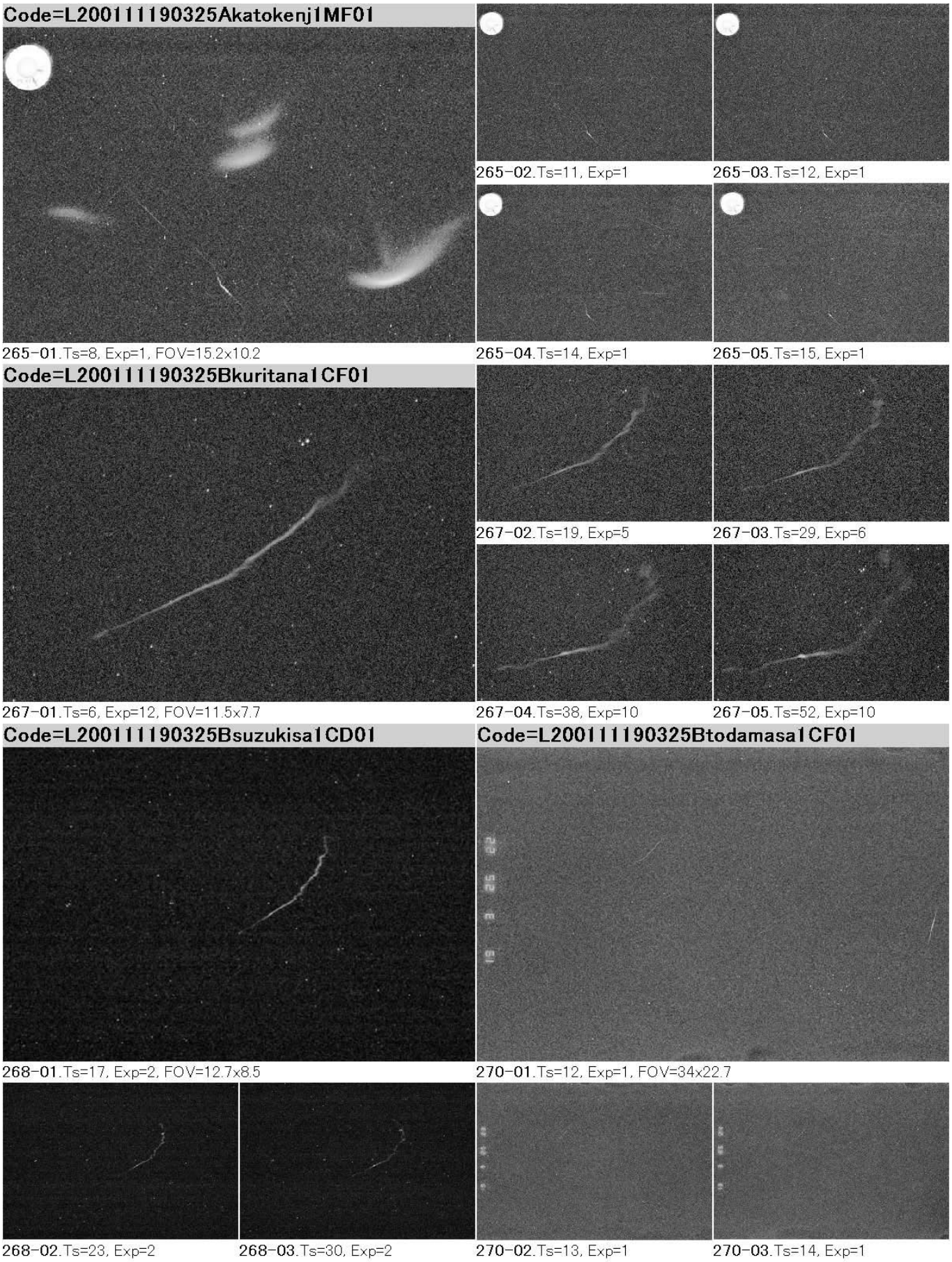

Fig. 4-24. Image sequences No. 265, 267, 268, and 270. All of the examples except the No. 265 were simultaneously observed with each other and with No. 269 (Train 104).

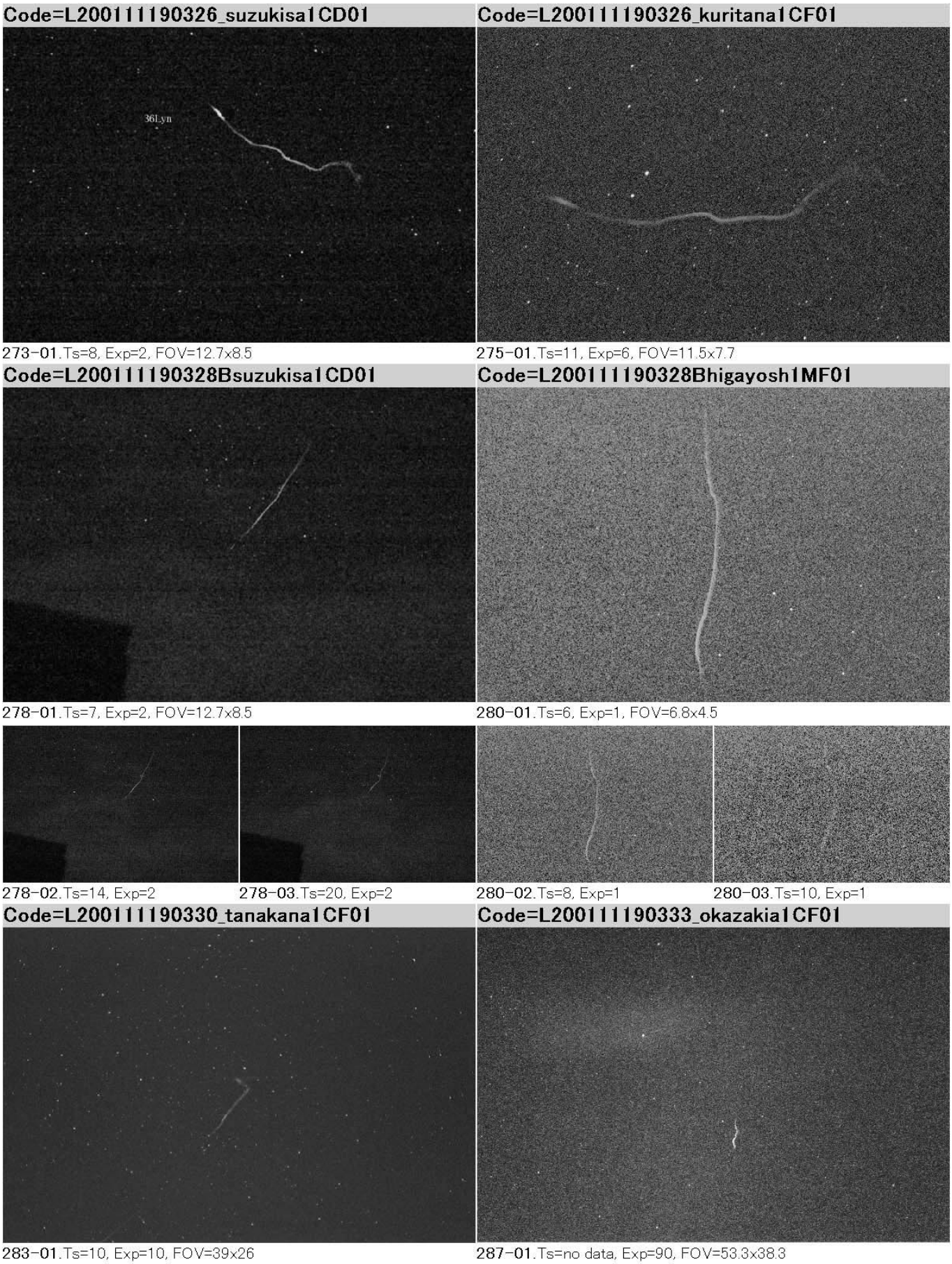

Fig. 4-25. Image sequences No. 273, 275, 278, 280, 283, and 287. The No. 273 and 275 were simultaneously observed with each other and with No. 274 (Train 107). The No. 278 and 280 were also simultaneously observed with each other with all examples from No. 278 to No. 282 (Train 109).

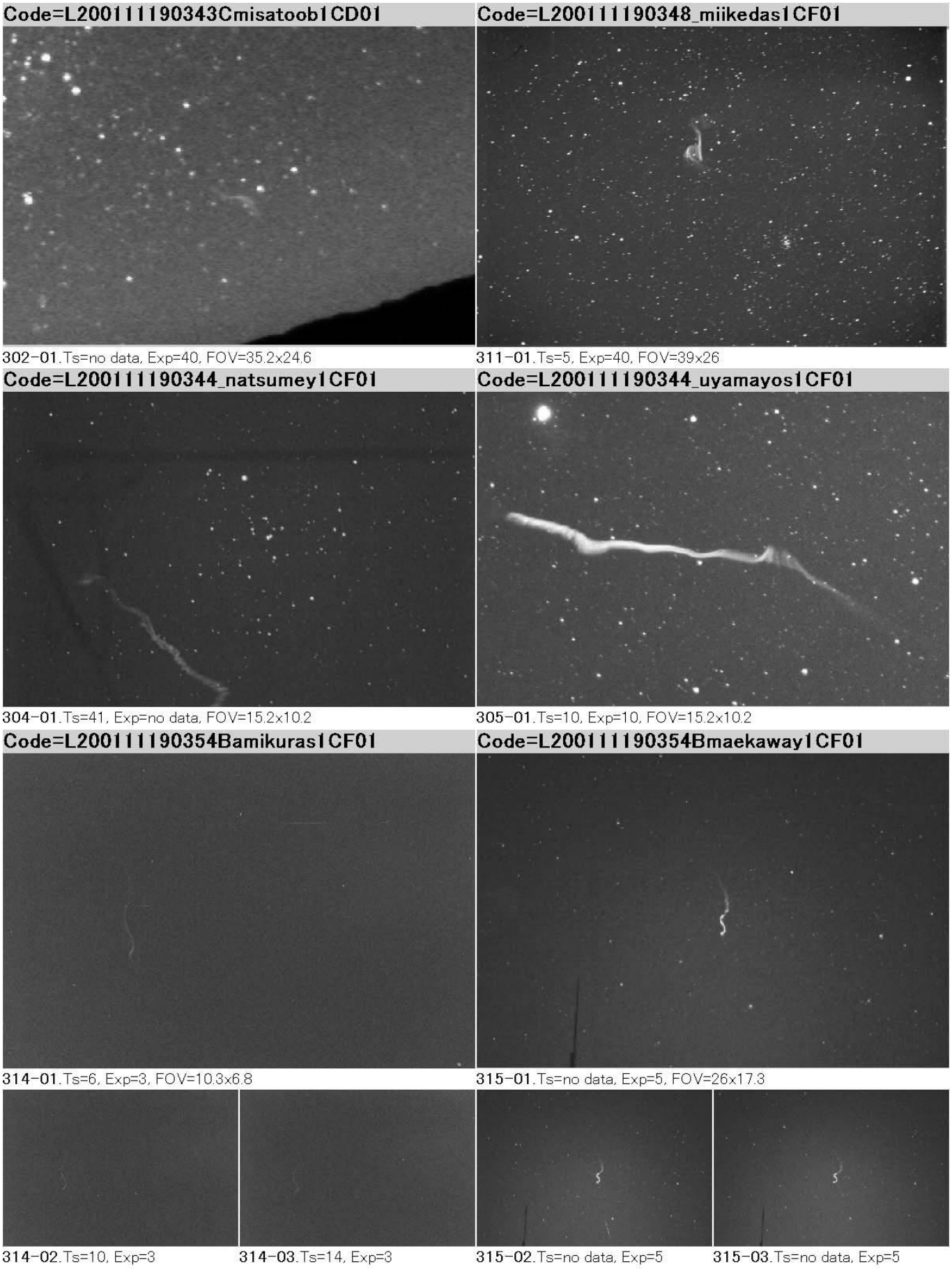

Fig. 4-26. Image sequences No. 302, 304, 305, 311, 314, and 315. The No. 304 and 305 were simultaneously observed with each other and with No. 306 and 307 (Train 124). The No. 314 and 315 were also simultaneously observed with each other and with all examples from No. 314 to No. 319 (Train 130).

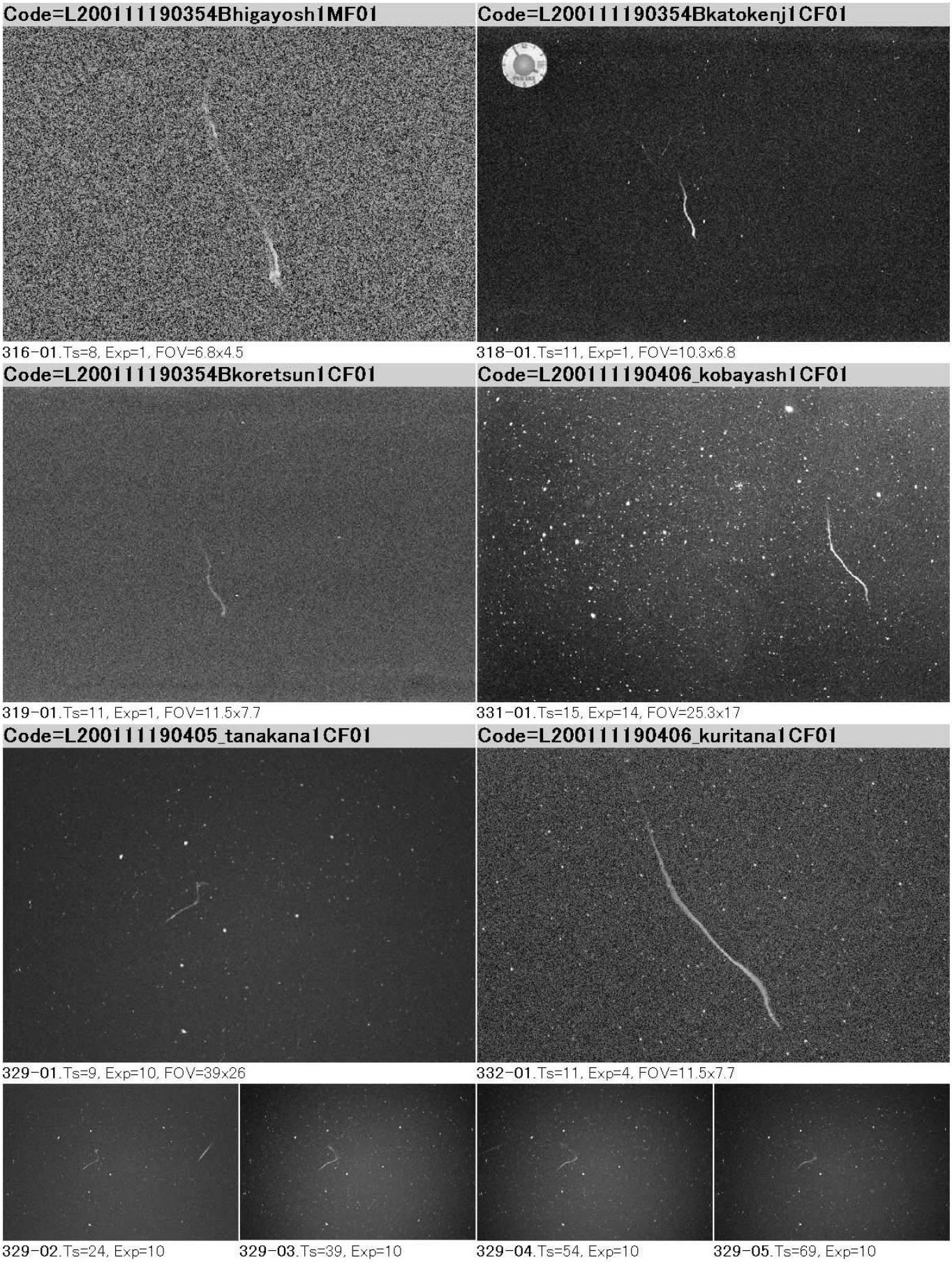

Fig. 4-27. Image sequences No. 316, 318, 319, 329, 331, and 332. The No. 316 and 318 were simultaneously observed with each other and with all examples from No. 314 to No. 319 (Train 130). The No. 331 and 332 were also simultaneously observed with each other and with all examples from No. 331 to No. 335 (Train 138).

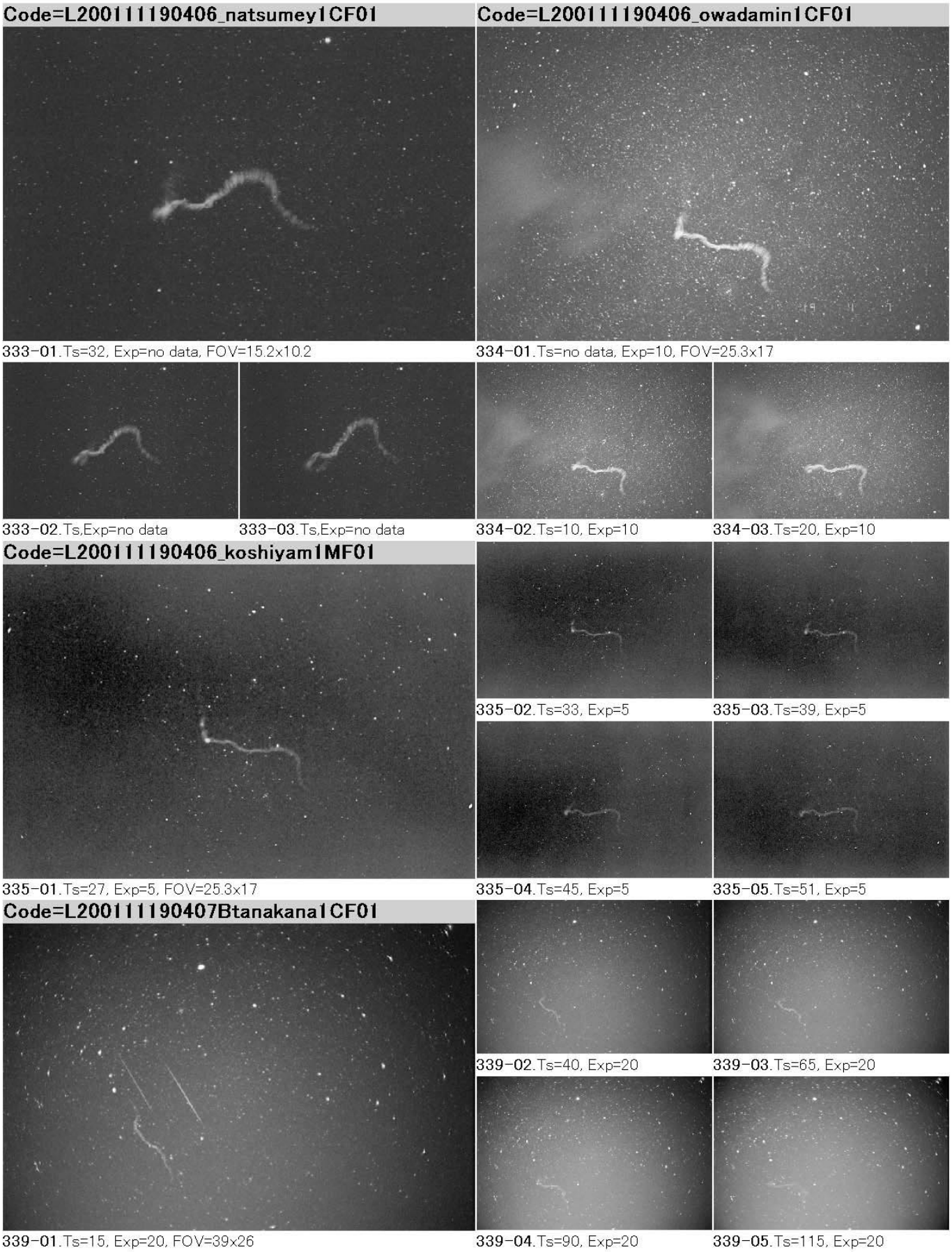

Fig. 4-28. Image sequences No. 333, 334, 335, and 339. All of the examples except the No. 339 were simultaneously observed with each other and with No. 331 and 332 (Train 138).

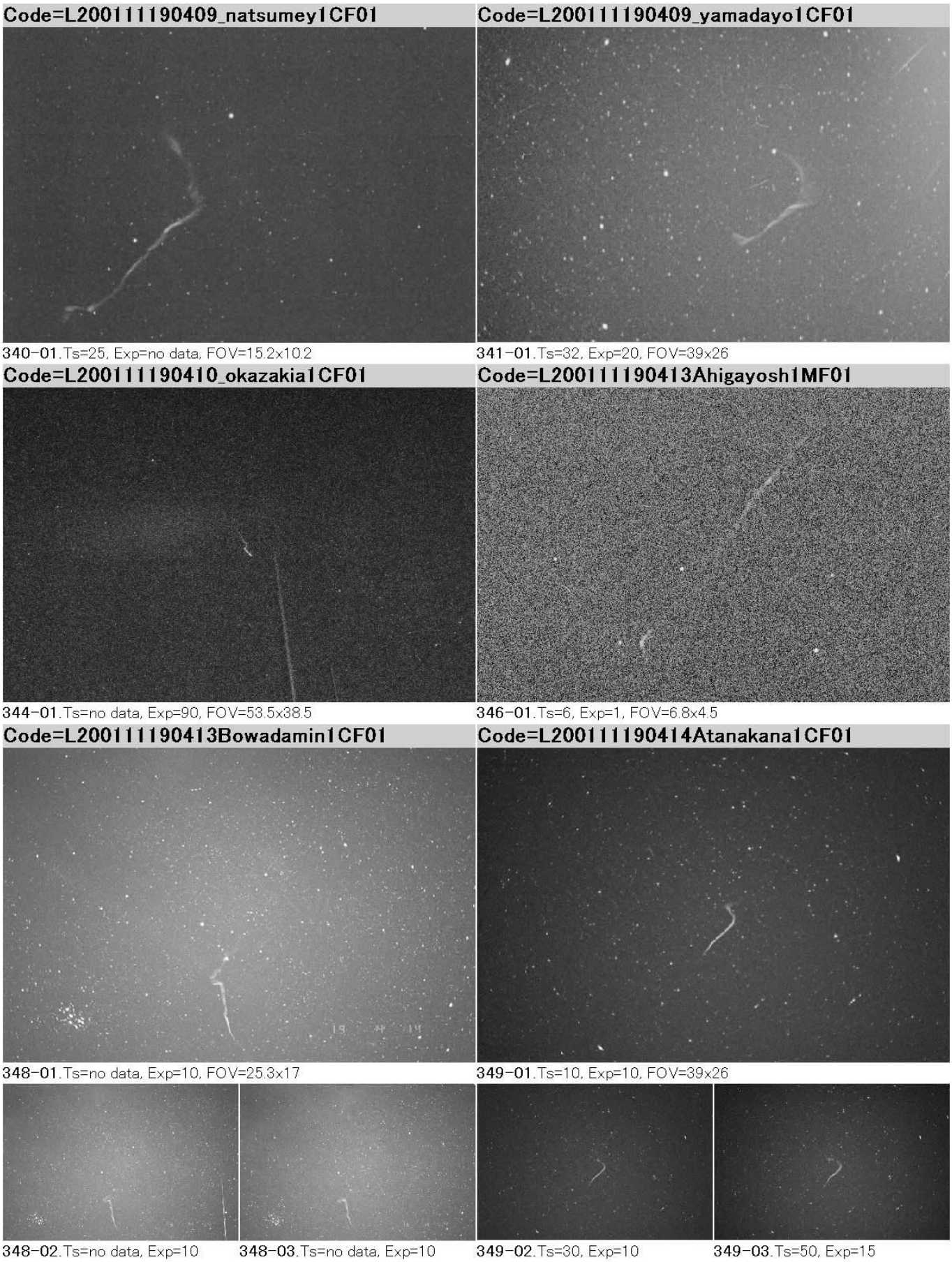

Fig. 4-29. Image sequences No. 340, 341, 344, 346, 348, and 349. The No. 340 and 341 were simultaneously observed with each other and with No. 342 and 343 (Train 141).

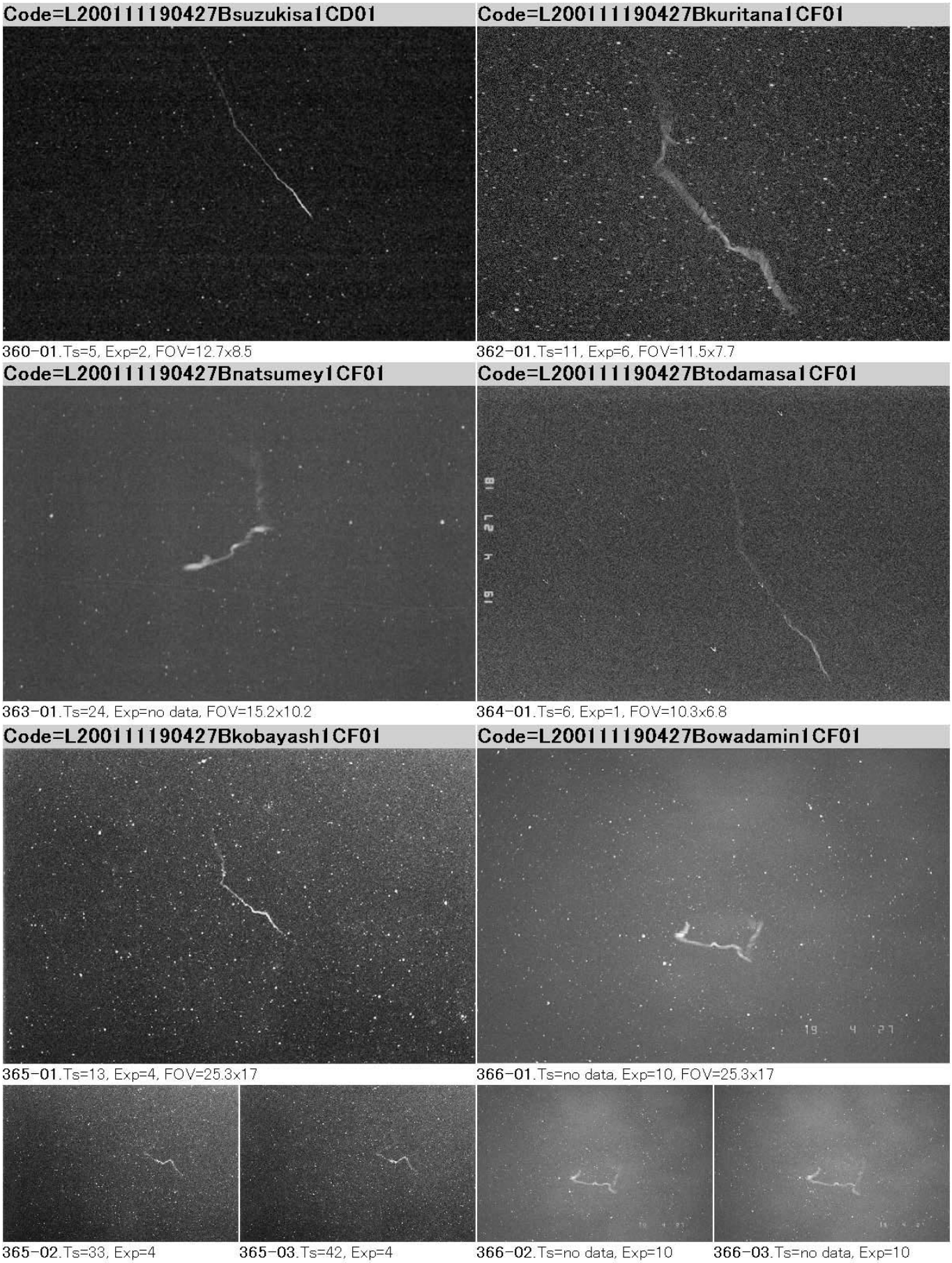

Fig. 4-30. Image sequences No. 360, 362, 363, 364, 365, and 366. All of the examples were simultaneously observed with each other and with No. 361 and 367 (Train 153).

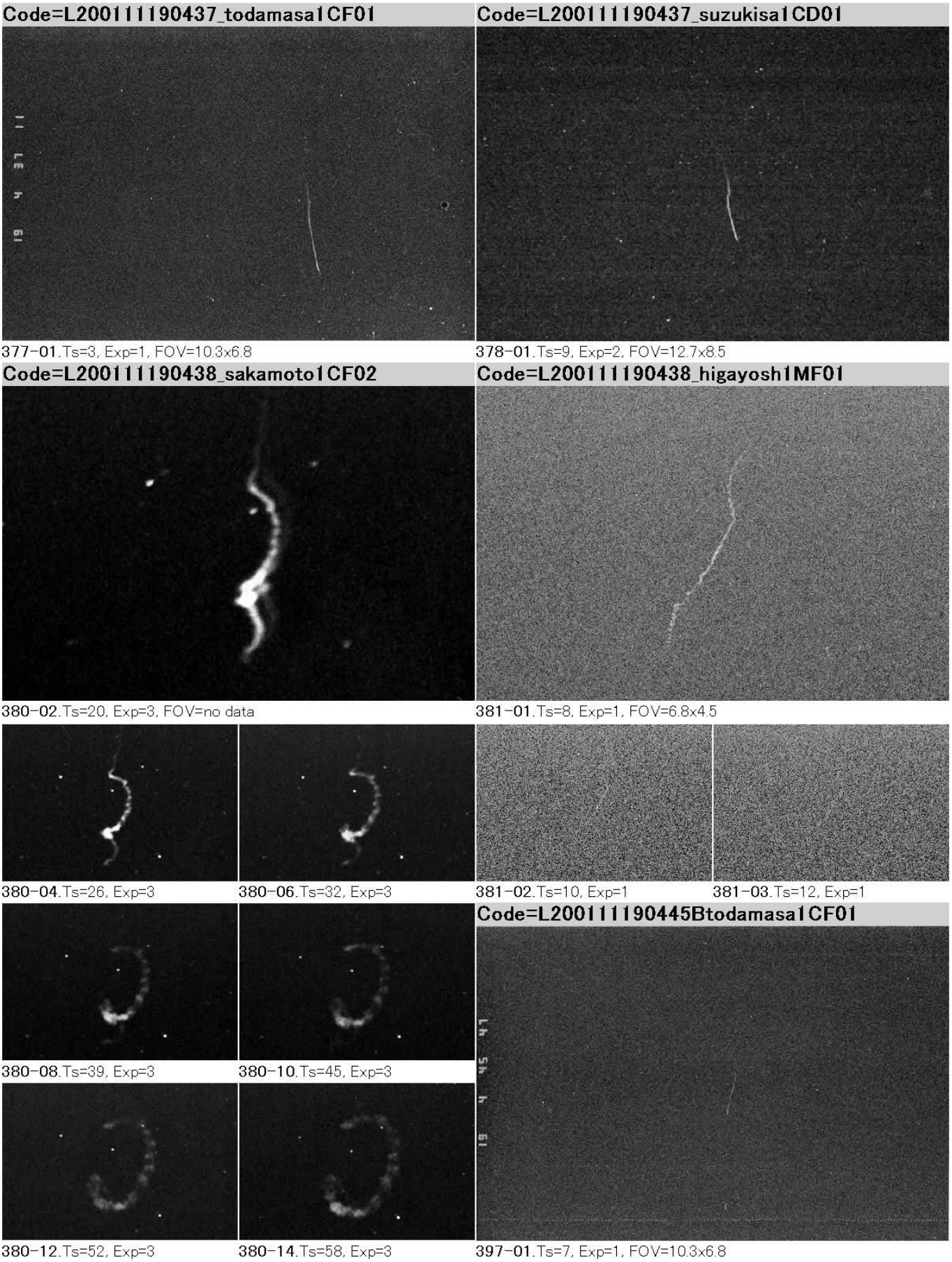

Fig. 4-31. Image sequences No. 377, 378, 380, 381, and 397. The No. 377 and 378 were simultaneously observed with each other and with No. 379 (Train 159). The No. 380 and 381 were also simultaneously observed with each other and with No. 382 (Train 160).

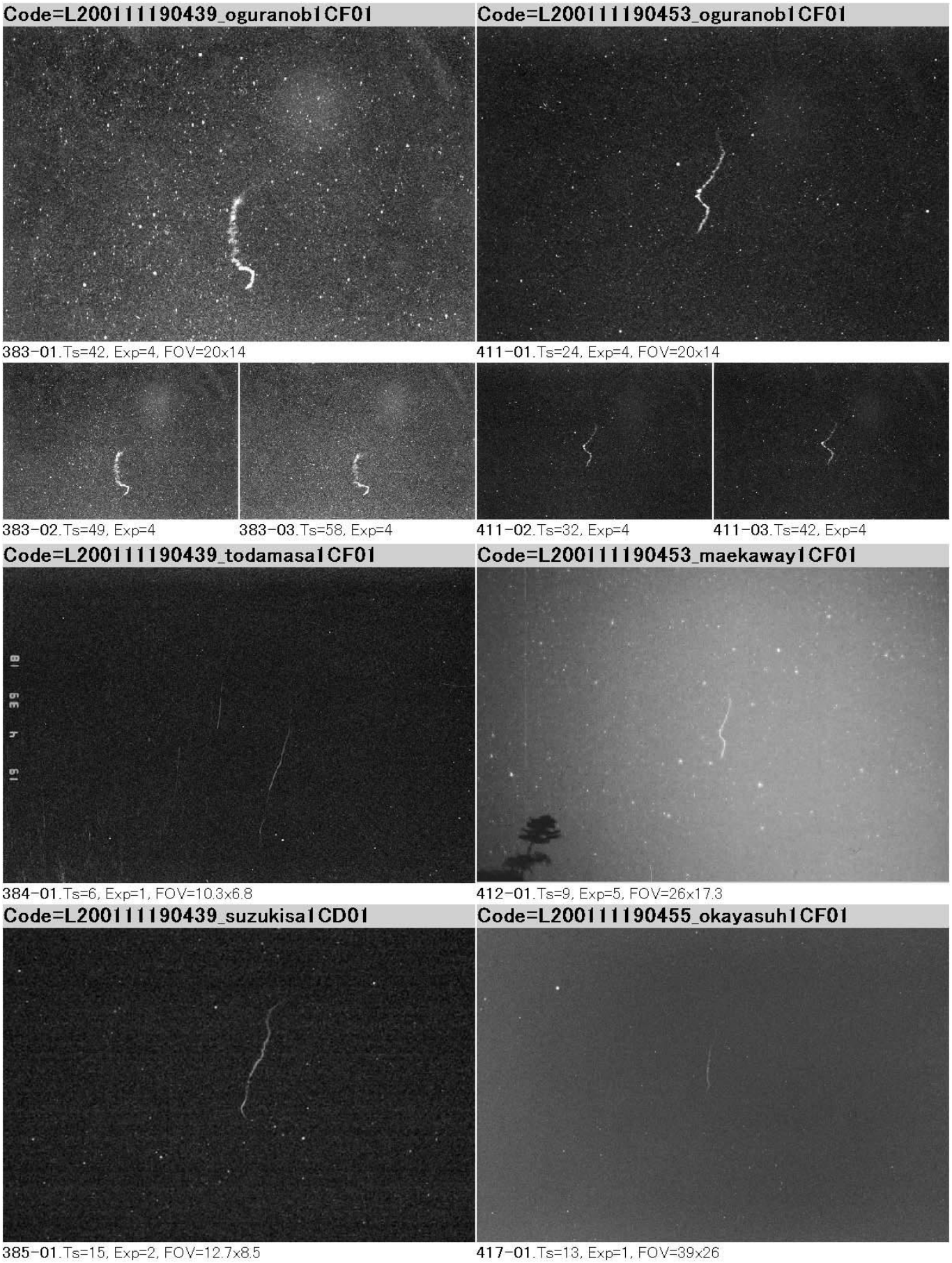

Fig. 4-32. Image sequences No.383, 384, 385, 411, 412, and 417. The No. 383, 384, and 385 were simultaneously observed with each other and with all examples from No. 383 to No. 388 (Train 161). The No. 411 and 412 were also simultaneously observed with each other (Train 174). Train 417 is one of the simultaneous observations for Train 175.

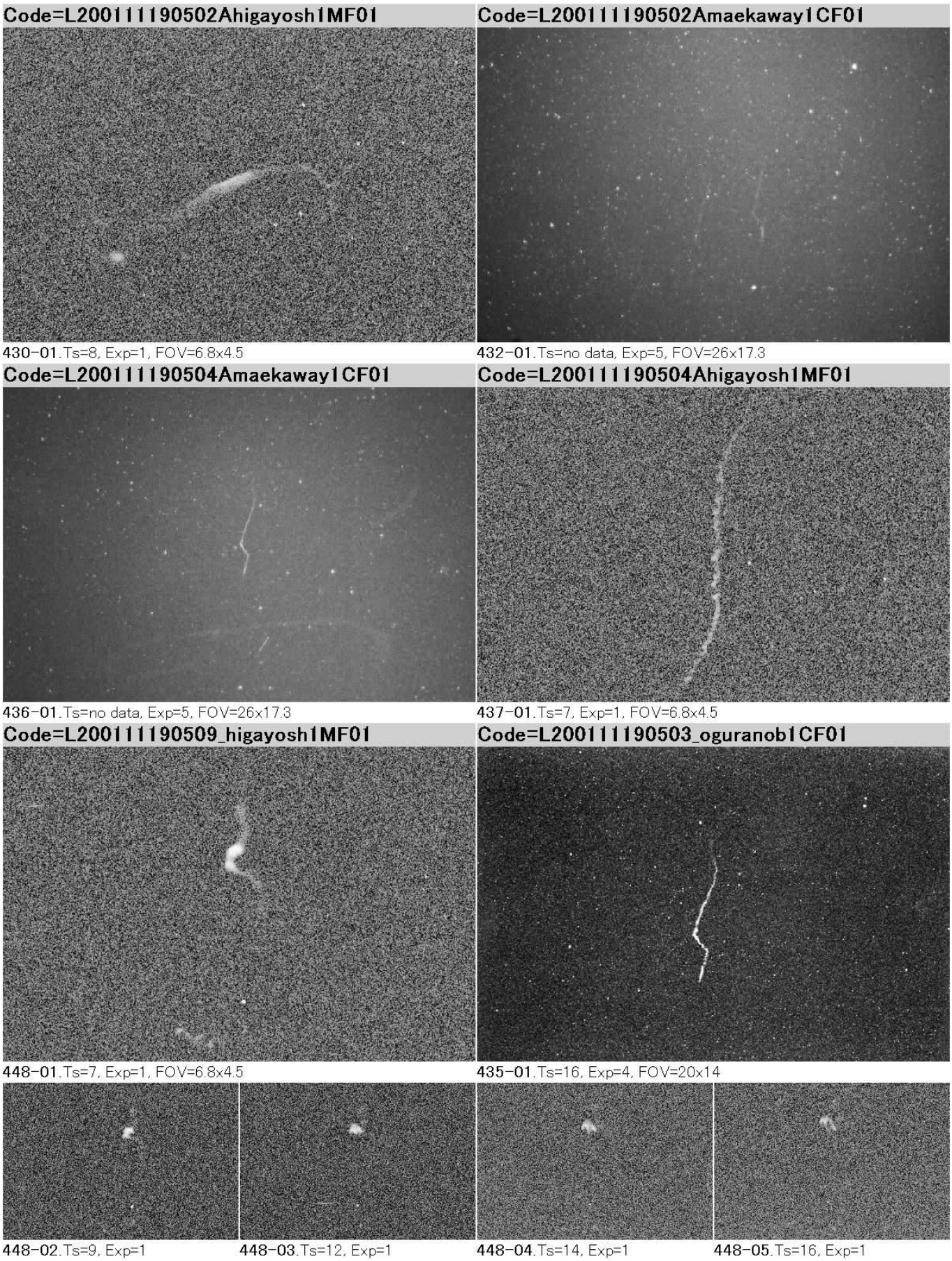

Fig. 4-33. Image sequences No.430, 432, 435, 436, 437, and 448. The No. 430 and 432 were simultaneously observed with each other and with No. 431 (Train 180). The No. 436 and 437 were also simultaneously observed with each other and with No. 438 (Train 183).

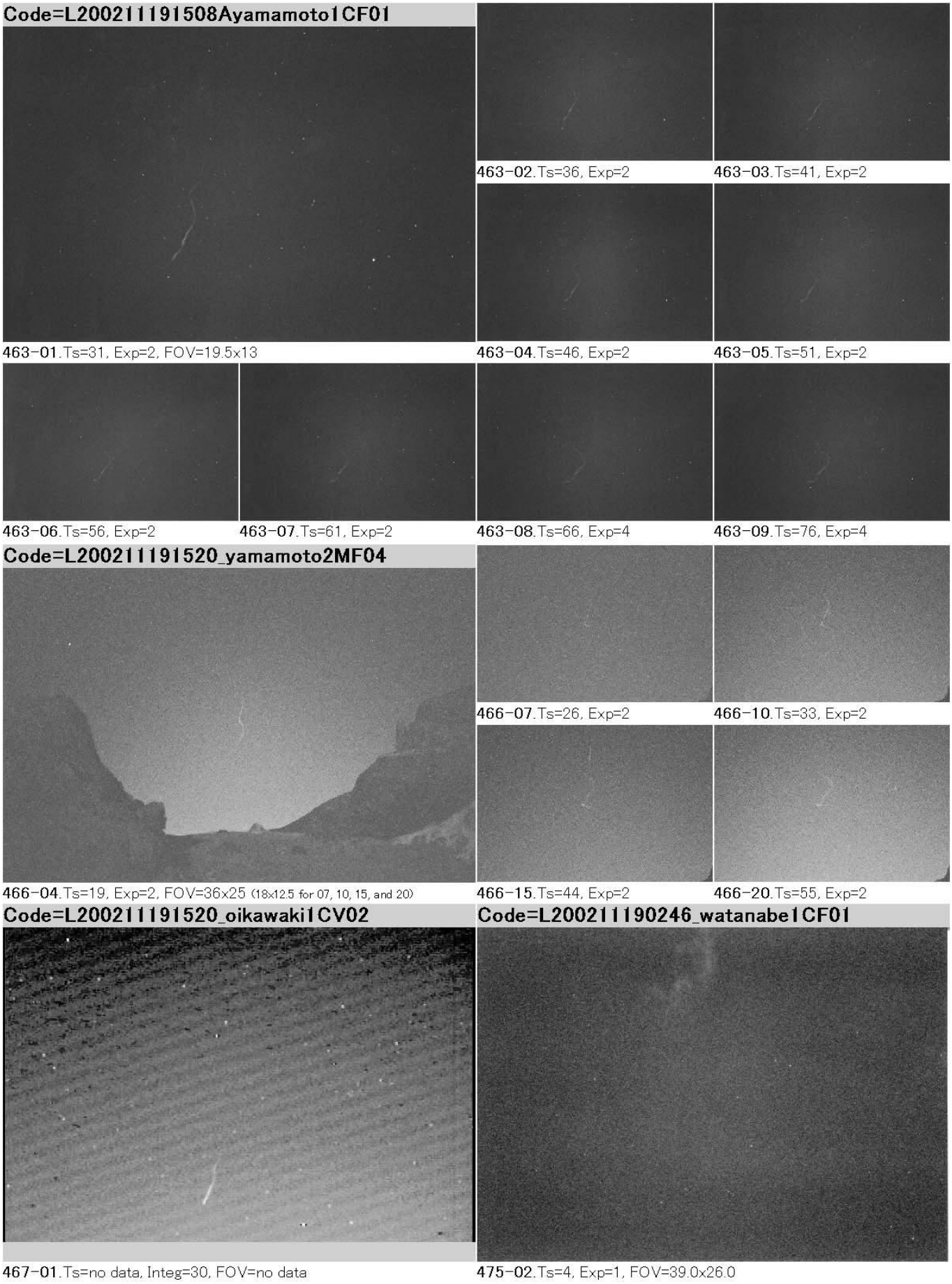

Fig. 4-34. Image sequences No.463, 466, 467, and 475. The No. 466 and 467 were simultaneously observed with each other and with No. 468 and 469 (Train 200). Note that the No. 463, 466, and 467 were observed in Canary islands, Spain (LT=UT=JST–9h).

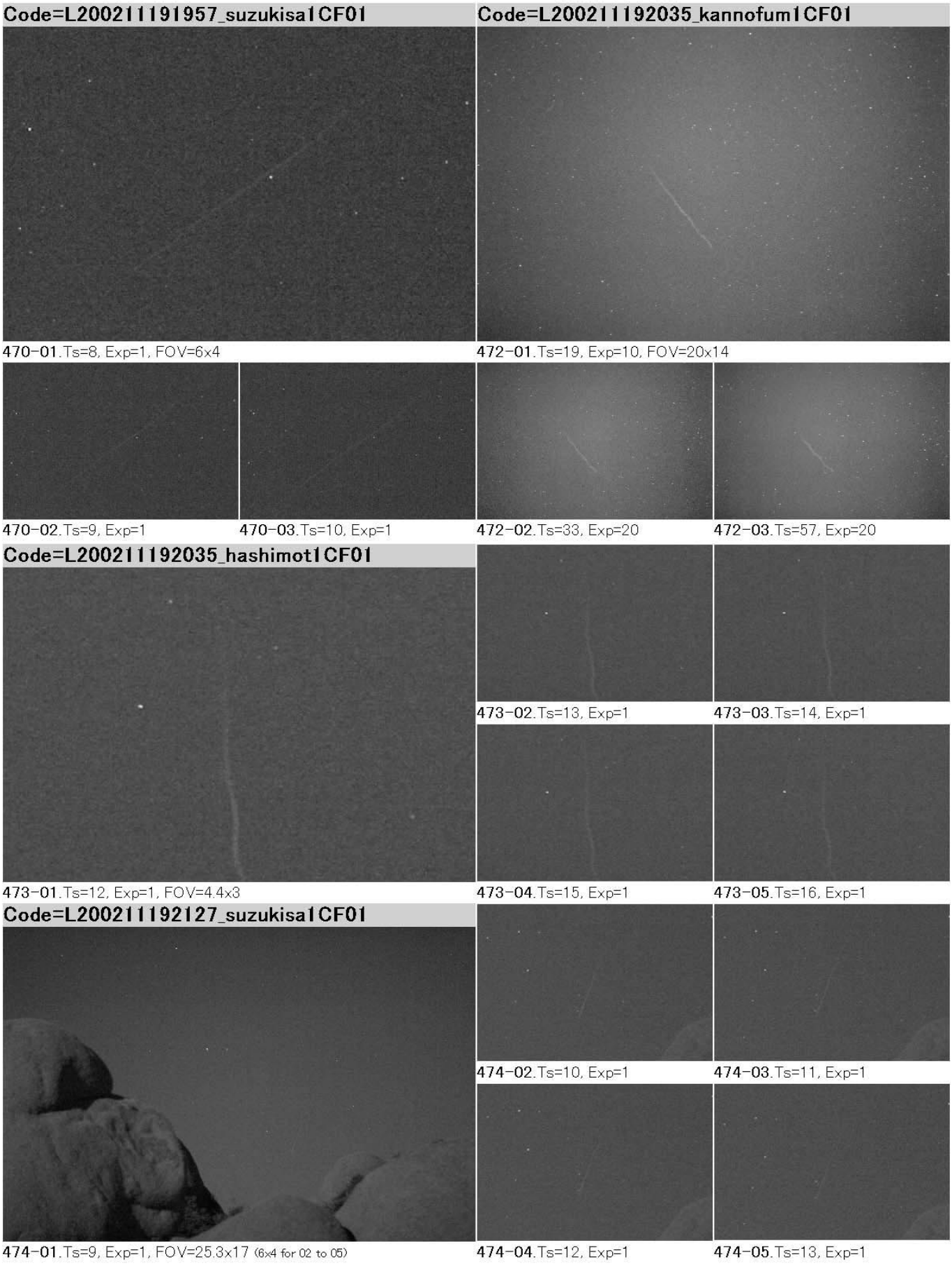

Fig. 4-35. Image sequences No. 470, 472, 473, and 474. The No. 472 and 473 were simultaneously observed with each other and with No. 471 (Train 202). Note that all of the examples were observed in Arizona or California, USA (LT=UT–7h=JST–16h).

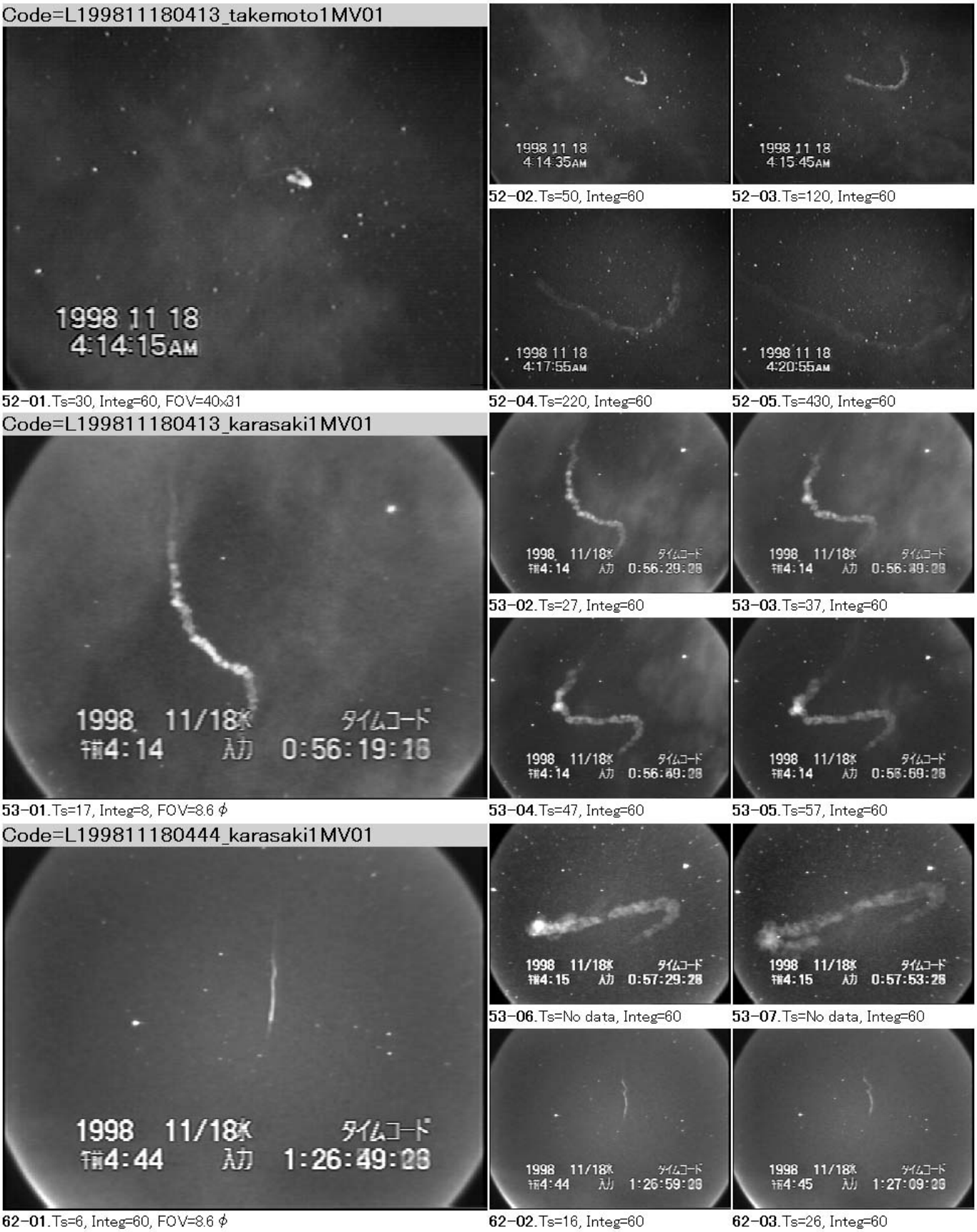

Fig. 5-01. Image sequences No. 52, 53, and 62. The No. 52 and 53 were simultaneously observed with each other and with all examples from No. 38 to No. 57 (Train 30).

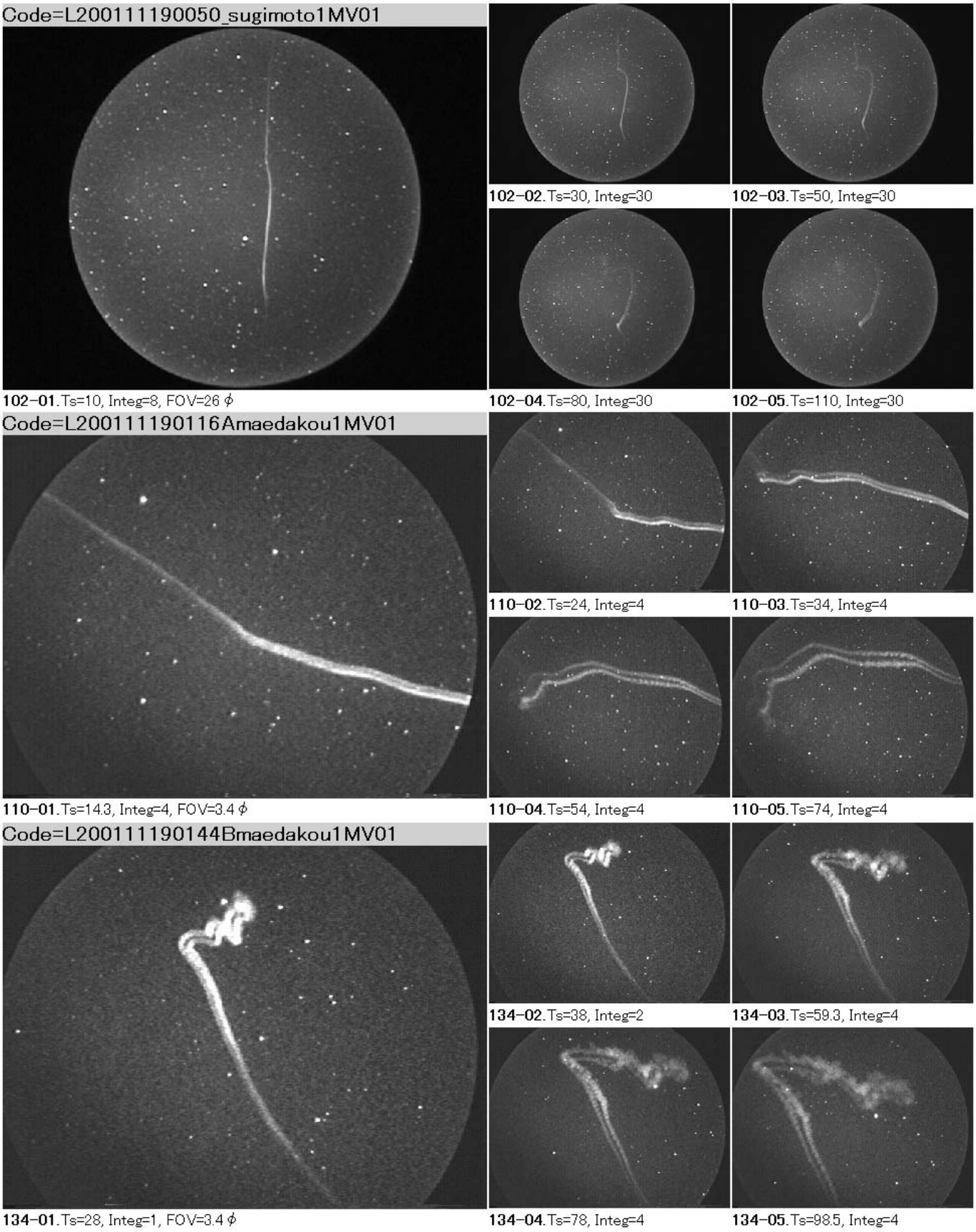

Fig. 5-02. Image sequences No. 102, 110, and 134. The No. 102 was simultaneously observed with No.100 and 101 (Train 46).

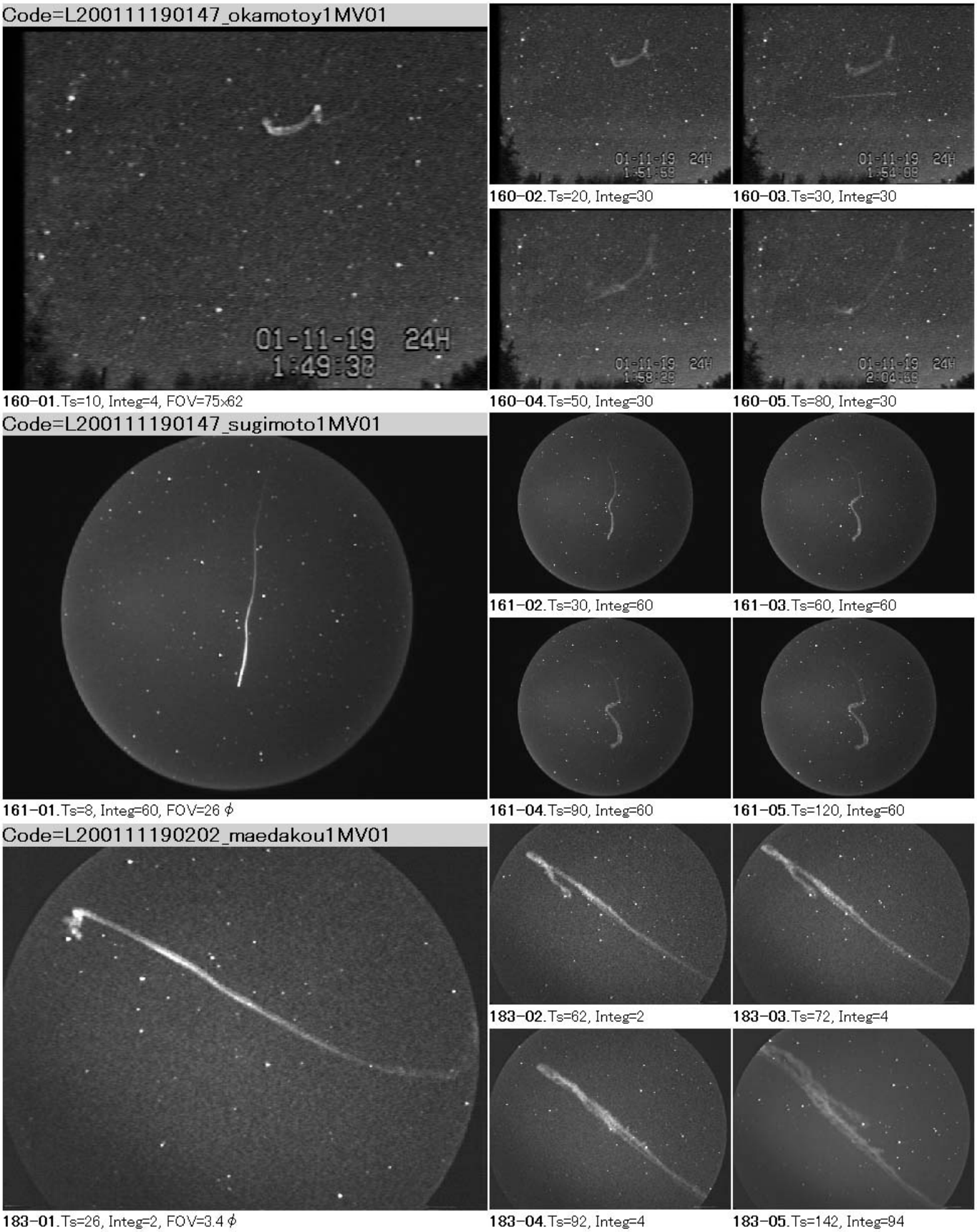

Fig. 5-03. Image sequences No. 160, 161, and 183. The No. 160 and 161 were simultaneously observed with each other and with all examples from No. 136 to No. 164 (Train 58). The train 58 was observed continuously for about 1 hour.

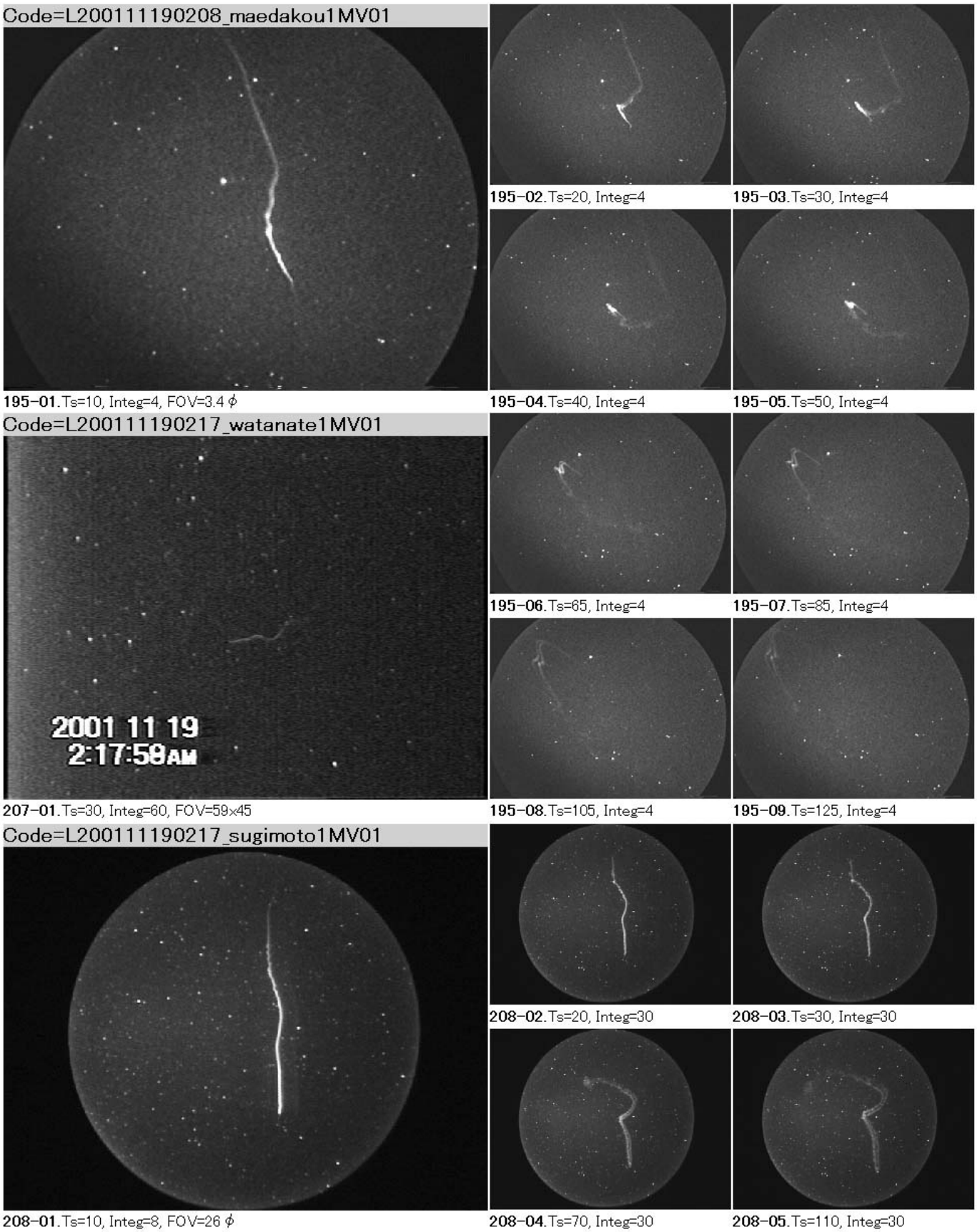

Fig. 5-04. Image sequences No. 195, 207, and 208. The No. 207 and 208 were simultaneously observed with each other and with all examples from No. 199 to No. 208 (Train 75).

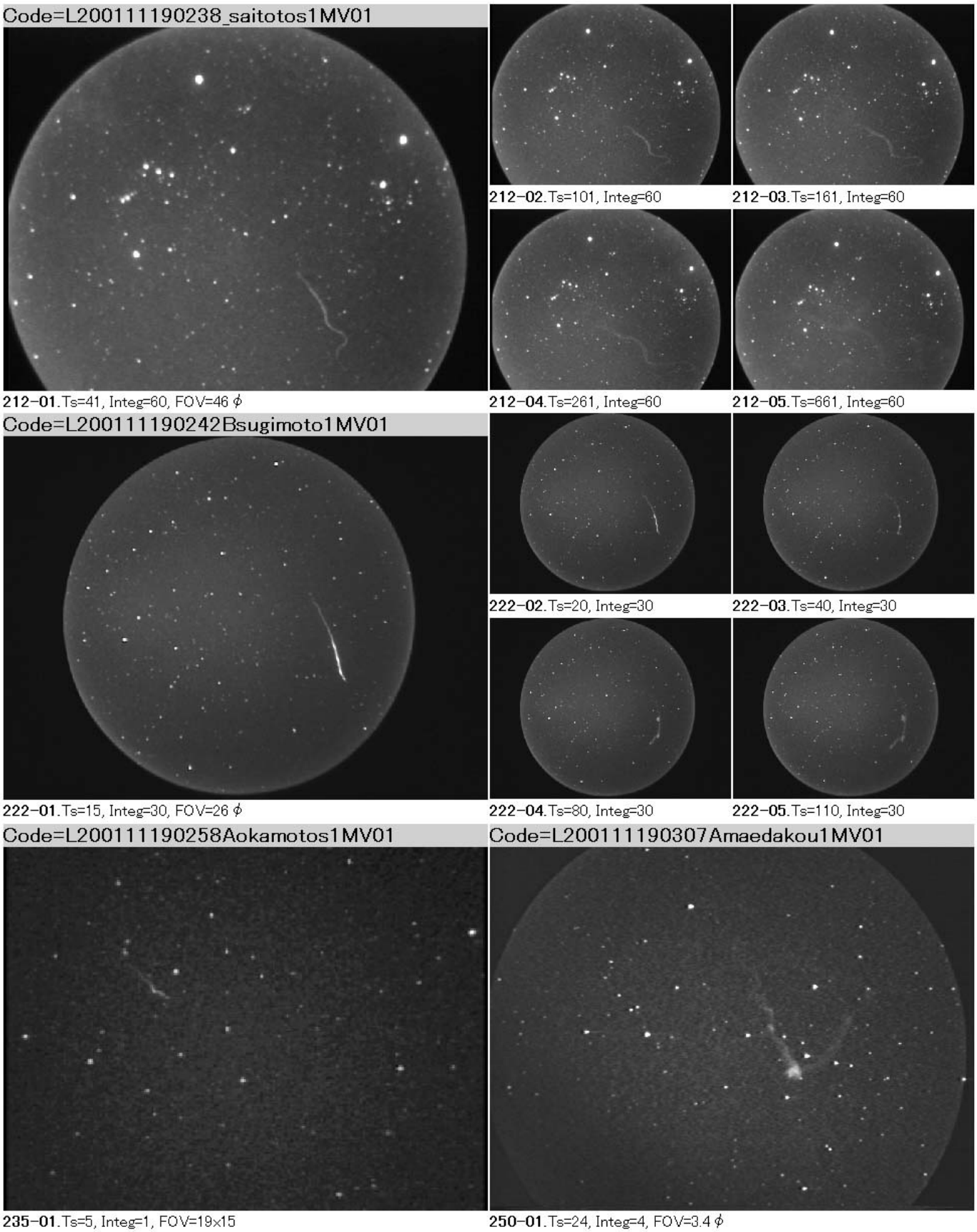

Fig. 5-05. Image sequences No. 212, 222, 235, and 250. A bright parent fireball of Train 77 was fortunately observed in the same FOV of the video file of No. 212.

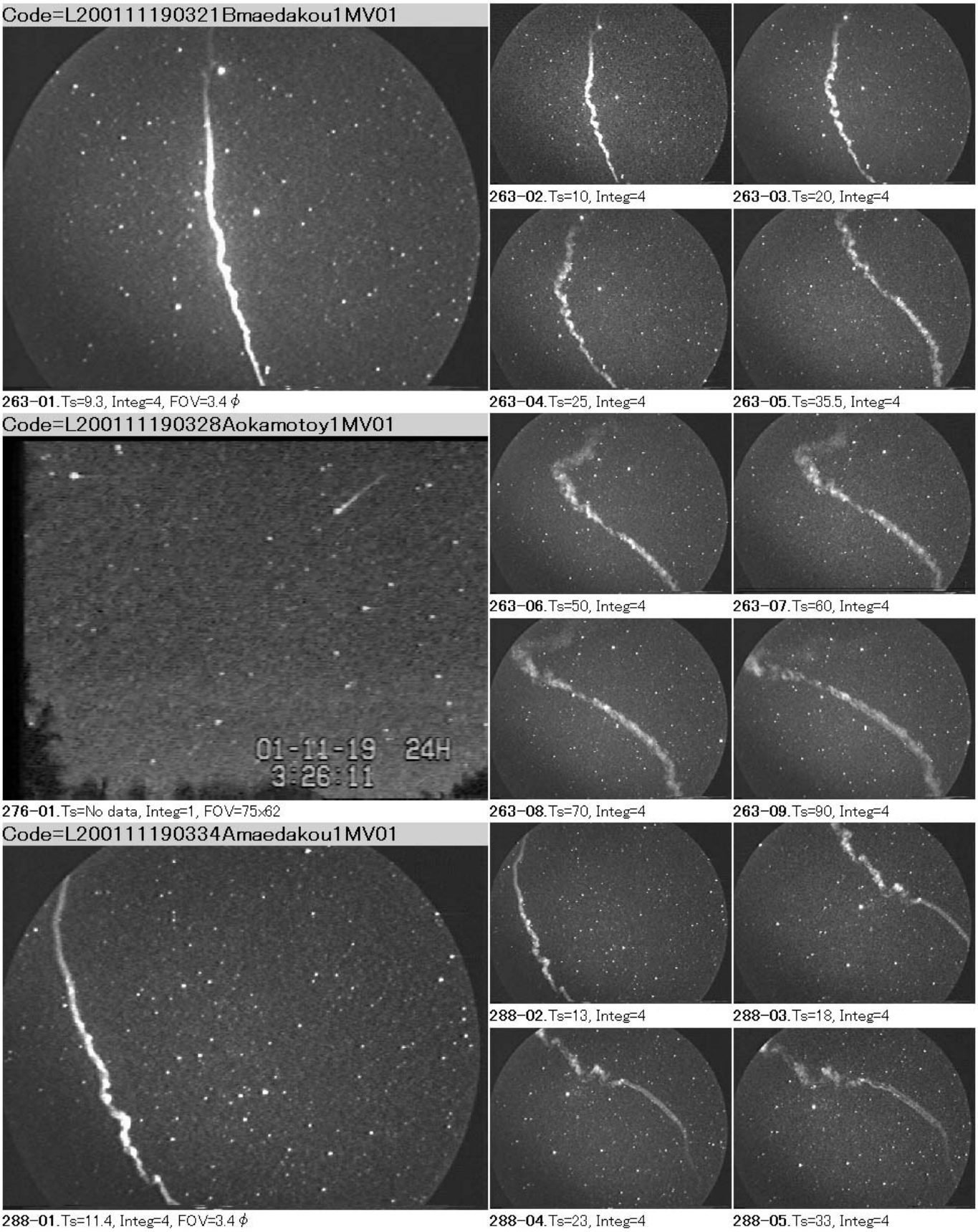

Fig. 5-06. Image sequences No. 263, 276, and 288.

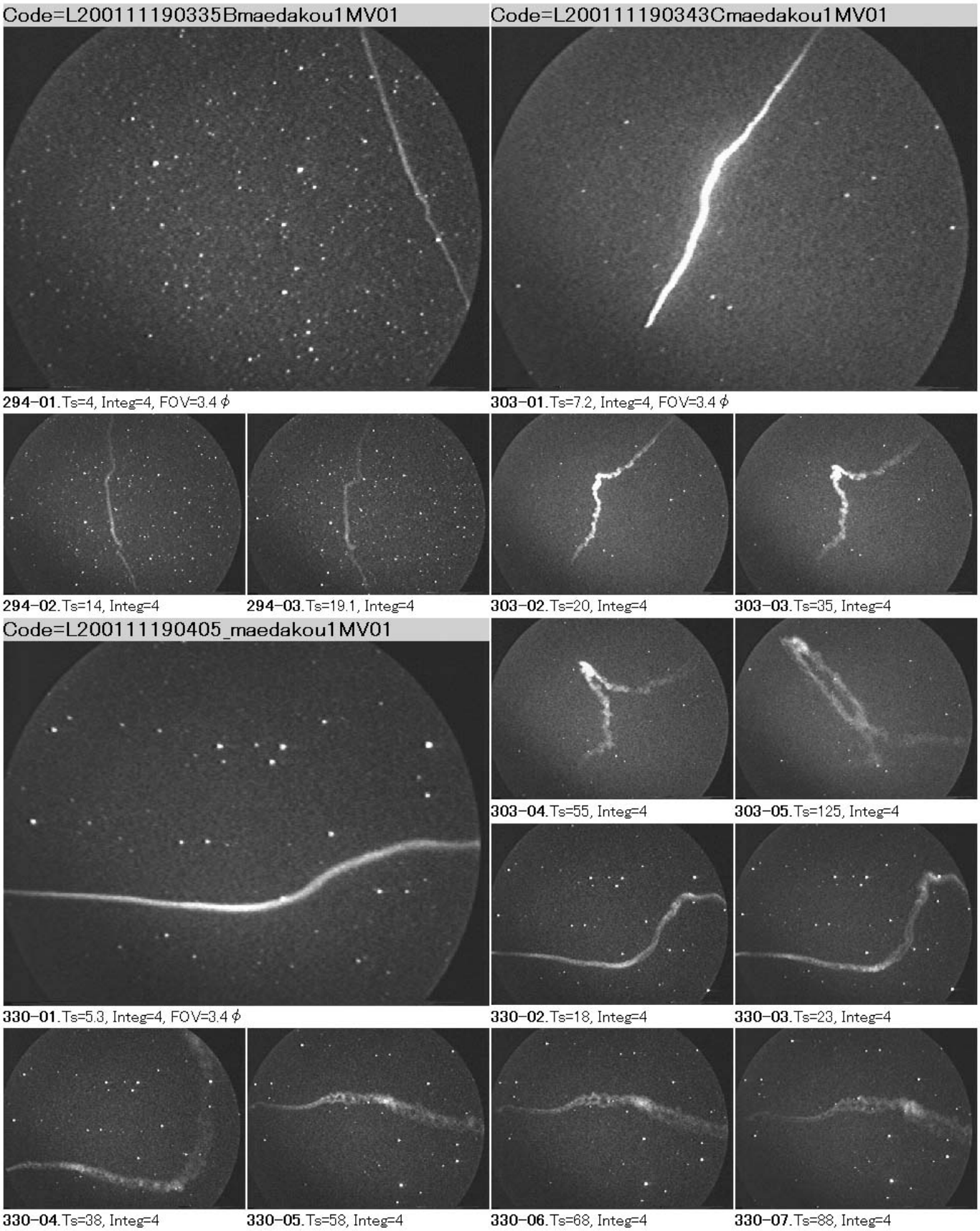

Fig. 5-07. Image sequences No. 294, 303, and 330. A "Mesh" structure was clearly observed in the later part of image sequence No. 330.

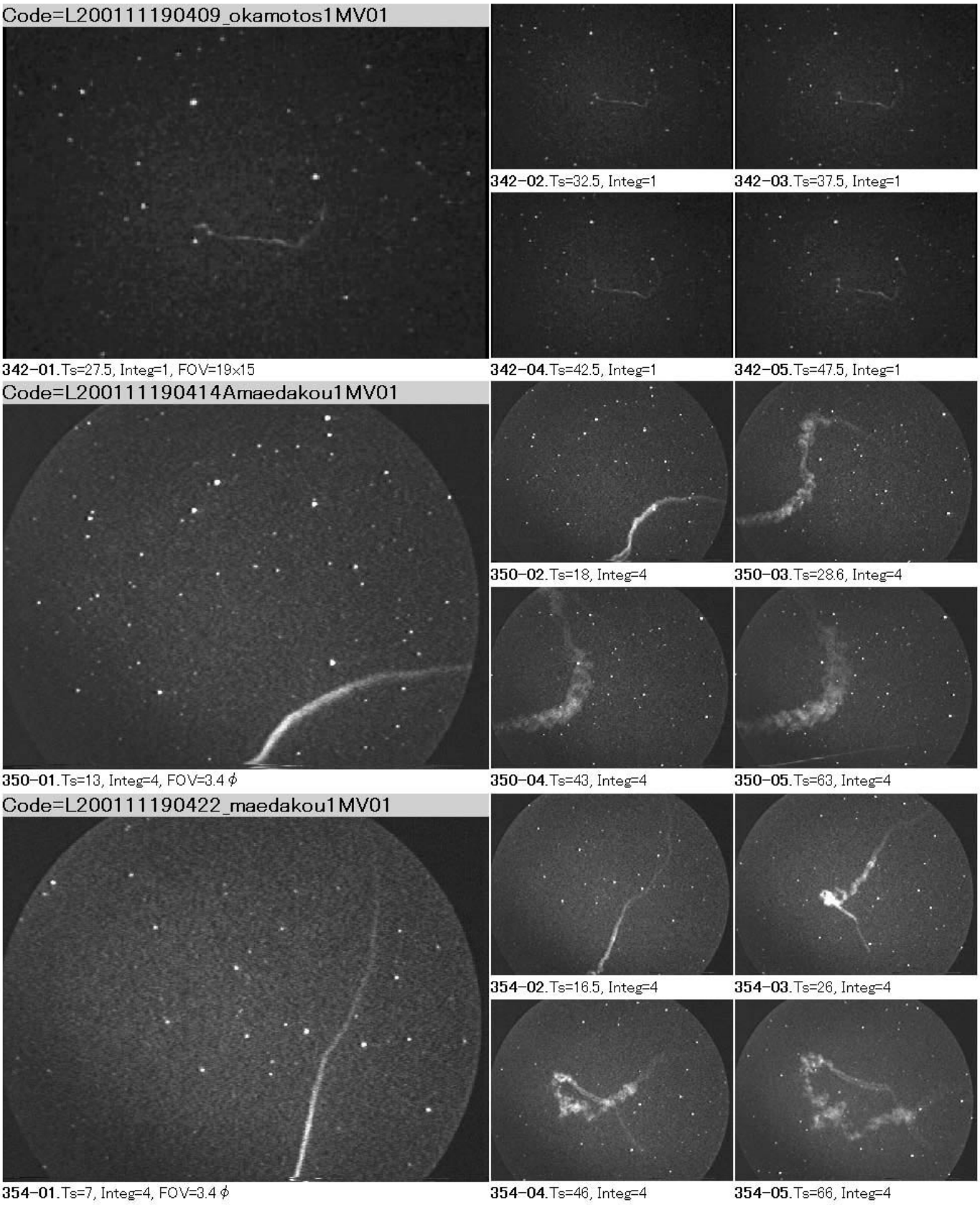

Fig. 5-08. Image sequences No. 342, 350, and 354. The No. 342 was simultaneously observed with No. 340, 341, and 343 (Train 141).

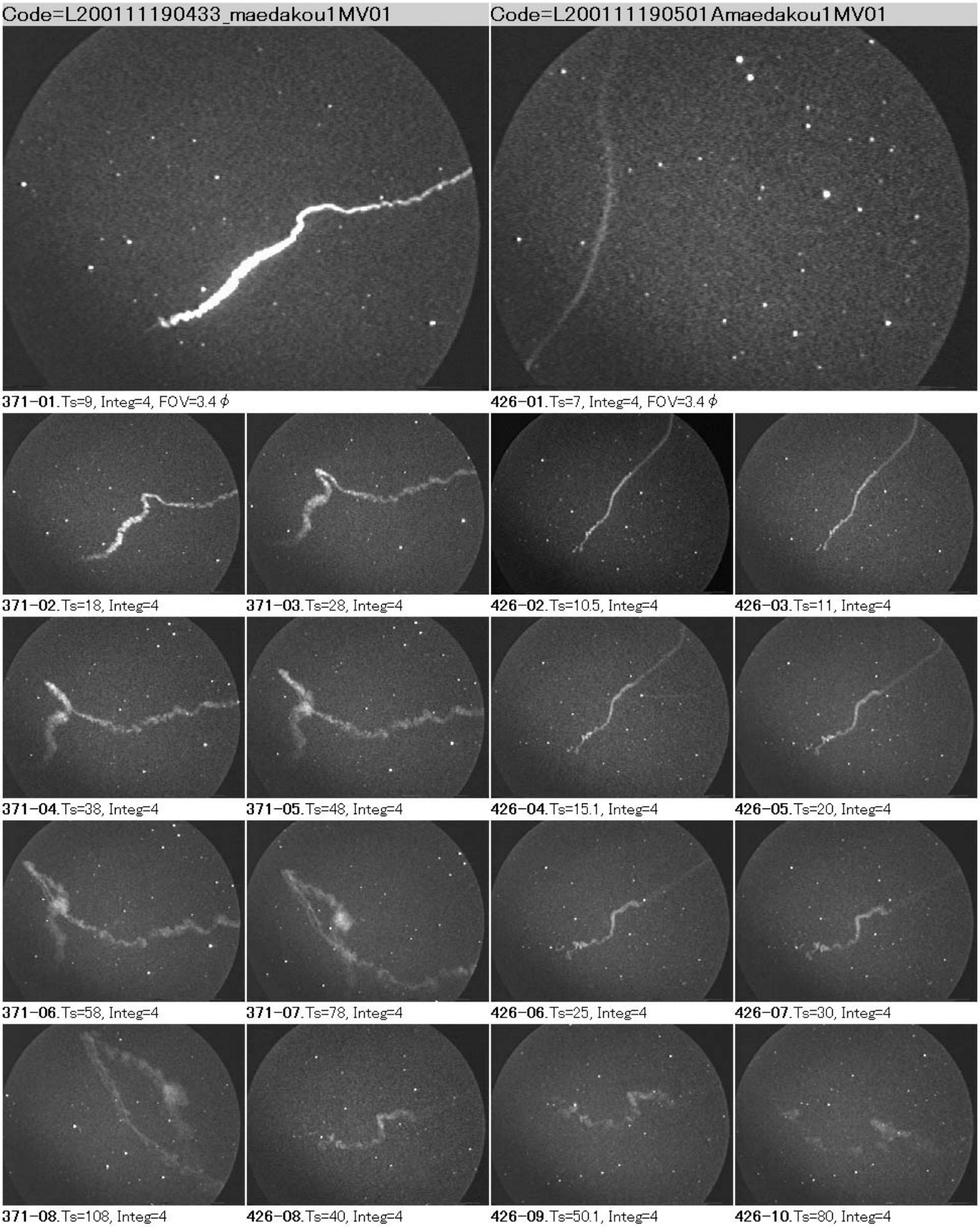

Fig. 5-09. Image sequences No. 371 and 426.

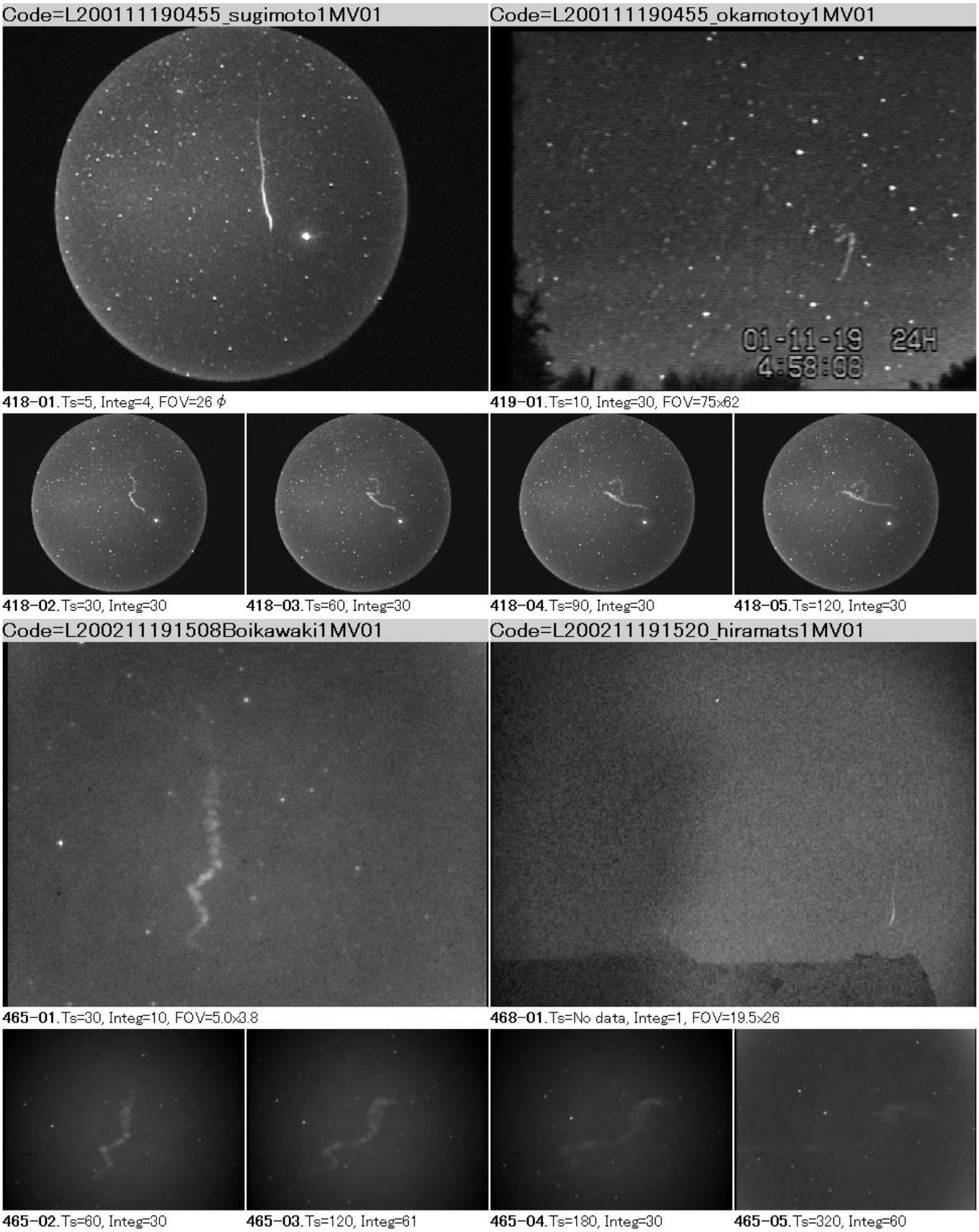

Fig. 5-10. Image sequences No. 418, 419, 465, and 468. The No. 418 and 419 were simultaneously observed with each other and with all examples from No. 413 to No. 421 (Train 175). The No. 468 was simultaneously observed with No. 466, 467, and 469 (Train 200). Note that the No. 465 and 468 were observed in Canary islands, Spain (LT=UT=JST–9h).

4. Discussion

Each historical perihelion passage of the comet 55P/Tempel-Tuttle has generated Leonid meteor storms on the Earth, and the high incidence velocity of the Leonids results in the frequent appearance of very bright fireballs. Hence, the generation rate of persistent meteor trains during Leonid storms is considered to be much higher than during other meteor showers. The five-year period following the most recent perihelion passage of the comet Tempel-Tuttle in 1998 therefore represented a rare opportunity to obtain valuable data regarding persistent meteor trains. The concerted observation plan implemented during the METRO campaign resulted in the establishment of reliable observation techniques for obtaining high-quality images of persistent meteor trains, and has led to the collection of a statistically sufficient number of persistent train images.

Vast numbers of images were successfully collected by the METRO campaign because many amateur observers were voluntarily contributed to the observation campaign. However, much time was needed for data collection as well as much effort was required for one-by-one confirmation of complete datasets for each observation. Another difficulty during the surprising outburst of Leonid's persistent trains in 2001 was in the identification process of multiple persistent trains observed within one minutes.

From the vast numbers of persistent train images obtained in 2001, the hourly rate (HR) of photographed persistent trains could be investigated in comparison with the HR of observed parent fireballs. As was shown in Table 1, significant number of persistent trains were continuously observed for a few hours even after the storm peak at around 18:10 UT on Nov. 18, 2001. The circumstance is worth discussing because the numbers of persistent trains might naturally be in correlation with those of observed meteors. In figure 6, the HR trend of photographed persistent trains is plotted in comparison with the visual observation of Leonids in

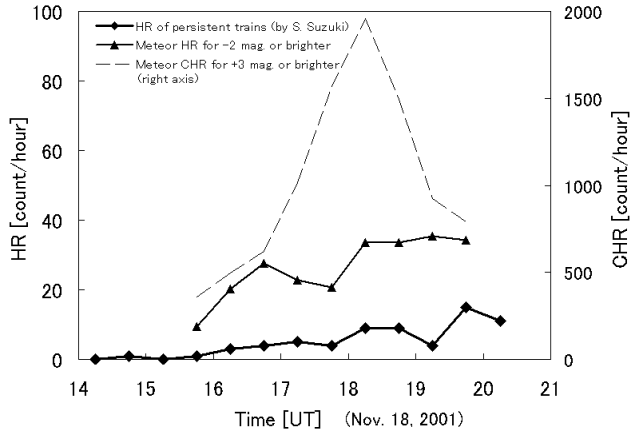

Fig. 6. Hourly rate (HR) of photographed persistent trains at around the Leonid storm peak in 2001. The HR data of persistent trains was obtained by one observer (S. Suzuki) who reported the maximum numbers of persistent train images in all collaborators. The HR and CHR distributions for Leonid meteors were provided by Uchiyama (2004, private communication) on the basis of his statistical study of Japanese visual observation in 2001.

2001 (Uchiyama 2004, private communication). Although the CHR trend for all meteors clearly decreased just after the peak time, no clear decrease of bright meteors was confirmed. The HR trend of persistent trains correlated not with the CHR trend of all meteors but with the HR trend of bright meteors. Appearance probability of persistent trains per bright meteors (–2 mag. or brighter) was derived to be about 20 %.

Ogawa and Uchiyama (2001) studied the ZHR value per magnitude class for corresponding visual observation data and concluded that the ZHRs per magnitude class for –2 magnitude or brighter were almost constant at around the peak time. Another statistical study of the Leonids in 2001 also suggested that the effect of 9th revolution dust trail indicated no symmetric trend (Uchiyama 2002). Lyytinen and Van Flandern (2000) predicted dust trails of 10th and 11th revolutions would slightly effective in background activity of Leonids at around 19:10 UT on Nov. 18, 2001. The long-lasting fireball storm with vast numbers of persistent trains suggested a possible encounters to old dust trails as an exceptional source of fireballs.

A morphological study of Leonid's persistent trains by using 102 series of fine image examples obtained in 2001 was summarized by Higa et al. (2003). Large-scale structures of persistent trains were classified into two types: 66 (64.7 %) single-striation trains and 36 (35.3 %) double-striation ones. Typical single-striation train is Train 30 (e.g. Fig. 3-01) and double-striation one is Train 58 (e.g. Fig. 3-05), for example. Tiny structures of persistent trains were classified into 3 categories: 75 (73.5 %) examples of knot structures, 21 (20.6 %) spiral structures, and 6 (5.9 %) mesh structures. Typical spiral structure is shown in image sequence No. 205 (Figure 4-17) and mesh structure is indicated in sequence No. 330 (Fig. 5-07), whereas knot structures are frequently seen in many image sequences. These tiny structures are considered to be formed by turbulent diffusion process of dense train plasma in upper atmosphere.

The METRO campaign for imaging Leonid meteor trains was promoted during the 1998–2002 period (Toda et al. 2003) and involved the distribution of a campaign manual. The collaborating amateur observers appeared eager to incorporate the proposed observation techniques, and a large number of persistent trains were successfully imaged by amateur observers using their own equipment and the techniques suggested. These earnest collaborators undertook these observations positively and voluntarily, and were happy to provide their results to the organizers of the METRO campaign. With the recent expansion of computer access, the organizers were able to maintain close correspondence with the collaborators through electronic mailing lists, allowing the observation techniques to be discussed. The success of the METRO campaign again demonstrates the eagerness and skill of amateur Japanese observers. It is considered that providing scientifically interesting and observable targets with clear objectives, suitable observation manuals, and comprehensive reports in scientific meetings, are the keys to securing the motivation of collaborators. The METRO campaign can thus be identified as a "social participation science," that is, groundbreaking science that can be

undertaken using the motivation and skills of highly educated people living in an advanced information society. It is expected in the near future that the development of scientific studies in collaboration with the general public will emerge in many scientific fields.

5. Conclusion

Collaboration with many skillful amateur observers for the imaging of persistent meteor trains during the 1998–2002 Leonids perihelion event was successfully achieved through the promotion of the METRO campaign in Japan. The program resulted in the collection of 439 image sequences of Leonid meteor trains including multiple-site observations. This data set has led to the first statistical analysis of the morphology of persistent meteor trains. For example, a three-dimensional analysis of multiple-site observation results has clearly revealed the large-scale spiral structures of persistent trains (Yamamoto et al. 2003), and the statistical study of persistent train morphology has now been well established (Higa et al. 2003). Detailed analyses using the 53 examples of multiple-site observations will be carried out in the near future, through which the detailed three-dimensional structure of the persistent meteor trains is expected to be revealed.

Image data recorded in two parts on this catalogue will be stored to future generations. The catalogue of persistent train images may prove to be invaluable, because although the period of the comet Tempel-Tuttle is relatively short (33 years), not every perihelion return of the parent comet will generate meteor storms with many persistent meteor trains. Thus the image catalogue is recorded for reference and will be beneficial for researchers in future generations.

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References

Abe, S., Yano, H., Ebizuka, N., Kasuga, T., Sugimoto, M., and Watanabe, J-.I. 2003, UV video spectroscopy of Leonid fireballs and persistent trains, *Inst. Space Astro. Sci. Rep. SP,* **15**, 149–158.

Asher, D.J. and McNaught, R.H. 2000, Expectations for the 2000 Leonids, *WGN*, **28**, 138–143.

Baggaley, W.J. 1977, Hollow meteor trains, *Nature*, **270**, 588.

Borovička, J. and Koten, P. 2003, Three phases in the evolution of Leonid meteor trains, *Inst. Space Astro. Sci. Rep. SP*, **15**, 165–174.

Higa, Y., Toda, M., Yamamoto, M.-Y., Fujita, M., Suzuki, S., Ishizuka, Y., and Maeda, K. 2003, METRO campaign in Japan III: High resolution images obtained in the campaign and morphology of the meteor train, *Inst. Space Astro. Sci. Rep. SP*, **15**, 245–252.

Jenniskens, P., Nugent, D., and Plane, J.M.C. 2000, The Dynamical evolution of a tubular Leonids persistent train, *Earth, Moon and Planets*, **82-83**, 471–488.

Liller, W. and Whipple, F.L. 1954, High-altitude winds by meteor-train photography, *Rocket exploration of the*

upper atmosphere, eds. Boyd, and Seaton, Pargamon Press, pp.112–130.

Lyytinen, E J. and Van Flandern, T. 2000, Predicting the strength of Leonid outbursts, *Earth, Moon, and Planets*, **82-83**, 149–166.

McNaught, R.H. and Asher, D.J. 1999, Leonid dust trails and meteor storms, *WGN*, **27**, 85–102.

McNaught, R.H. and Asher, D.J. 2002, Leonid dust trail structure and predictions for 2002, *WGN*, **30**, 132–143.

Ogawa, H. and Uchiyama, S. 2001, The 2001 Leonids meteor storm 2001 over Japan, *WGN*, **29**, 206–213.

Shigeno, Y., Toda, M., and Kobayashi, M. 1998, A spiral meteor train, *WGN*, **26**, 220–225.

Suzuki, S. 2003, Near infrared, visible spectral observation of meteor trains, *Inst. Space Astro. Sci. Rep. SP*, **15**, 175–182.

Tanioka, K., Matsubara, T., Ohkawa, Y., Miyakawa, K., Suzuki, S., Takahata, T., Egami, N. 2003, Ultra-high-sensitivity new super-HARP pickup tube and its camera, *IEICE Trans. Electron*., **E86-C**, 9.

Toda, M., Yamamoto, M.-Y., Higa, Y., Fujita, M. 2003, Meteor train observation (METRO) campaign in Japan I: Evolution of the campaign and observation results during 1998–2001, *Inst. Space Astro. Sci. Rep. SP*, **15**, 229–236.

Toda, M., Yamamoto, M.-Y., Higa, Y., and Watanabe, J.-I. 2004, Catalogue of Persistent Train I: Meteor Train Images during 1988–1997 and the Development of an Optimum Observation Technique, *Publ. Natl. Astron. Obs. Japan*, **7**, 53–66.

Trowbridge, C.C. 1907, Physical nature of meteor trains, *Ap. J*., **26**, 95–116.

Uchiyama, S. 2002, Estimated ZHR profiles of the 4-revolution and 9-revolution dust trails during the 2001 Leonid meteor storm, *WGN*,**30**, 47–55.

Vaubaillon, J. 2002, Activity level prediction for the 2002 Leonids, *WGN*, **30**, 144–148.

Yamamoto, M.-Y., and Toda, M. 1998, Meteor train observation campaign, *http://www3.plala.or.jp/MY_Yamamoto/campaign/* (in Japanese).

Yamamoto, M.-Y., Toda, M., Higa, Y., and Fujita, M. 2003, METRO campaign in Japan II: Three-dimensional structures of two Leonids meteor trains in early stage, *Inst. Space Astro. Sci. Rep. SP*, **15**, 237–244.

Yamamoto, M.-Y., Toda, M., Higa, Y., and Maeda, K. 2005, Image archive of persistent meteor trains, *http://www.ele.kochi-tech.ac.jp/masayuki/METRO/*.