REPORT NO. DOT-TSC-FA953-PR-79-2

DETECTION AND ASSESSMENT OF SECONDARY SONIC BOOMS IN NEW ENGLAND

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PROGRESS REPORT

Prepared for

U.S. DEPARTMENT OF TRANSPORTATION
FEDERAL AVIATION ADMINISTRATION
Office of Associate Administrator for
Policy and International Aviation Affairs
Office of Environment and Energy
Washington DC 20590

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OCTOBER 1979

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SUMMARY

Measurements of acoustic signals in the Boston area during summer 1979 are reported. The measurements demonstrate that the secondary sonic boom events frequently reported by New England residents are created by the Concorde passage off the New England coast en route to J. F. Kennedy Airport. Reception times for such events are highly correlated with Concorde flight times; the time delay between aircraft time at closest point of approach to Hyannis, MA, and signal reception at Malden, MA, is constant to within 53 seconds. Ray trace computations for one selected event, based on best available meteorological data and on FAA radar measurements of Concorde flight profiles, predict signal arrival times to within ten seconds of that observed and predict wave front azimuthal angles to within 4°.

Signal amplitudes show wide fluctuations from flight-to-flight and from day-to-day. The average measured event maximum peak-to-peak pressure amplitude for May, June, July, August and September (first half of month) are 0.15, 0.14, 0.19, 0.20, and 0.11 pounds per square foot. The largest individual values were 0.63, 0.69, 0.65, 0.59, and 0.32 for the five months, respectively. Simultaneous measurements carried out at other locations in the Boston area show that there are also wide variations with geographic location for the same event.

A brief set of measurements for four days in July were made at Applebachsville, PA. These show similar day-to-day variability and are correlated with Concorde flights into Dulles Airport.

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1. INTRODUCTION

This report summarizes the June, July, August and September 1979 measurements of secondary sonic booms resulting from supersonic aircraft operations off the New England coast. (Report DOT-TSC-FA953-PR-79-1 contains data for May, 1979).

Secondary sonic boom events were reported in the New England (N.E.) area during the summer of 1978. These events were reported as muffled "thumps" and low-frequency "rumbles" and occurred predominantly in the morning hours between 8:00 and 10:30 a.m. Reports were received from citizens as far north as Maine and along New England coastal regions in New Hampshire, Massachusetts and Rhode Island. Because of the widespread nature of the reported events and their low frequency nature, it was speculated at that time that these events originated from the shock wave of a supersonic aircraft.

Preliminary investigation of the phenomena by the Department of Transportation-Transportation Systems Center (DOT/TSC) during September 1978 showed that, indeed, there was some correlation in timing between boom data measured north of Boston and visual sightings at Chatham, MA, of the Concorde passage enroute to J.F. Kennedy Airport. Data at that time were, however, insufficient to clearly establish the Concorde as the primary source of these secondary sonic booms.

The May 1979 data showed a definite correlation between the measured booms and radar tracking data on JFK bound Concordes off the east coast of New England. The measured signals were seen to originate from these Concordes during their last minutes of supersonic flight.

2. TECHNICAL BACKGROUND

FAA flight rules require supersonic transports (SST's) to fly at subsonic speeds over U.S. land areas in order to prevent sonic booms from impacting the U.S. environment. For aircraft approaching U.S. boundaries, flight rules specify slowing to subsonic speeds well before encountering U.S. airspace, in order to insure that direct sonic shock waves do not encroach upon the U.S.

Although these requirements are adequate to prevent primary shock waves from impacting U.S. population centers, secondary effects are possible. A sonic shock wave is a significant source of low-frequency acoustical energy (below 10 Hz). Since sound attenuation due to atmospheric absorption decreases with decreasing frequency, low-frequency acoustical waves can propagate long distances through the atmosphere with relatively little attenuation. Even though this sound is largely infrasonic (i.e., low-frequency sound below the audio-frequency range of human hearing), it was speculated that sufficient energy reaches New England from off-shore supersonic flights to excite structures and create a perceivable acoustical event.

The major propagation mechanism of these long-distance effects is the refraction of low-frequency waves in the upper atmosphere due to wind and temperature grandients. The upward traveling shock waves generated by an aircraft during supersonic flight are bent towards the ground by atmospheric wind and temperature gradients. They can then be reflected off the ground surface back to the upper atmosphere, repeating the cycle (see Figure 1). Following optical refraction laws, low frequency energy can travel long distances between the ground and the upper atmosphere.

For aircraft generating sonic booms off the New England coast, the "first bounce" off the stratosphere of this low-frequency acoustic energy is the most critical, particularly when meteorological conditions are favorable and the waves propagate relatively freely. Sufficient acoustical energy can then arrive onshore to create a perceivable acoustic event. Essentially, this refractive mode of low-frequency acoustical wave propagation extends the supersonic impact of an SST beyond its primary boom carpet when meterological conditions are favorable. The approximate range for a "first bounce" impact can be anywhere from fifty to two-hundred miles beyond the primary carpet.

Meteorological conditions play an important role in this long-distance propagation of acoustical shock waves. Of the family of rays that leave the aircraft and are refracted, only a small fraction reach the ground. Only when the sum, of the component of the wind velocity in the direction of propagation and the sound speed, at some altitude above the flight altitude exceeds the corresponding sum at the ground is it possible for these rays to reach the ground beyond the primary carpet area. The geometry of the paths may be such that large areas on the ground are not reached by any rays (creating quiet zones) while in areas further from the flight trajectory, rays may touch down, such that energy is received. This phenomena, known as anomalous or abnormal sound, has been studied on various occasions in connection with large explosions near the ground. It has, up to now, not been studied in much detail in connection with sonic boom propagation. The extreme sensitivity of the propagation paths to the sound speed and wind velocity profiles and to large scale turbulence in the atmosphere suggests that the energy received at any point will vary substantially with meteorological conditions.

This effect of upper atmospheric wind currents explains the absence of reports in New England during the winter months when the stratospheric winds are predominantly westerly, thus inhibiting refractive propagation. On the other hand, during the summer months when strong easterly winds predominate, the secondary sonic boom events become evident.

Despite the refractive propagation effects discussed above, it is not clearly evident that the shock waves generated by routine supersonic flight have sufficient acoustical energy to travel the distances involved and still cause the perceived acoustic events reported. Given the atmosphere's basic structure, only a relatively small fraction of the acoustic energy created by the Concorde's supersonic flight should reach the ground via paths that are refracted downwards in the stratosphere. If this energy were uniformly spread over a wide range of lateral distances, then it is doubtful that the secondary booms would ever be audible. However, an aspect of sonic boom propagation that must be considered is that of focusing, which could produce an audible effect in a relatively small area. Thus, the reported events in New England may be caused by circumstances when wind and temperature profiles, aircraft heading, speed, and location are in the right combination to produce an augmentation (or focusing) of acoustic energy at the location of the observer.

3. EXPERIMENTAL APPROACH

3.1 BASIC APPROACH

Low-frequency pressure level events were measured with three microphone measuring systems deployed in a triangular array during the period May 3, 1979, to September 14, 1979. The signals from each of the microphones along with a time code signal were recorded on a multitrack, FM tape recorder. The difference in arrival time between microphones and the position and dimensions of the array were used to compute the direction of the arriving wave front. This arriving ray vector can then be used to project back to the signal source.

In addition to the three microphone array deployed, a single microphone recording system with time code synchronization was also deployed on occasion at several sites throughout the Greater Boston area. Measurements were made simultaneously with the multimicrophone and the single microphone systems to show the variability of the signals measured with site locations.

3.2 MEASUREMENT SITES

A prime measurement site was selected within the expected "first bounce" impact area in the Middlesex Fells Reservation in Malden, MA. (Figure 2). A lightly-wooded area was selected to provide natural wind reduction with relatively little attenuation of the expected signals.

Six other sites were chosen within a twenty-five mile radius of Boston to show the variability of the data with site location. The sites shown in Figure 2 were in Wilmington, Georgetown, Marlboro, Medfield, Sharon, and Cohasett, MA.

A measurement site was also sought with coordinates relative to the flight track of inbound Concorde flights to Dulles International Airport similar to those of the Malden site relative to inbound Concorde flight to JFK. Measurements were made during the week of July 23, 1979 at a site in Applebachsville, Pennsylvania, that met this requirement (see Figure 3).

3.3 INSTRUMENTATION AND DEPLOYMENT

Low-frequency (infrasonic) microphone systems, consisting of B & K 4146 one-inch condenser microphones and B & K 2631 Microphone Carrier System were used (Figure 4). The infrasonic data were band-filtered (0.5 to 30 Hz) and recorded on a four-track FM Instrumentation Tape Recorder HP Model 3960A. The microphones were enclosed in a weather proof wooden enclosure (30" x 20" x 16") to further reduce the effects of wind noise.

Three low-frequency microphone systems were placed in a triangular array 250 feet apart (Figure 4). This triad was deployed at the Malden, MA., site except during the weeks of July 9 - 13, 1979, and July 23-26, 1979, when it was deployed at Georgetown, MA., and Applebachsville, PA., respectively.

A single low-frequency microphone system was deployed at the Malden MA., site during these two weeks to provide continuity of the data. The single system was also deployed on occasion at sites in Wilmington, Marlboro, Medfield, Sharon, and Cohasett, MA., to provide a measure of the variability of the secondary boom with location within a 25 mile radius of Boston.

A vibration measuring system consisting of an Endevco Accelerometer Model 2217E with signal conditioners was deployed in a residential home at 11 Wilton Drive, Wilmington, MA., on June 20, 1979. The accelerometer was cemented at the center of a 54 by 60 inch by one-quarter inch plate glass window located in an east-facing room at the rear of the house. Lateral acceleration levels (2Hz to 1KHz) of the glass were recorded in synchronism with the infrasonic data from the low-frequency microphone system located outside approximately 100 feet from the window.

To measure and record the event as perceived by a listener, an acoustic measuring system using a ½" General Radio 1962-9610

Electret condenser microphone was also deployed on occasion. Measured outdoor acoustic data (15 Hz - 20 KHz) were recorded on a Nagra model IVSJ instrumentation tape recorder.

A time code signal was recorded on all recorders for exact time synchronization.

3.4 FLIGHT DATA

Flight track data to identify any aircraft in a position to be the source of the measured event were obtained from the FAA Data Systems Office in Nashua, N.H. Flight track data were obtained from the air traffic control radar system. These data include aircraft flight number, speed, altitude, position and time of day. Physical data from the on-board recorders of several selected flights were obtained from British Airways to supplement the radar data.

3.5 WEATHER DATA

Local weather was recorded continuously on site. High altitude data were obtained from rocketsonde observations from Wallops Island, Virginia. Local high altitude data were obtained from balloon observations, and from satellite-infrared radiance data - all obtained through the courtesy of the Air Resources Laboratory of the National Oceanic and Atmospheric Administration.

3.6 DATA ANALYSIS

Utilizing a Nicolet Scientific Dual Channel FFT (Fast Fourier Transform) Analyzer Model 411A, cross-correlation techniques yield the time difference and chronology of the signals measured by the triangular microphone array. These data were used to calculate the azimuth and elevation angles of the arriving ray vector. In addition, the narrow band frequency spectra and peak pressure levels of the signals were obtained.

To study the effects of atmospheric temperature and wind profiles on the propagation of the Concorde's booms from its flight tracks to the New England area, an atmospheric acoustic ray tracing program has been adapted to TSC's data processing system. The ray tracing program is a version by E.B. Wright of NRL of the original developed by R.J. Thompson of Sandia Laboratories.

4. MEASUREMENT DATA

During the period May 3, 1979 to September 14, 1979, infrasonic measurements were made at Malden MA., at six other sites in the Greater Boston area (see Figure 2), and at a site in Applebachsville, PA (see Figure 3). Measurements were made on a daily basis throughout the period at the Malden site with measurements simultaneously made (one site at a time) at each of the other sites to obtain a measure of the variability of the data with geographic location.

4.1 SUMMARY DATA

Tables 1 through 1D contain summary data of the events recorded on a daily basis at the Malden site for May, June, July, August, and September, 1979, respectively. (Table 1, Summary Data for May 1979, is repeated for convenience. See Progress Report DOT-TSC-FA-953-PR-79-1 for all other May data.) Table 1E summarizes the data measured at the remaining seven sites.

An inspection of these tables shows the variability of the measured peak-to-peak pressure change resulting from the unstable stratospheric winds. Of the events measured, seven were recorded with peak-to-peak pressure changes in excess of 0.5 pounds per square foot. The strongest signal (0.69 pounds per square foot) was measured on June 14, 1979. The lowest signals were measured during September, 1979, and signalled the end of the 1979 season of easterly stratospheric winds. The 1979 measurement program was therefore terminated on September 14, 1979.

On September 6, 1979, Air France Flight AF-001 flew a track approximately 40 miles south of the usual JFK-bound flight track. It is not known at this time if the new flight track and operational procedures or the absence of easterly stratospheric winds on that particular day resulted in the low pressure levels measured for that particular flight.

A comparison of data in Table 1E (Miscellaneous Sites) with data at the Malden site during the same time frame shows the variability of the data because of geographic location. It is seen that the levels measured in Georgetown were generally greater than those in Malden. At the remaining five sites in Massachusetts, the reverse was generally true. This is further illustrated in Section 4.2 in the comparison of pressure level time histories.

Angular dimensions of the arriving ray vector are also included in these tables. The azimuth angle is the calculated head- of the arriving ray measured clockwise from true north. The measured azimuth angle averaged approximately 278 degrees re true north at Malden. If the aircraft is taken to have a 250 degree heading, the azimuth angle indicates (see Section 4.4, Ray Tracing) the aircraft was traveling at approximately Mach 1.31 when the shock wave was launched (See Figure 2).

The eplased time tabulated is the difference between the time of the measured maximum peak-to-peak pressure change and the time of the closest point of approach (CPA) of the aircraft to Hyannis, MA., as determined by radar. The statistical consistency of the elapsed time over the summer indicates conclusively that these JFK bound flights are the source of the secondary shock waves in New England. Further, it indicates that the shockwaves in question are launched from a specific portion of the flight track of the aircraft.

Technicians on site heard the majority of the signals measured and in some cases were able to obtain a sound level meter reading (on the fast scale) unencumbered by local disturbances. These have also been tabulated. The highest SPL measured on June 18, 1976, overloaded a sound level meter set for a full scale reading of 60 dBA. A peak-to-peak pressure change of 0.68 pounds per square foot was recorded for this event, one of the highest levels measured during the summer.

4.2 PRESSURE LEVEL SIGNATURES

Representative time histories of pressure level changes recorded are presented. Figures 4 - 14 show the day-to-day as well as the hour-to-hour (or flight-to-flight) variability of the signals measured at the Malden measurement site during the 1979 measurement program. Extremes in the hour-to-hour variability can be seen in Figures 8 and 10 for July 18 and 26, 1979, while Figure 12 for August 15, 1979, shows a marked similarity in the two events measured.

An examination of the Malden signatures shows that not only do the amplitudes change but the complexity, duration, and multiplicity of the waveforms also vary. The waveforms appear less complex in May and September than those in the intervening months. It was noted in the May report that azimuth calculations showed the waveform was made up of signals that arrived from various azimuth angles. When the upper level winds begin to inhibit the refracted wave from touching down, as in May and September, the number of paths is reduced and the pressure signatures become less complex (see Figures 13 and 14 here as well as Figure 5 of the May report).

A direct comparison can be made in Figures 15 and 22 of the signals measured at Malden with the simultaneous recording of data recorded at Marlboro, Medfield, Cohasset, Georgetown, and Sharon, MA. Both the amplitude and shape of the signatures vary. The larger of the levels are measured in Malden, with the exception of those measured in Marlboro and Georgetown.

In Figures 23 and 24, pressure level time histories of data recorded in Applebachsville, PA., resulting from Concorde flights in-bound to Dulles International Airport, are presented. The signatures shown have the same degree of day-to-day variability as have the Malden data. The phenomena is obviously the same as that observed in New England.

Figure 25 contains time histories of both exterior infrasonic pressure changes and window vibration accelerations measured on June 20, 1979, at a residential home at 11 Wilton Drive, Wilmington, MA. The lateral accelerations of the 54 by 60 by one-quarter inch plate glass window are seen to be in synchronism with the outside pressure changes resulting from the secondary sonic boom. In this instance, technicians both inside and outside the home heard the event.

4.3 FREQUENCY SPECTRA

A narrow band frequency analysis was performed, averaging a four second period of data around the maximum pressure change recorded. Frequency spectra for several representative events are presented in Figures 26-31. The signal drop-off above 30 Hz is characteristic of the TSC infrasonic measuring system, which was adjusted for a high frequency cutoff at 30 Hz.

Figures 26-29 contain the frequency spectra for representative events measured in Malden during June, July, August, and September, 1979. (See Figures 6, 7, 11 and 14 for pressure level time history data). Figure 30 contains frequency data for events measured on July 11, 1979, in Georgetown and can be compared with the frequency spectra (Figure 27) for the same events measured in Malden. (Also see the pressure level histories in Figures 21 and 7).

Figure 31 contains frequency spectra for signals from two flights measured in Applebachsville, PA. (See Figures 23 and 24 for the pressure level time histories).

Figure 32 contains the frequency spectra for the infrasonic event measured on June 20, 1979 in Wilmington, MA, and the spectra of the window pane vibrations. (See Figure 25 for the corresponding time histories.)

4.4 RAY TRACING

To obtain a quantitative insight into the spatial extent of the secondary boom impacted area, a numerical simulation (ray tracing) was carried through for the event associated with

BA Flight 171 on June 20, 1979. Meteorological data used in the simulation, shown in Figures 33, 34 and 35 and transmitted to TSC by William Hass of NOAA, is derived from three sources. The meteorological network's rawinsonde (balloon borne) data yields temperature, wind speed and wind direction profiles for the considered date in the Boston area for altitudes up to 32,000 m. An analysis of satellite measurements of infrared emission from the atmosphere give particular values for the meteorological variables at 36614 m, 43422 m, 48791 m, and 55869 m altitude, also for the Boston area. A third set of data, at altitude intervals of 1000 m, from 22000 m to 55000 m, is derived from rocketsonde observations above Wallops Island, Virginia, on the June 20, 1979, date. The extent to which the actual profiles above Boston at any given time on the considered date may deviate from the available data profiles has not yet been assessed. The Wallops data set is intrinsically more accurate than the satellite data set, but does not necessarily describe the atmosphere above Boston. The solid lines in Figures 33, 34 and 35 represent the smoothed profiles adopted in our calculations.

The ray tracing program yields the horizontal ranges, if any, at which a ray may touch the ground, given the meteorological profile, the source altitude, the initial ray azimuth angle θ_o, and the initial ray elevation angle ϕ_o.

In order that the refracted ray touch the ground for any ϕ_o and for fixed θ_o, it is necessary that the effective sound speed profile (sound speed plus wind component in direction θ_o) have a maximum value above the source altitude that is larger than the value at the ground. Two such effective sound speed profiles based on the selected meteorological model are shown in Figure 36 for azimuth angles of 276 and 335 degrees. The former allows the existence of secondary booms, the second precludes it.

Rays launched by a supersonic aircraft are constrained such that their initial direction makes an angle of $\cos^{-1}(1/M)$

with the flight direction. Consideration of the geometry associated with this constraint leads to the conclusion that ϕ_o and θ_o must be related by the equation, $1/M = \cos \phi_o \cos (\theta_o - \theta_{AH})$, where θ_{AH} is the aircraft heading; $\theta_o - \theta_{AH}$ and ϕ_o must be between -90 and 90 degrees. Thus, for example, were the airplane heading in a direction of 250 degrees and were one to consider rays leaving the flight track in the azimuth direction of θ_o = 277 degrees, the only admissible rays would be those with elevation angles (ϕ_o) of 30.3 and -30.3 degrees.

Each point on the aircraft trajectory is a source of rays that satisfy the requirements just described, so successive computations carried out for different points along the aircraft's flight profile enable one to determine a pattern of points on the ground at which secondary booms are expected to be received. The derived pattern (Figure 37) exhibits two carpet edges for secondary booms. The inner-most line is the interior edge of the ground region where secondary booms with no intermediate ground reflection are predicted.

The outer line in Figure 37 is the interior edge of the ground region where secondary booms with one intermediate ground reflection are received.

The extent to which these computations are representative has yet to be assessed, but it is expected that the two lines may move 10-15 km in either direction with typical fluctuations in meteorological conditions at altitudes of 40-55 km. Since the wind speeds are not precisely known at these altitudes over the Boston area, the uncertainties in carpet edge locations are probably of this order of magnitude.

The computational results indicate that the signal, at the Malden site, from the June 20th BA 171 flight arrived with an azimuthal propagation direction of 276.5 degrees. The received ray left the flight track at a point 223.8 km from the site at a time 09:27:59 (E.D.S.T.) and had a travel time of 12 minutes, 12 seconds to the Malden site, so the predicted arrival time is 09:40:11. The pressure time history at Malden for the considered event (see Figure 6) shows arrivals at 09:39:18 (3 seconds duration), at 09:40:12 (12 seconds duration), and 09:40:42 (30 seconds duration). The peak amplitude occurs at 09:41:00 (see Table 1A) and arrives with a propagation azimuth of 280 degrees. The measured elevation angle on arrival is 16 degrees; the computations yield a value of 13 degrees.

The multiple arrivals in the measured time history are tentatively interpreted as: (1) ground wave at 09:39:18, (2) stratospheric arrival, without intermediate ground reflection, at 09:40:12, and (3) stratospheric arrival, with one intermediate ground reflection, at 09:40:42. The interpretation (2) is supported by agreement of its arrival time with the computed arrival time for such a ray path. The interpretation assigned to (3) requires that the computed interior carpet edge for such arrivals, shown in Figure 37, be moved eastward such that the Malden site lies within the carpet. That the actual footprint includes the Malden site is not unexpected, given the uncertainty in the meteorological conditions at the time of the event.

The interpretation just described for the third arrival is further supported by the numerical calculations that show, at those ranges where both stratospheric arrivals are received, the time delay between the two is 0.16 seconds per kilometer of propagation distance (44 seconds/268 km), which extrapolates to 37 seconds at 223.8 km. Also, the relatively high amplitude of the third arrival is consistent with the theoretical result that ray focusing is strongest just behind the edge of the carpet for each category of stratospheric arrivals. If the Malden site lies within both carpets, then the highest amplitude arrival must be associated with the carpet whose edge is closest.

The ground wave interpretation for the first arrival is consistent with its average transit speed, 330 meters per second. Theoretical considerations suggest the ground wave is launched by a ray traveling from the flight trajectory to the edge of the primary boom carpet and that the ground wave thereafter travels with the speed of sound at the ground. The launching ray takes 152 seconds to travel 46 km to the edge of the primary carpet, the ground wave would then take 523 seconds to reach the Malden site, so that the theoretically predicted arrival time is 09:39:14, which compares extremely well with the observed arrival time of 09:39:18.

5. FUTURE WORK

No further measurements are planned at this time. A final report will be prepared and submitted in draft form on Feburary 22, 1980. The report will address further the phenomena of focusing and will assess possible changes in the flight track to minimize the secondary sonic boom effect in the New England area.

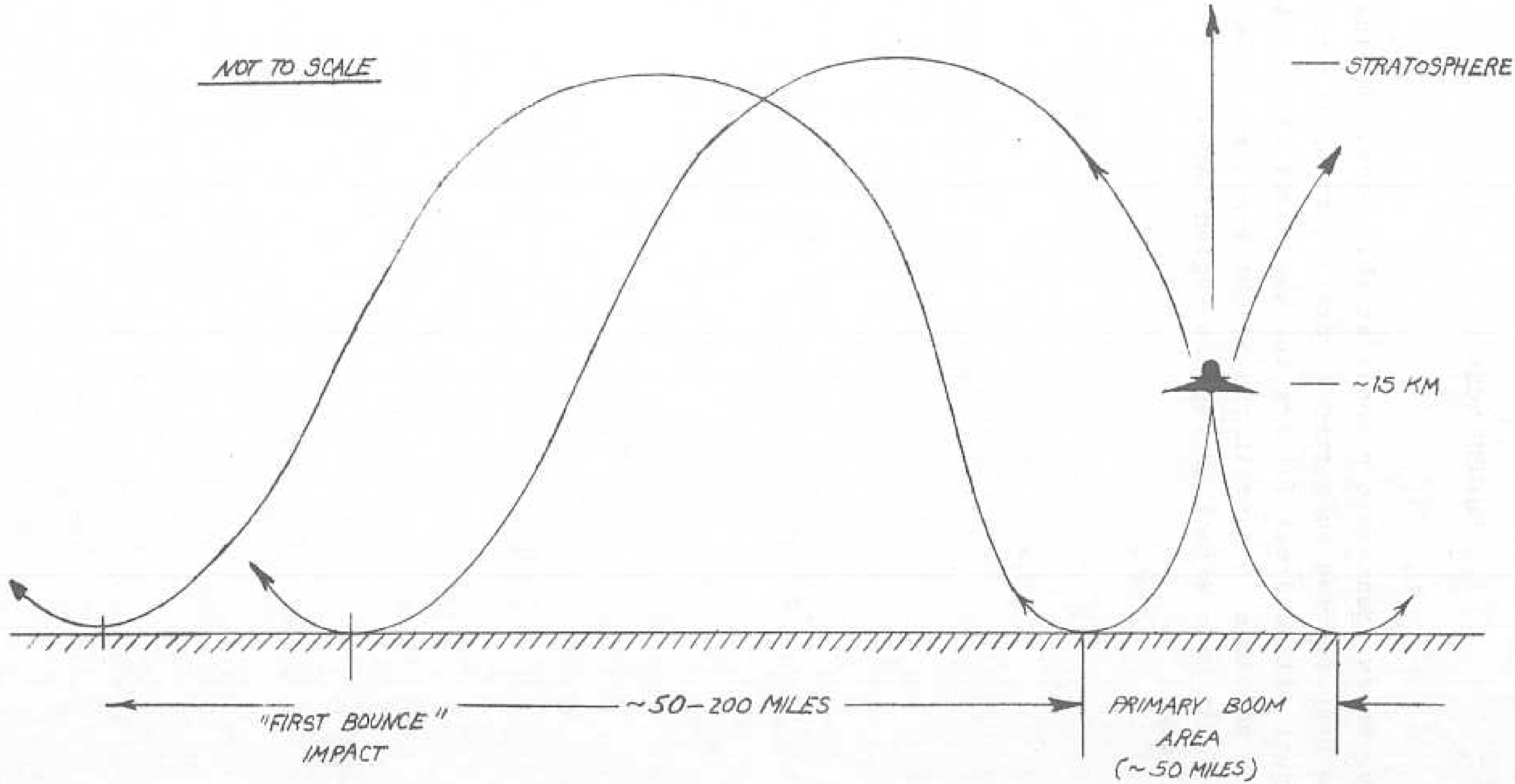

FIGURE 1 - Schematic of refractive sonic boom propagation.

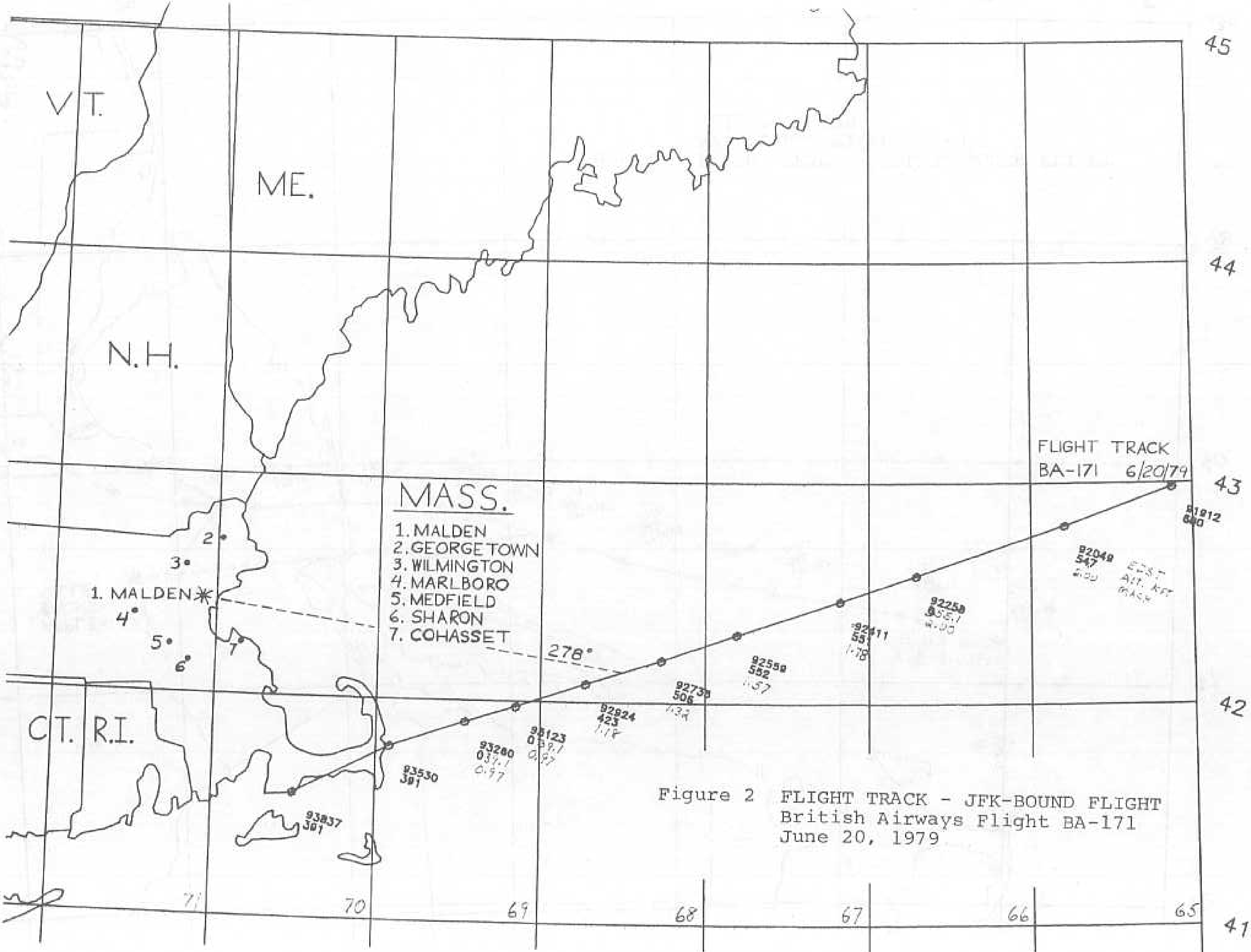

Figure 2 FLIGHT TRACK - JFK-BOUND FLIGHT
British Airways Flight BA-171
June 20, 1979

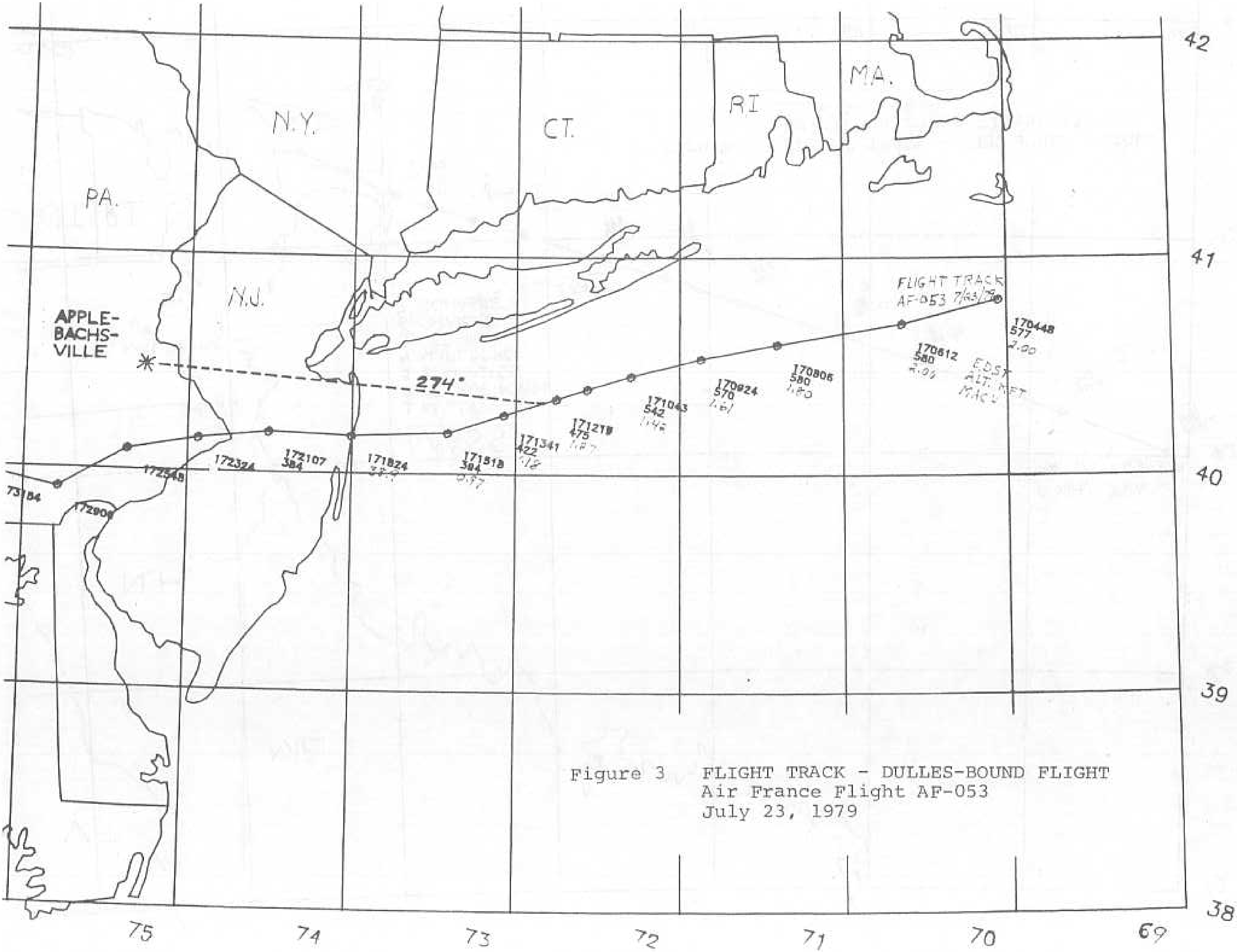

Figure 3 FLIGHT TRACK - DULLES-BOUND FLIGHT
Air France Flight AF-053
July 23, 1979

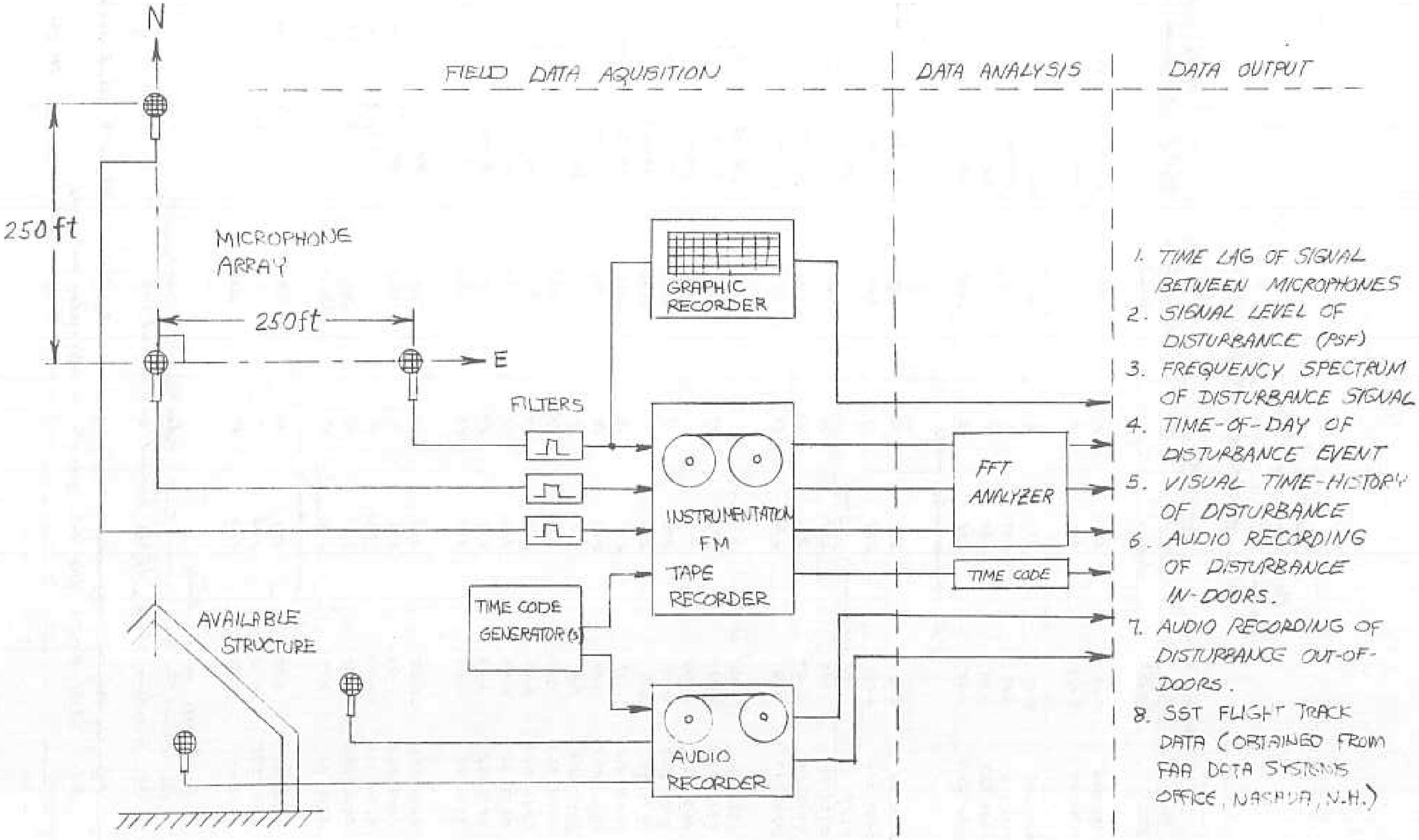

FIGURE #4 — MONITORING SYSTEM SCHEMATIC

Table No. 1

May Summary Data
Secondary Sonic Boom Detection
Malden Ma. (42°26'34" N, 71°05'07" W)

Date 1979	Time EDST.	Max. Pres. Change Peak to Peak lbs/ft²	Arriving Ray: Azimuth degrees (1)	Arriving Ray: Elevation degrees	Elapsed Time (2) Seconds	Flight No	Heard by Field Observers	Meas. SPL dBA
May 3	0130:00.6	0.081	279	8	(3)	BA-171	No	
4	0938:37.7	0.033	281	10	(3)	BA-171	No	
7	0931:10.7	0.12	281	6	259.7	BA-171	Yes	
8	0933:31.3	0.13	279	7	256.3	BA-171	Yes	
9	0929:02.7	0.63	280	7	287.7	BA-171	Yes	
10	0931:21.5	0.13	278	10	255.0	BA-171	Yes	
11		No measurements made						
14	0932:21	0.12	278	16	253.0	BA-171	Yes	46
15	0937:57.5	0.041	278	28	314.5	BA-171	No	
16	0930	No measureable signal				BA-171	No	
17	0934:19	0.055	278	19	(3)	BA-171	No	
18	0813:55	0.027	280	29	(3)	AF-001	No	
18	0932:23	0.027	276	19	(3)	BA-171	No	
21	0753:30	Not recorded on Tape			(3)	BA-173	Yes	
21	0823:09	0.072	281	17	(3)	AF-001	No	
21	0930:34.8	0.049	—	—	(3)	BA-171	No	
22	0743:55.5	0.25	278	10	241.5	BA-173	Yes	48
22	0811:44	0.19	278	11	240.0	AF-001	Yes	
22	0931:08.8	0.17	278	16	243.8	BA-171	Yes	
23	0820:43.6	0.10	279	19	283.6	AF-001	No	
23	0941:08.6	0.11	275	19	233.6	BA-171	Yes	52
24	0740:55.6	0.15	276	15	260.6	BA-173	Yes	
24	0821:05.3	0.07	280	14	(3)	AF-001	Yes	
24	0933:35	0.04	276	17	230.0	BA-171	No	
25	0819:56	0.02	271	24	(3)	AF-001	No	
25	0937:45	0.03	276	15	220.0	BA-171	No	
29	0830:55.1	0.36	282	10	265.1	AF-001	Yes	
29	0848:02.5	0.26	276	4	213.5	BA-173(3)	Yes	
29	0931:56.7	0.02	75	—		Unidentified	No	
29	0936:15.6	0.20	278	11	230.6	BA-171	Yes	
30	0815:56	0.068	276	15	266.0	AF-001	No	
30		No measurements made						
31	0728:54	0.39	279	17	264.0	BA-173	Yes	48
31	0811:51.5	0.35	282	9	276.5	AF-001	Yes	48
31	0942:40	0.34	280	12	263.0	BA-171	Yes	46

(1) Degrees as True North
(2) Elapsed Time from measured Event to Radar Track time CPA Hyannis MA.
(3) Telephone check, flights arrived on Time at JFK

Note: On May 18 measurement window expanded from 0900 to noon hours to 0730 to 1030 hours
Note: Flight BA-173 does not operate on Wednesday and Friday

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Table No. 1A
June Summary Data
Secondary Sonic Boom Detection
Malden Ma. (42°26'35"N, 71°05'07"W)

Date 1979 June	Time EDST	Max Press. Change Peak to Peak lb/ft.²	Arriving Ray Azimuth degrees(1)	Arriving Ray Elevation degrees	Elapsed Time(2) seconds	Flight No.	Heard by Field Technician	Plane SPL dBA
1	0812:08.5	0.25	282	16	344.5	AF-001	Yes	
1	1800:30.3	0.26	277	15	306.3	BA-171	Yes	
4	0732:57.8	0.15	274	17	186.8	BA-173	Yes	
4	08[illegible]:16.7	0.11	281	17	266.7	AF-001	Yes	
4	0934:37.5	0.25	277	11	217.5	BA-171	Yes	
5	0733:21	0.32	276	19	295.5	BA-173	Yes	
5	0810:26.5	0.11	279	18	312.5	AF-001	Yes	
5								
6	0815:11.5	0.27	278	13	336.8	AF-001	Yes	
6	0951:45.3	0.16	276	20	344.6	BA-171	Yes	
7	0746:36.3	0.25	280	18	272.1	BA-173	Yes	
7	0816:00.7	0.19	281	16	278.2	AF-001	Yes	
7	0952:54	0.29	277	17	280.0	BA-171	Yes	
8	0812:53	0.33	282	19	286.0	AF-001	Yes	
8	0933:05.7	0.12	279	18	253.7	BA-171	Yes	
11	0737:25.3	0.35	280	23	291.8	BA-173	Yes	
11	0814:29	0.10	282	24	321.0	AF-001	Yes	
11	0952:28	0.174	275	15	258.0	BA-171	Yes	
12	0743:14.5	0.22	275	8	223.8	BA-173	Yes	
12		Flight 2 hours late no measurements made				AF-001		
12	0937:01.6	0.24	276	17	225.6	BA-171	Yes	
13	0820:30.4	0.20	279	17	257.4	AF-001	Yes	
13	0925:30	0.17	276	10	218.5	BA-171	Yes	
14	0750:11	0.49	278	13	227.5	BA-173	Yes	
14	0821:03.4	0.36	280	13	285.5	AF-001	Yes	
14	0938:17.5	0.69	277	17	249.3	BA-171	Yes	
15	0811:09.8	0.61	282	12	237.8	AF-001	Yes	
15	0953:49.3	0.69	280	5	254.0	BA-171	Yes	
18	0736:35.8	0.31	277	14	250.0	BA-173	Yes	
18	0818:46	0.27	267	25	228.5	AF-001	Yes	
18	0941:56	0.13	278	17	241.8	BA-171	No	
19	0730:36.8	0.12	278	20	95.3	BA-173	No	
19	0815:17.8	0.13	269	10	111.1	AF-001	Yes	
19	0942:53.4	0.23	275	4	100.0	BA-171	Yes	
20	0816:31	0.13	279	16	(3)	AF-001	Yes	
20	0940:57.9	0.23	280	16	247.9	BA-171	Yes	
21	0737:34.7	0.34	279	18	268.4	BA-173	Yes	
21	0818:00	0.25	281	26	283.3	AF-001	Yes	
21	0947:25	0.31	277	15	265.9	BA-171	Yes	
22	0818:57	0.13	278	23	328.0	AF001	Yes	
22	0935:51	0.21	277	28	(3)	BA-171	Yes	
25	0744:19	0.30	279	16	265.0	BA-173	Yes	
25	0819:44.8	0.14	280	22	262.5	AF-001	Yes	
25	0941:58.5	0.32	275	4	221.9	BA-171	Yes	
26	0750:54.3	0.34	279	15	238.0	BA-173	Yes	
26	0812:02.3	0.28	281	16	262.0	AF-001	Yes	
26		Flight 2 hours late no measurements made				BA-171	-	
27	0815:01.3	0.40	280	6	262.6	AF-001	Yes	
27	0943:01.8	0.25	277	29	228.0	BA-171	Yes	
28	0736:56.2	0.35	277	9	152.9	BA-173	Yes	
28	0814:22.3	0.45	280	16	230.1	AF-001	Yes	
28	0930:21.3	0.49	278	26	242.3	BA-171	No	
29	0814:20.4	0.44	282	19	267.4	AF-001	Yes	
29	0949:26.2	0.26	277	8	251.2	BA-171	Yes	

(1) Degrees re True North
(2) Elapsed Time from measured Event to Radar Track Time CPA Hyannis Ma.
(3) Telephone check, flight landed on Time at JFK

Table No. 1B
July Summary Data
Secondary Sonic Boom Detection
Malden Ma. (42°26'34"N, 71°05'07"W)

Date 1979 July	Time EDST	Max. Pres. Change Peak to Peak lbs/ft²	Arriving Ray Azimuth degrees (1)	Arriving Ray Elevation degrees	Elapsed Time (2) seconds	Flight No.	Heard by Field Technicians	Meas. SPL dBA
2-6	No measurements made				–			
9	0724:21.5	No measurements made			287.5	BA-173	Yes	
9	0811:16.0	0.15	–	–	258.2	AF-001	Yes	
9	0928:46.3	0.25	–	–	252.3	BA-171	Yes	
10		Flight late no measurements			–	BA-173	–	
10	0813:10.2	0.12	–	–	254.2	AF-001	Yes	
10	0936:29.3	0.21	–	–	225.3	BA-171	Yes	
11	0825:56.8	0.11	–	–	240.1	AF-001	Yes	
11	0931:53.4	0.17	–	–	153.4	BA-171	Yes	
12	0733:37.8	0.33	–	–	–	BA-173	Yes	
12	0815:19.0	0.13	–	–	237.0	AF-001	Yes	
12	0941:53.0	0.20	–	–	221.2	BA-171	Yes	
13	0813:20.6	0.18	–	–	277.0	AF-001	Yes	
13	0932:33.6	0.12	–	–	246.9	BA-171	Yes	
16	0832:42.9	0.11	279	21	–	BA-173	Yes	
16	1036:29.5	0.09	285	20	272.3	AF-001	Yes	
16	1004:13.4	0.07	282	19	264.9	BA-171	Yes	
17	0726:04.7	0.17	278	14	233.3	BA-173	Yes	
17	0810:01.3	0.15	279	27	254.3	AF-001	Yes	
17	0952:39.9	0.11	280	17	225.6	BA-171	Yes	
18	0808:14.0	0.08	280	11	239.0	AF-001	Yes	48
18	0941:02.5	0.68	274	29	202.5	BA-171	Yes	≈60
19	0726:47.2	0.17	280	25	245.7	BA-173	Yes	56
19	0809:24.8	0.33	277	21	190.3	AF-001	Yes	46
19	0945:25.0	0.21	276	23	187.0	BA-171	Yes	45
20	0808:30.4	0.65	278	12	204.1	AF-001	Yes	56
20	0923:20.0	0.31	278	20	203.9	BA-171	Yes	<45
23	No measurements made				–	BA-173	–	
23	0814:16.5	0.10	–	–	239.6	AF-001	Yes	
23	0936:22.3	0.11	–	–	222.8	BA-171	Yes	54
24	No measurements made				–	BA-173	–	
24	"	"	–	–	–	AF-001	–	
24	"	"			–	BA-171	–	
25	0809:33.5	0.12	–	–	266.9	AF-001	Yes	
25	0949:33.2	0.22	–	–	278.6	BA-171	Yes	
26	0726:36.5	0.47	–	–	268.7	BA-173	Yes	56
26	0818:32.3	0.04	–	–	304.6	AF-001	No	
26	0933:05.7	0.23	–	–	270.9	BA-171	Yes	50
27	0810:36.3	0.09	–	–	–	AF-001	Yes	
27	0934:57.7	0.23	–	–	248.5	BA-171	Yes	48
30	0733:14.3	0.21	278	18	236.5	BA-173	Yes	45
30	0814:01.7	0.19	–	–	254.0	AF-001	Yes	
30	0928:01.3	0.14	–	–	244.0	BA-171	Yes	45
31	No measurements made				–	BA-173	–	
31	"	"	"		–	AF-001	–	
31	"	"	"		–	BA-171	–	

Table No. 1C
August Summary Data
Secondary Sonic Boom Detection
Malden Ma. (42°26'34"N, 71°05'07"W)

Date 1979	Time EDST	Max. Pres. Change Peak to Peak lb/ft²	Arriving Ray Azimuth degrees(1)	Arriving Ray Elevation degrees	Elapsed Time (2) Seconds	Flight No.	Heard by Field Technician	Meas. EPL dBA
August								
1	0818:33.4	0.19	282	23	281.6	AF-001	Yes	55
1	0957:33.5	0.34	277	7	244.4	BA-171	Yes	
2						BA-173	-	
2	0817:03.4	0.34	277	16	243.7	AF-001	Yes	
2	0940:53.2	0.12	276	17	217.5	BA-171	Yes	
3		Flight late no measurements			—	AF-001	-	
3		Flight late no measurements			—	BA-171	-	
6		Flight cancelled			—	BA-173	-	
6	0819:15.3	0.18	277	20	247.1	AF-001	Yes	
6	0941:08.7	0.20	278	19	232.6	BA-171	Yes	45
7		Flight cancelled			—	BA-173	-	
7	0810:32.5	0.24	280	24	283.0	AF-001	Yes	
7	0941:36.0	0.59	280	19	268.5	BA-171	Yes	
8	0815:18.0	0.13	281	14	260.5	AF-001	Yes	52
8	1049:01.7	0.85	279	12	232.2	BA-171	Yes	
9		Flight cancelled			—	BA-173	-	
9	0815:51.6	0.11	282	6	237.6	AF-001	Yes	52
9		Flight cancelled			—	BA-171	-	
10	0812:31.8	0.26	280	19	267.2	AF-001	Yes	47
10		Flight late no measurements			—	BA-178	-	
13		Flight cancelled			—	BA-173	-	
13	1012:11.5	0.18	278	11	203.5	AF-001	Yes	
13	0956:07.9	0.47	278	12	216.9	BA-171	Yes	
14		Flight cancelled			—	BA-173		
14	0822:20.1	0.12	280	22	254.1	AF-001	Yes	
14	0935:52.2	0.24	281	23	255.2	BA-171	Yes	56
15	0817:27.7	0.30	275	17	202.2	AF-001	Yes	54
15	0943:26.6	0.23	278	15	216.1	BA-171	Yes	
16		Flight cancelled			—	BA-173		
16	0818:24.9	0.17	279	17	285.9	AF-001	Yes	47
16	0942:30.2	0.21	276	20	245.2	BA-171	Yes	
17	0817:11.0	0.30	282	26	222.0	AF-001	Yes	50
17	0948:40.0	0.30	280	12	261.5	BA-171	Yes	57
20		Flight cancelled			—	BA-173		
20	0812:44.8	0.13	278	10	245.7	AF-001	Yes	
20	0936:11.0	0.19	279	18	260.0	BA-171	Yes	52
21		Flight cancelled			—	BA-173		
21	0816:26.7	0.13	281	16	246.1	AF-001	Yes	
21	1108:25.8	0.29	276	16	223.5	BA-171	Yes	46
22		Flight late no measurements			—	AF-001		
22	0927:59.4	0.15	282	7	255.1	BA-171	Yes	47
23		Flight cancelled			—	BA-173		
23	0810:22.8	0.07	281	15	275.3	AF-001	No	
23	0941:19.3	0.16	281	16	—	BA-171	Yes	45
24	0815:30.6	0.35	282	15	297.6	AF-001	Yes	48
24	0926:52.3	0.21	279	11	244.8	BA-171	Yes	50
27	0725:32.5	0.27	277	15	213.6	BA-173	Yes	
27	0812:20.5	0.19	283	22	323.5	AF-001	Yes	48
27	0932:16.2	0.12	275	30	284.8	BA-171	Yes	
28	0735:57.2	0.17	276	18	277.7	BA-173	Yes	50
28	0806:26.2	0.06	279	5	216.7	AF-001	No	
28		Flight late no measurement			—	BA-171		
29	0818:01	0.07	—	—	242.0	AF-001	No	
29	0946:46	0.08	—	—	308.5	BA-171	No	
30	0745:01	0.13	—	—	248.1	BA-173	Yes	
30	0816:32	0.06	—	—	256.0	AF-001	No	
30	0937:10	0.14	—	—	236.5	BA-171	Yes	
31	0806:34	0.10	—	—	245.5	AF-001	No	
31	0946:50	0.15	—	—	256.8	BA-171	Yes	

(1) Degrees re True North
(2) Elapsed Time from measured Event to Radar Track Time CPA Lynn, Ma

Table No. 1D
September Summary Data
Secondary Sonic Boom Detection
Malden Ma. (42°26'34"N, 71°05'07"W)

Date 1979	Time EDST	Max Pres. Change Peak to Peak lbs/ft²	Arriving Ray Azimuth degrees[1]	Arriving Ray Elevation degrees	Elapsed Time(2) Seconds	Flight No.	Heard by Field Technicians	Meas. SPL dBA
September								
3		No measurements made						
4	0912:48.2	0.12	—	—	253.2	BA-173	Yes	
4	0810:57.0	0.04	—	—	239.2	AF-001	No	
4		Flight cancelled				BA-171		
5	0813:25.8	0.10	—	—	220.8	AF-001	Yes	
5	0929:10.5	0.07	—	—	246.1	BA-171	No	
6		Flight late no measurements				BA-173		
6	0818:09	<0.01(5)	—	—	189.0	AF001	No	
6	0956:11.3	0.11	—	—	267.3	BA-171	Yes	
7	0814:50.3	0.10	—	—	244.6	AF-001	No	
7	0947:36.0	0.25	—	—	243.9	BA-171	Yes	
10	0812:50.0	0.19	—	—	319.8	AF-001	Yes	
10	0936:10.2	0.26			268.7	BA-171	Yes	
11		No measurements made				BA-173		
11	0808:32.0	0.07	—	—	275.3	AF-001	No	
11	0935:14.1	0.16	—	—	283.6	BA-171	Yes	
12	0920:23	0.06	—	-	249.9	AF-001	Yes	
12	0941:42	0.32	—	—	231.0	BA-171	Yes	
13	0739:09	0.07	—	-	130.0	BA-173	No	
13	0825:36	0.13	—	-	149.0	AF-001	Yes	
13	0929:31	0.03	—	-	138.0	BA-171	No	
14	0821:52	0.01	—	—	273.0	AF-001	No	
14	0926:50	0.01	-	-	237.0	BA-171	No	

(1) Degrees re True North
(2) Elapsed Time from measured Event to Radar Track time CPA Hyannis Ma.

(5) Flight track approx 40 miles south of the usual JFK bound flights

Note: On September 19, 1979 measurement were discontinued for the 1979 season.

TABLE No. 1E

Summary Data

Secondary Sonic Boom Detection

Miscellaneous Sites

Date 1979	Time EDST	Max. Pres. Change Peak to Peak lbs/ft.²	Arriving Ray Azimuth degrees(1)	Arriving Ray Elevation degrees	Elapsed Time(2) Seconds	Flight No.	Heard by Field Technicians	Meas. SPL dBA
Georgetown Ma. (42°42'21"N, 70°58'58"W)								
July								
9	0724:15.9	0.41	284	9	285.9	BA-173	Yes	
9	0811:14.1	0.43	287	10	255.3	AF-001	Yes	
9	0928:42.1	0.30	282	6	248.1	BA-171	Yes	
10	1013:01.9	0.32	284	15	233.2	BA-173	Yes	
10	0813:08.8	0.35	289	18	252.8	AF-001	Yes	
10	0936:23.1	0.30	283	10	224.1	BA-171	Yes	
11	0825:50.9	0.40	287	15	234.2	AF-001	Yes	54
11	0931:49.5	0.20	283	10	185.5	BA-171	Yes	48
12	0	No measurements made				BA-173	Yes	
12	0815:27.0	0.15	286	17	245.0	AF-001	Yes	
12	0941:55.0	0.25	286	10	223.2	BA-171	Yes	
13	0813:21.8	0.29	287	16	278.2	AF-001	Yes	
13	0932:36.8	0.27	282	19	250.1	BA-171	Yes	
Wilmington Ma (42°33'14"N, 71°11'13"W)								
June								
20	0941:38.3	0.09	—	—	306.0	BA-171	Yes	
Marlboro Ma. (42°20'30"N, 71°30'45"W)								
June								
27	0944:36.8	0.25	—	—	323.0	BA-171	Yes	
Medfield Ma. (42°12'53"N, 71°16'43"W)								
June								
28	0930:58.7	0.09	—	—	277.7	BA-171	Yes	
Cohasset Ma (42°14'45"N, 70°51'26"W)								
June								
29	0928:17.7	0.18	—	—	182.7	BA-171	Yes	
Sharon Ma. (42°08'20"W, 71°10'00"W)								
August								
2	0817:07.4	0.11	—	—	247.7	AF-001	Yes	
2	0941:00.8	0.19	—	—	225.7	BA-171	Yes	
Applebachsville Pa. (40°29'12"N, 75°15'56"W)								
July								
23	1724:40.1	0.07	274	30	407.3 (4)	AF-053	NO	—
24	1655:08.3	0.18	—	—	3733 (4)	BA-189	Yes	47
25	/	Flight late no measurements			—	AF-053	—	
26	1652:50.5	0.36	—	—	3692 (4)	BA-189	Yes	57
27	1729:08.7	0.27	—	—	3821 (4)	AF-053	Yes	58

(1) – Degrees relative to True North

(2) – Elapsed Time from measured Event to Radar Track Time CPA Asbury Park N.J.

(4) – Elapsed Time from measured Event to Radar Track Time CPA Asbury Park N.J.

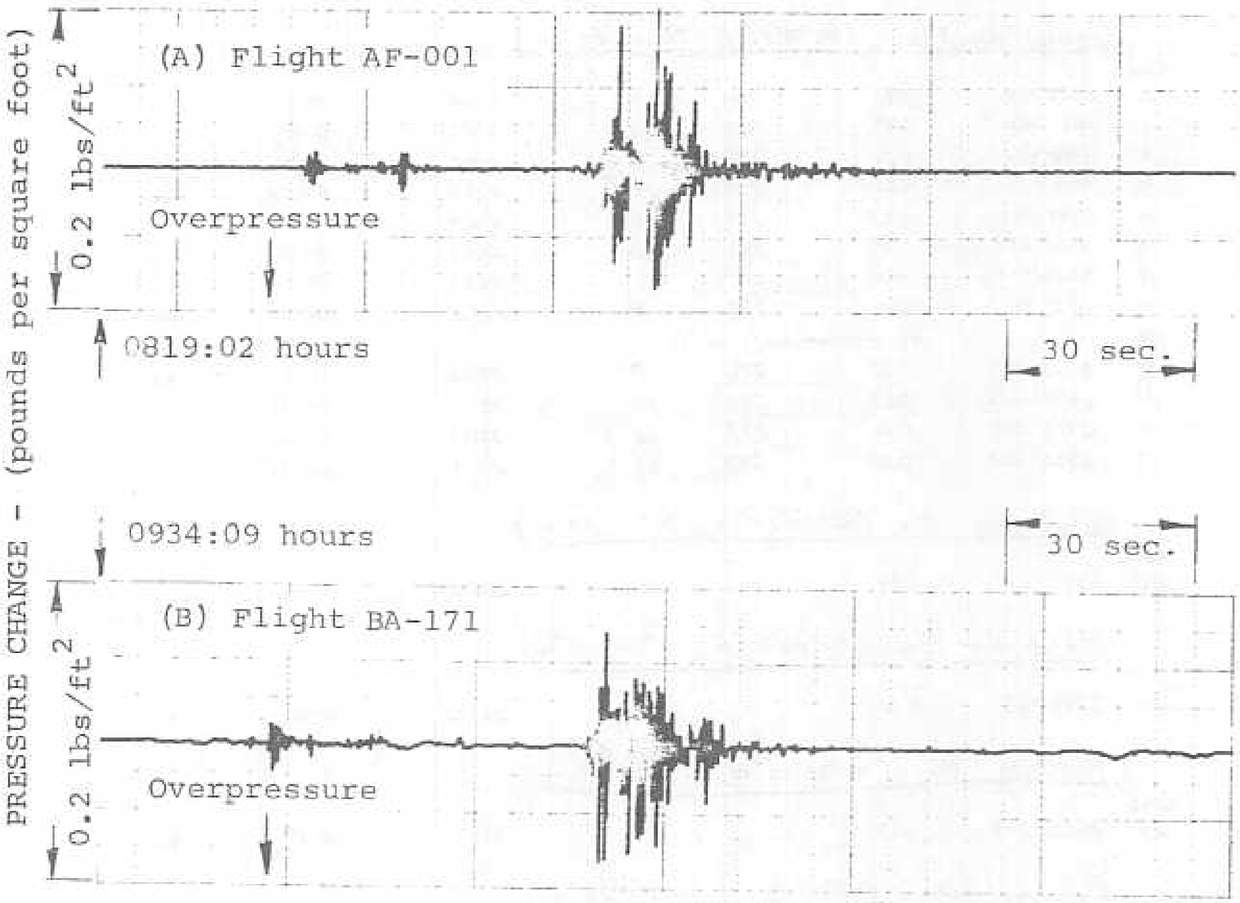


Figure 5 PRESSURE LEVEL TIME HISTORIES
Malden, MA. - June 13, 1979

A) Source: Air France Flight AF-001
B) Source: British Airways Flight BA-171

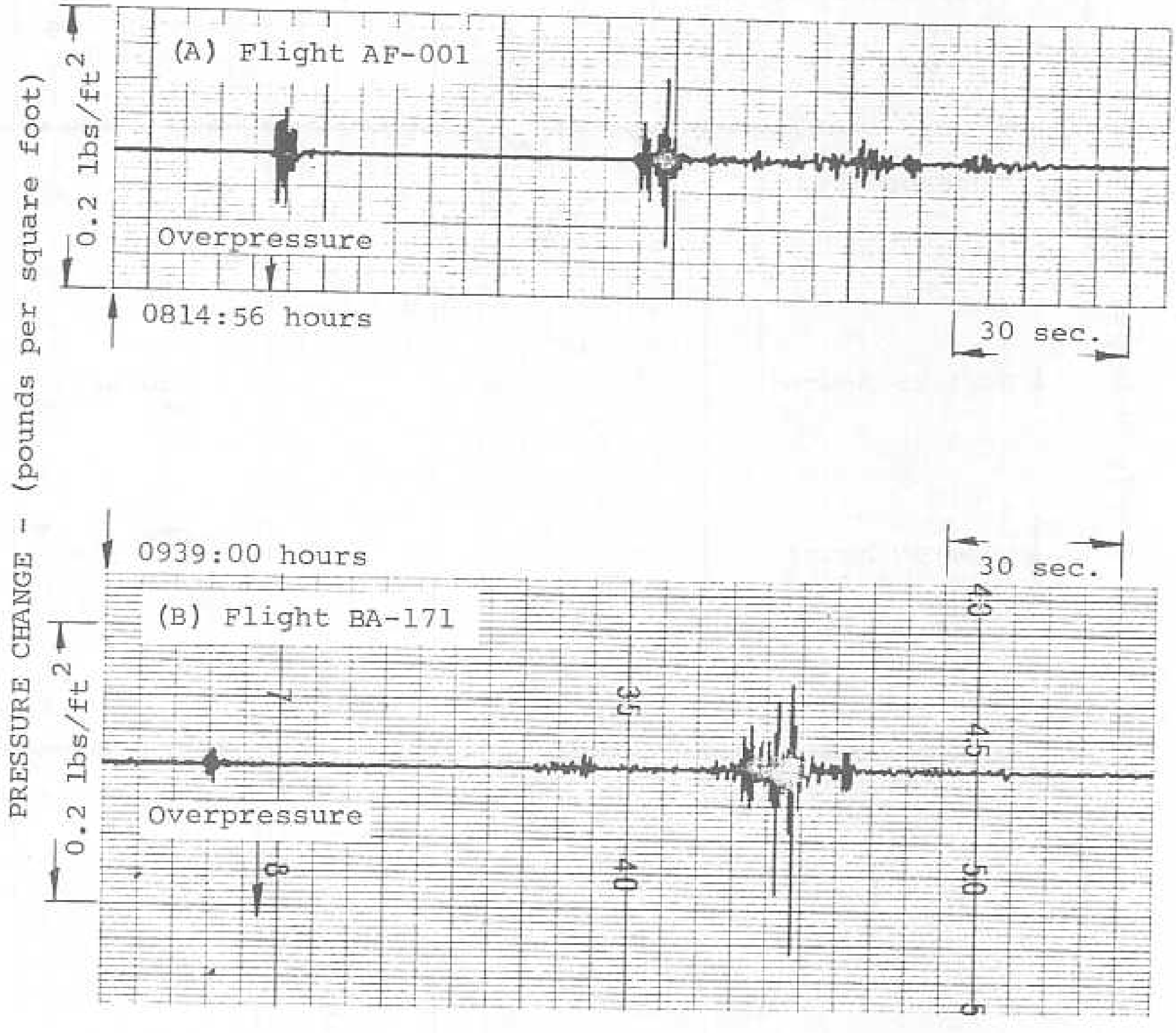


Figure 6 PRESSURE LEVEL TIME HISTORIES
Malden, MA. - June 20, 1979

A) Source: Air France Flight AF-001
B) Source: British Airways Flight BA-171

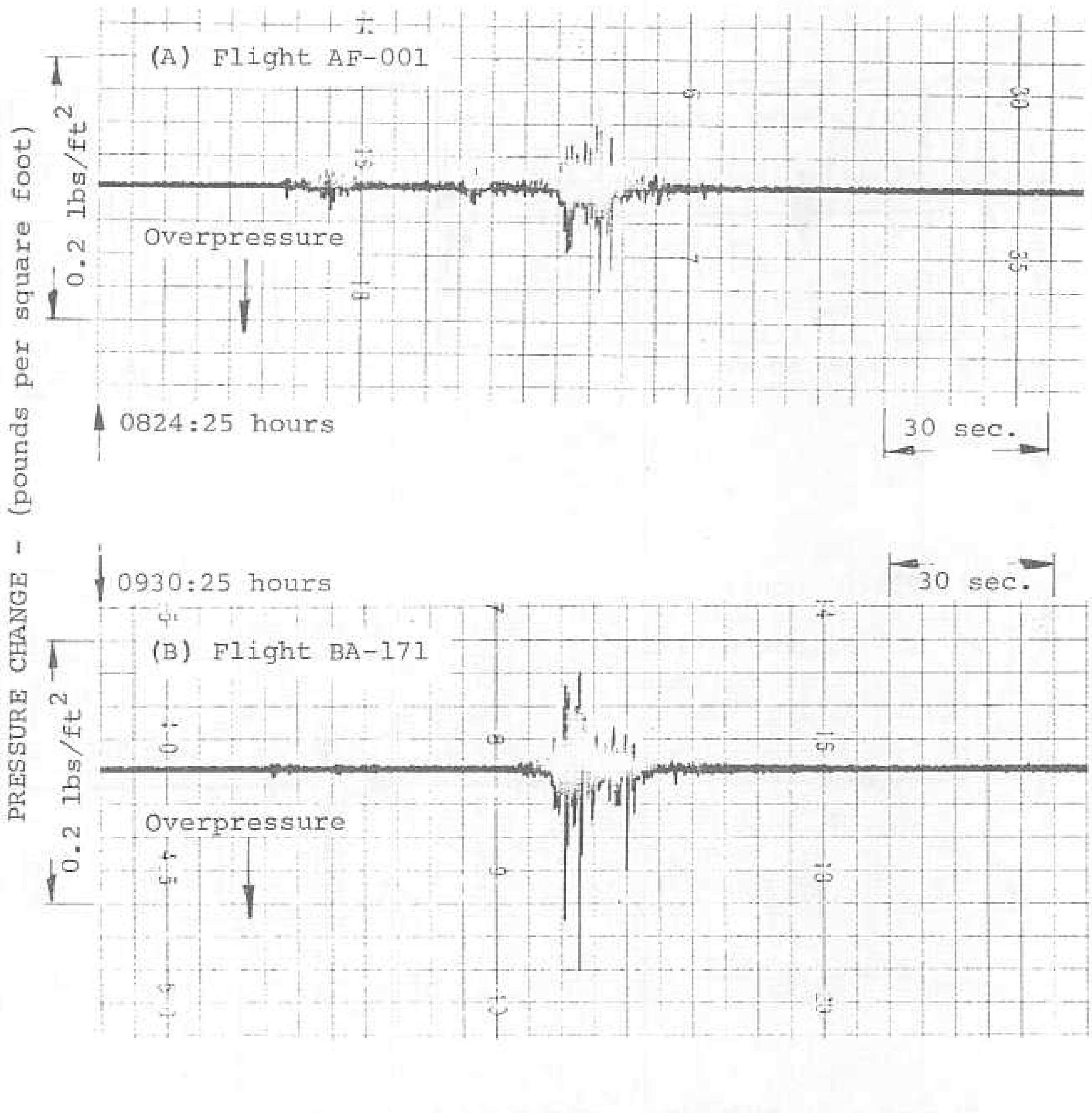


Figure 7 PRESSURE LEVEL TIME HISTORIES
Malden, MA. - July 11, 1979

A) Source: Air France Flight AF-001
B) Source: British Airways Flight BA-171

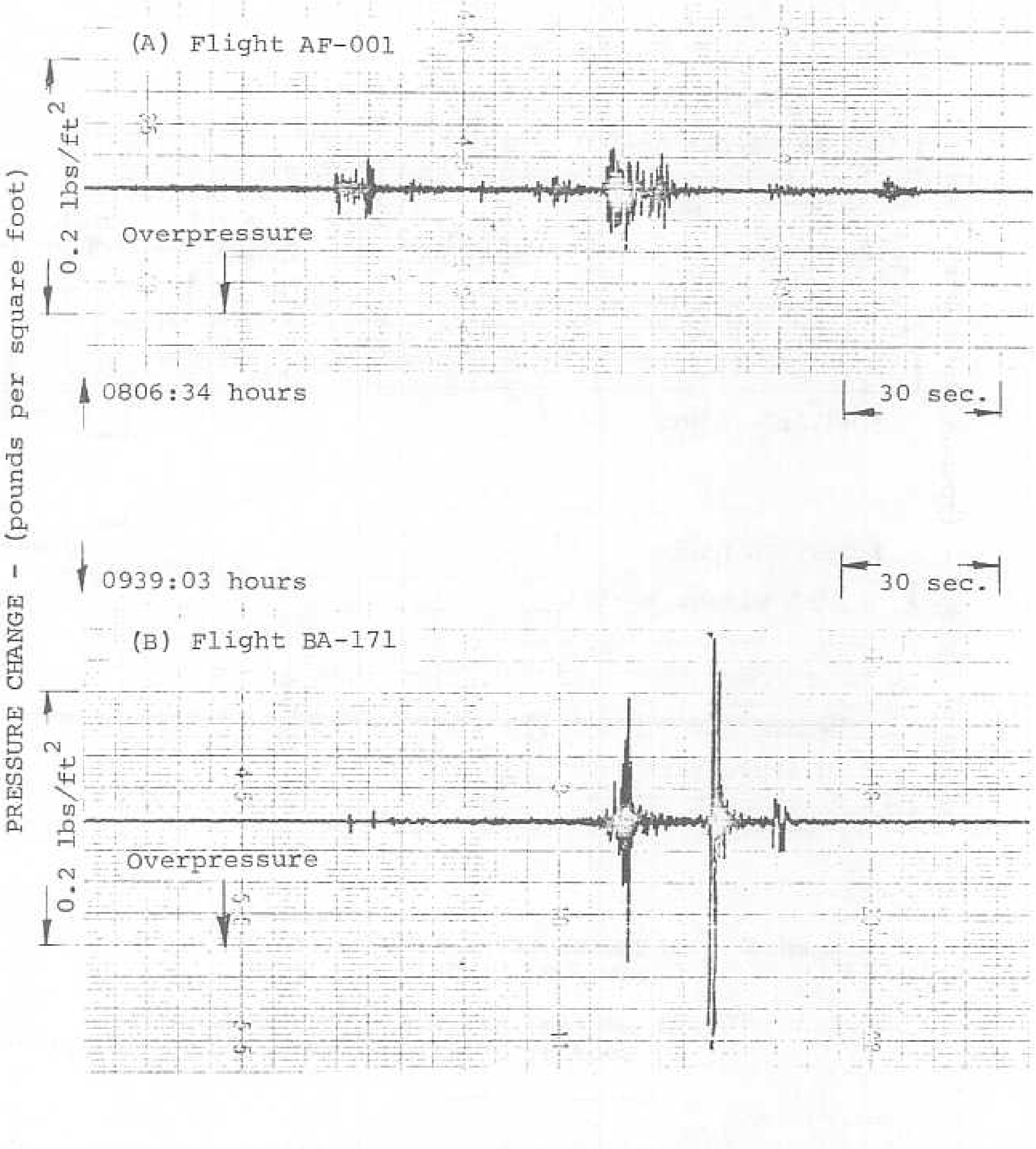


Figure 8 PRESSURE LEVEL TIME HISTORIES
Malden, MA. - July 18, 1979

A) Source: Air France Flight AF-001
B) Source: British Airways Flight BA-171

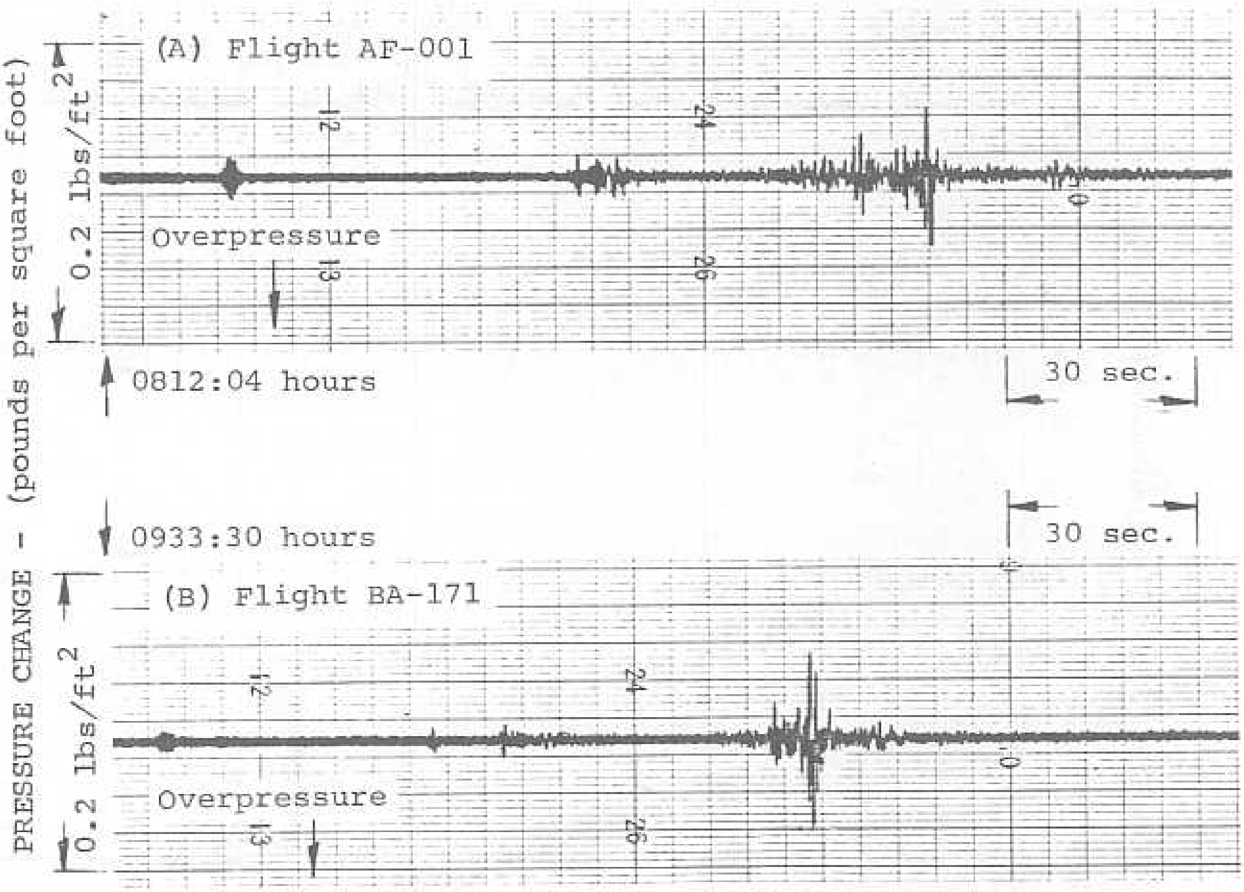


Figure 9 PRESSURE LEVEL TIME HISTORIES
Malden, MA. - July 23, 1979

A) Source: Air France Flight AF-001
B) Source: British Airways Flight BA-171

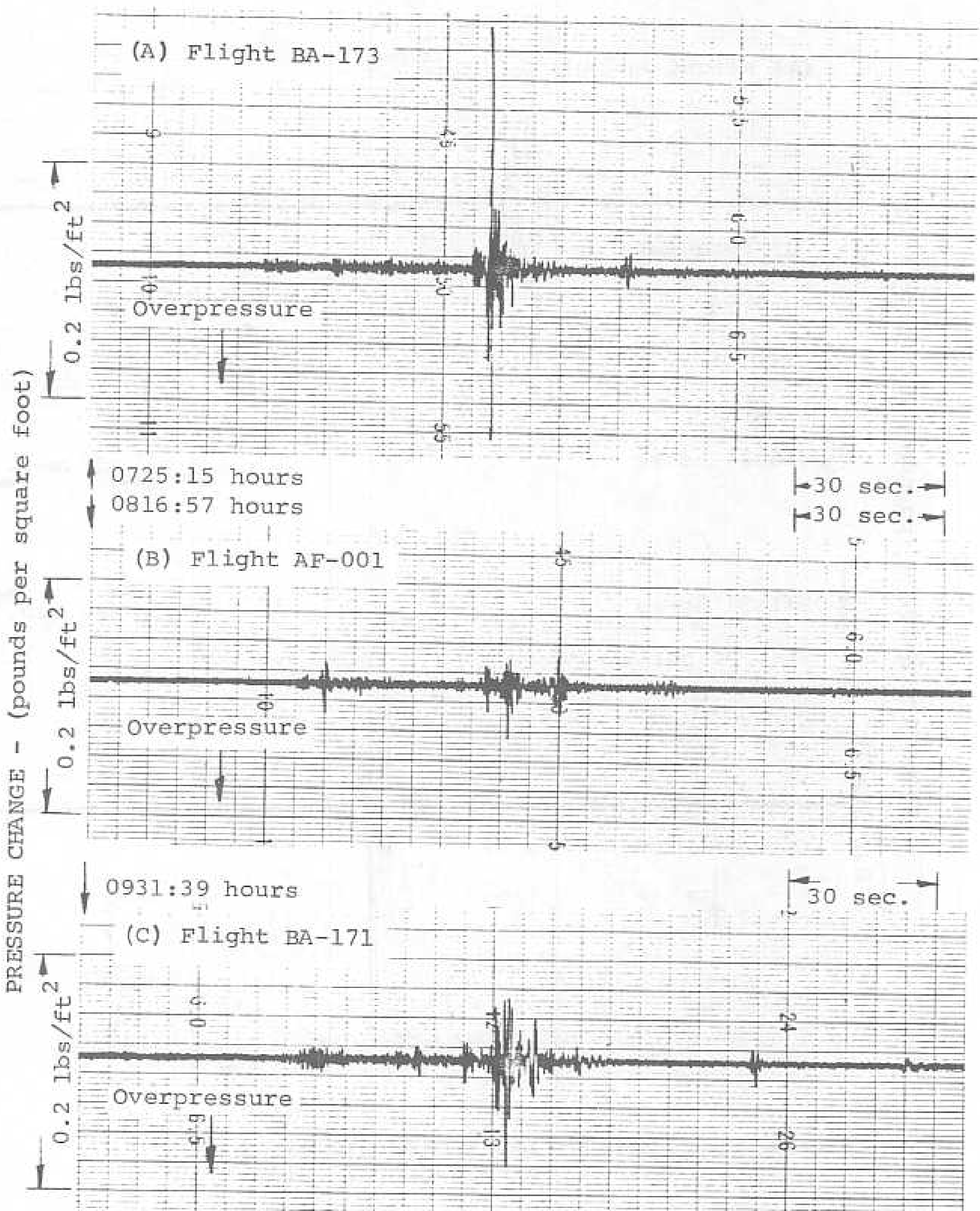


Figure 10 PRESSURE LEVEL TIME HISTORIES
Malden, MA. - July 26, 1979

A) Source: British Airways Flight BA-173
B) Source: Air France Flight AF-001
C) Source: British Airways Flight BA-171

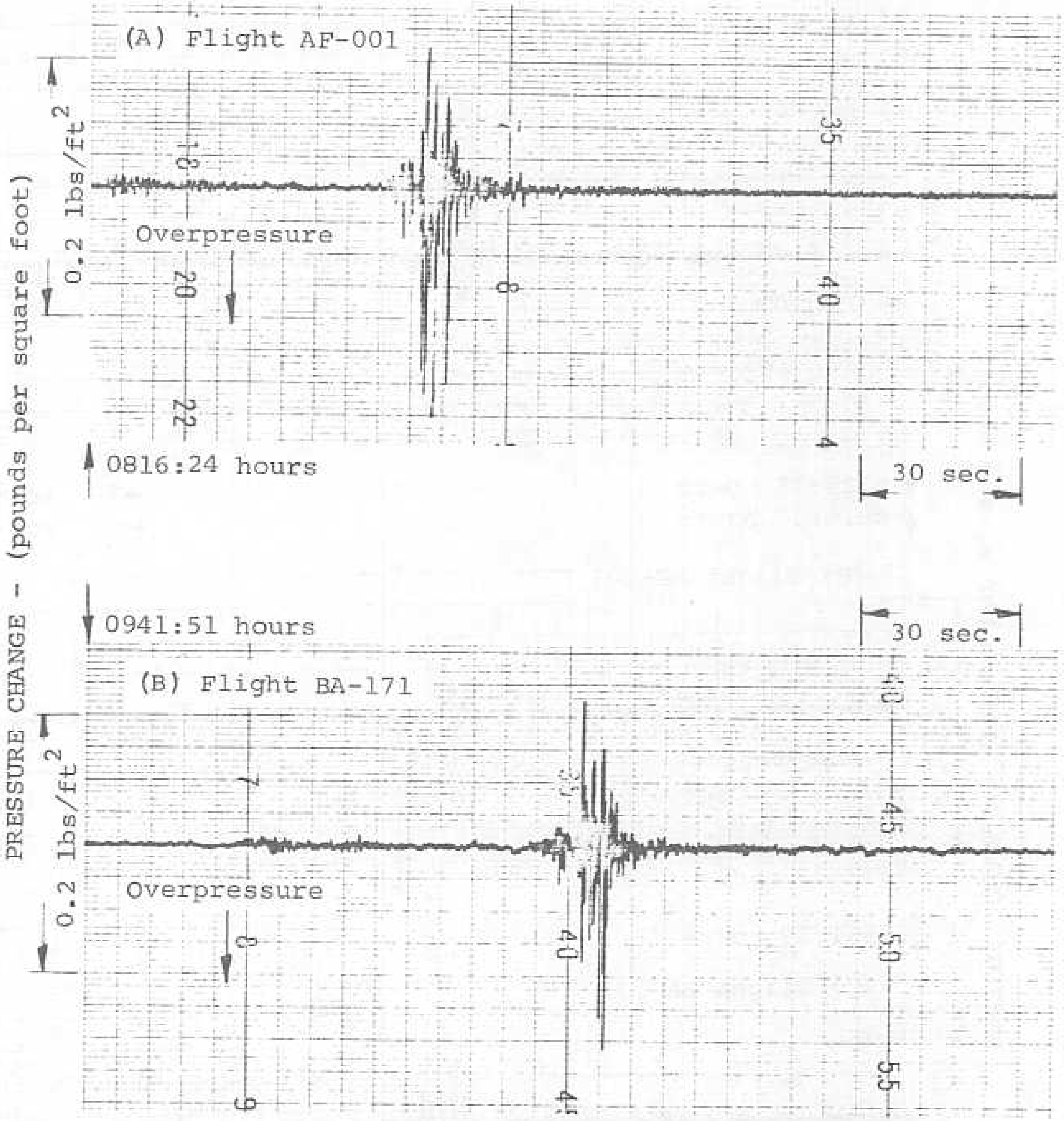


Figure 11 PRESSURE LEVEL TIME HISTORIES
Malden, MA. - August 15, 1979

A) Source: Air France Flight AF-001
B) Source: British Airways Flight BA-171

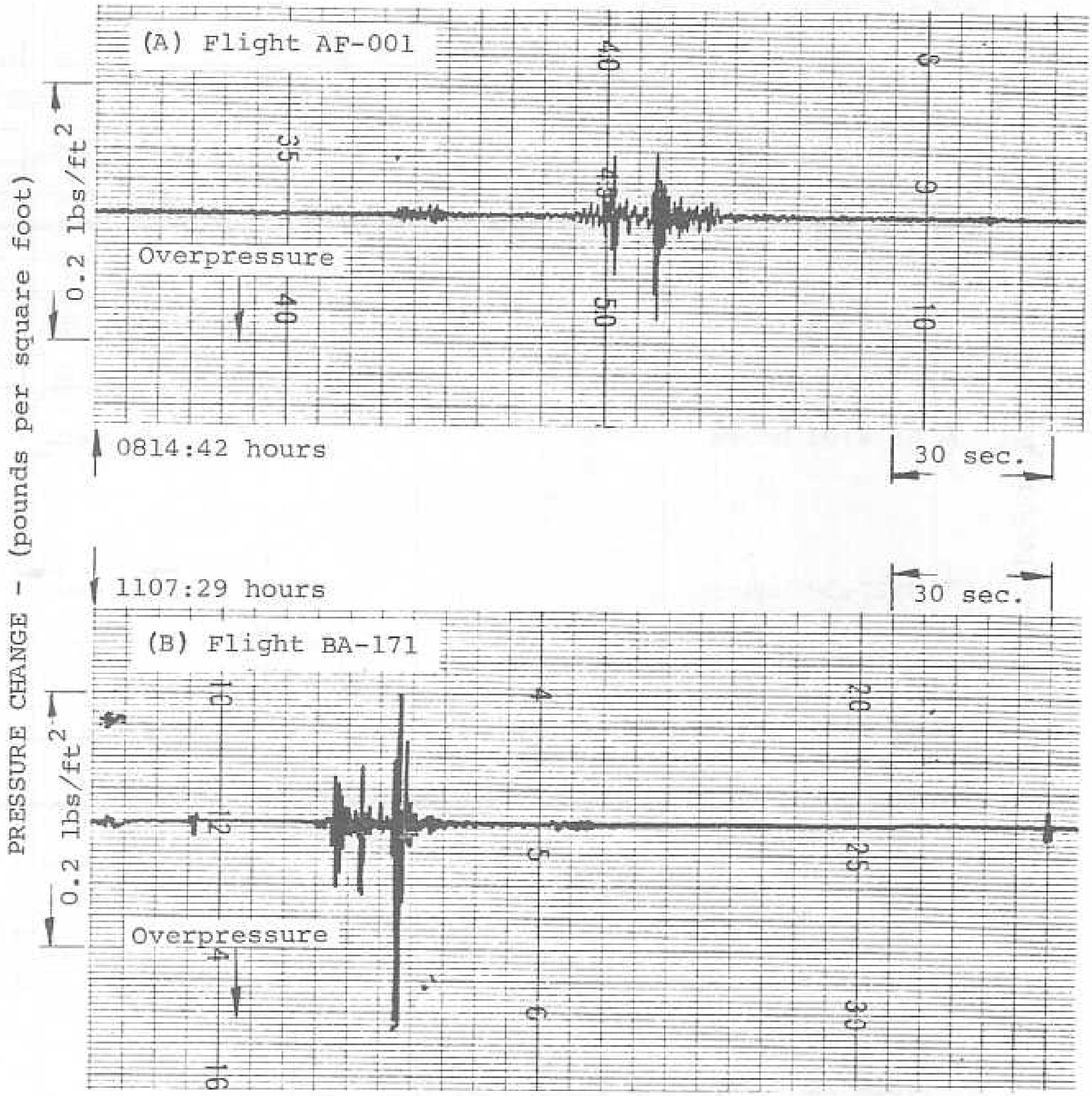


Figure 12 PRESSURE LEVEL TIME HISTORIES
Malden, MA. - August 21, 1979

A) Source: Air France Flight AF-001
B) Source: British Airways Flight BA-171

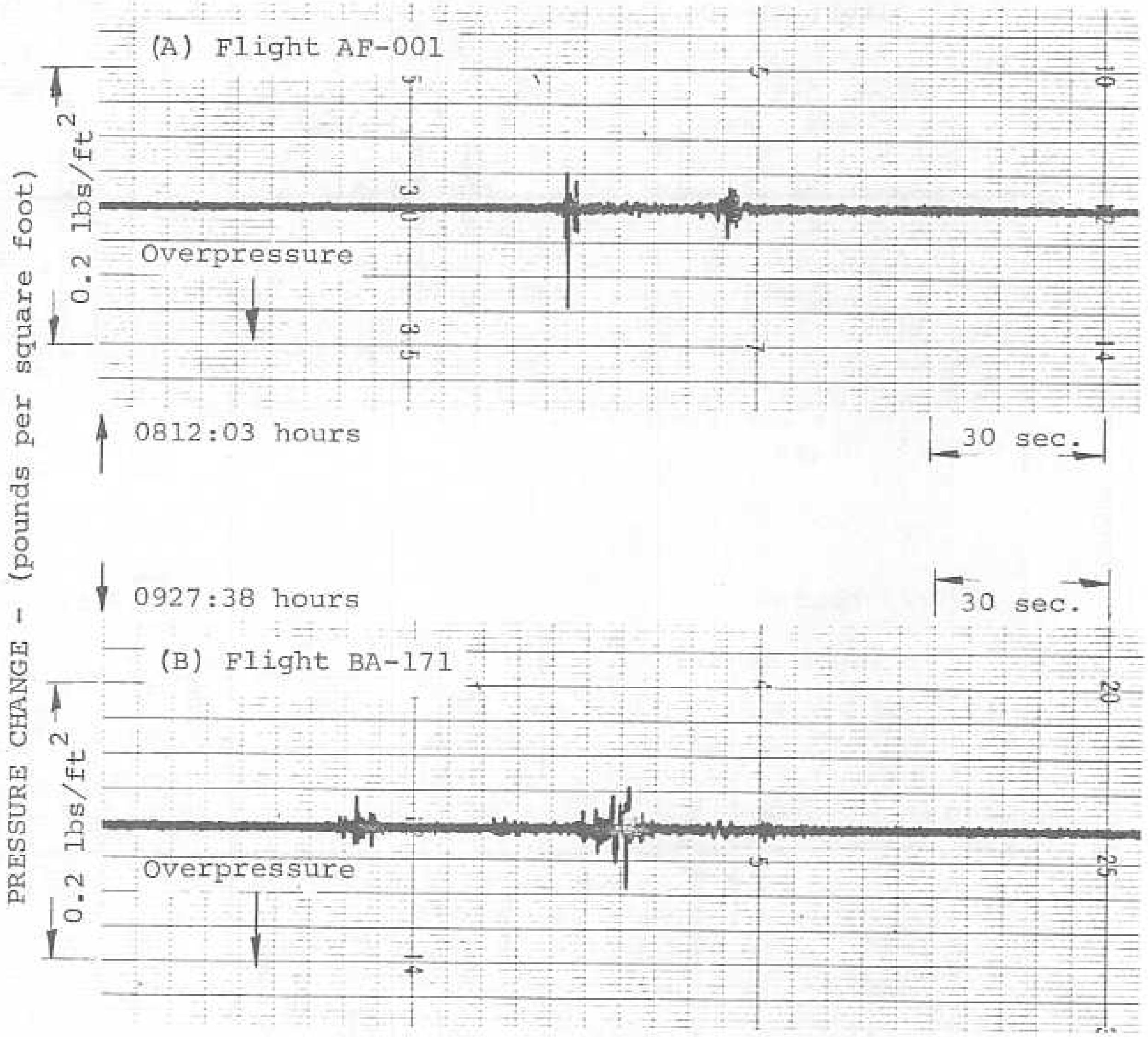


Figure 13 PRESSURE LEVEL TIME HISTORIES
Malden, MA. - September 5, 1979

A) Source: Air France Flight AF-001
B) Source: British Airways Flight BA-171

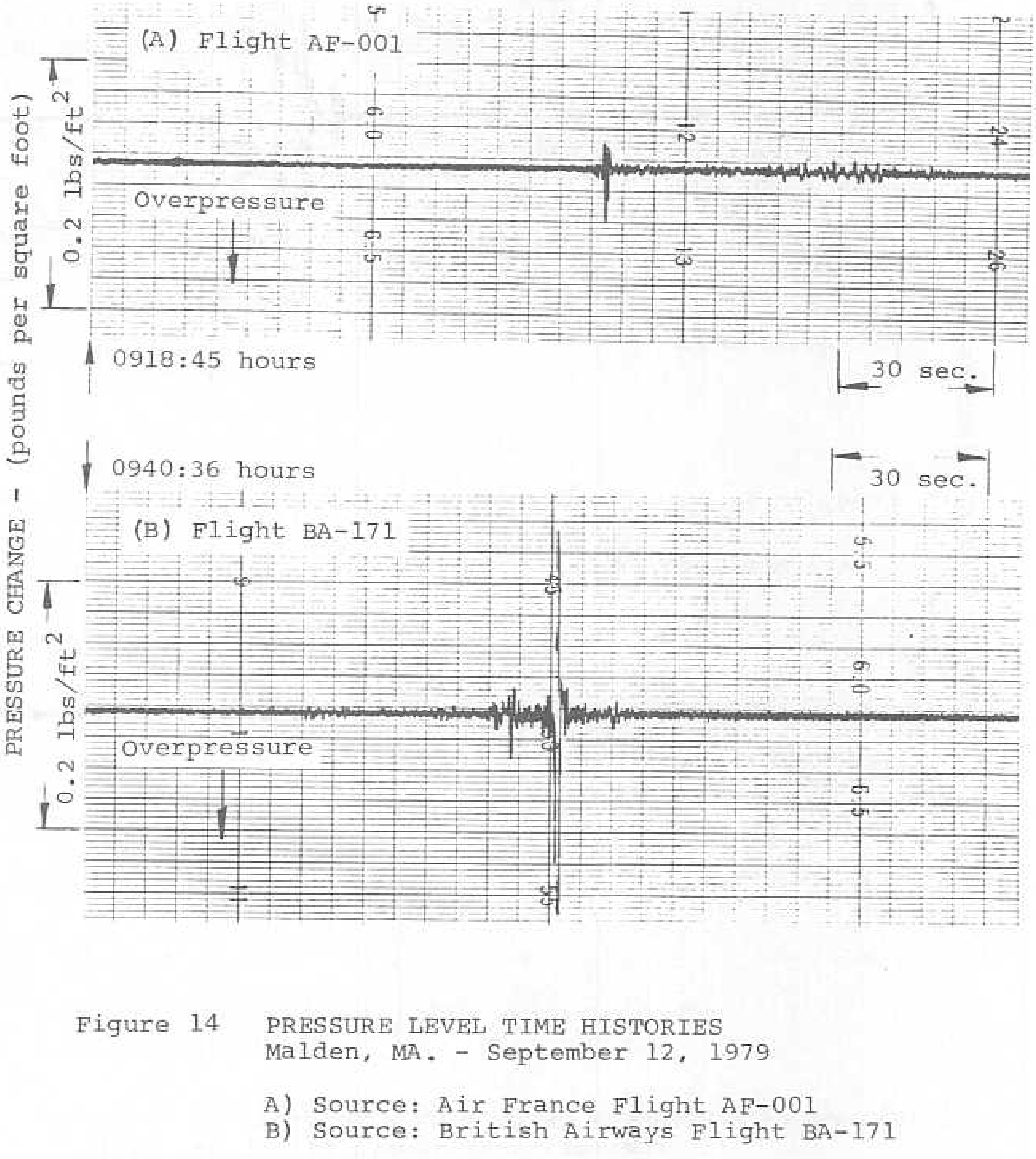


Figure 14 PRESSURE LEVEL TIME HISTORIES
Malden, MA. - September 12, 1979

A) Source: Air France Flight AF-001
B) Source: British Airways Flight BA-171

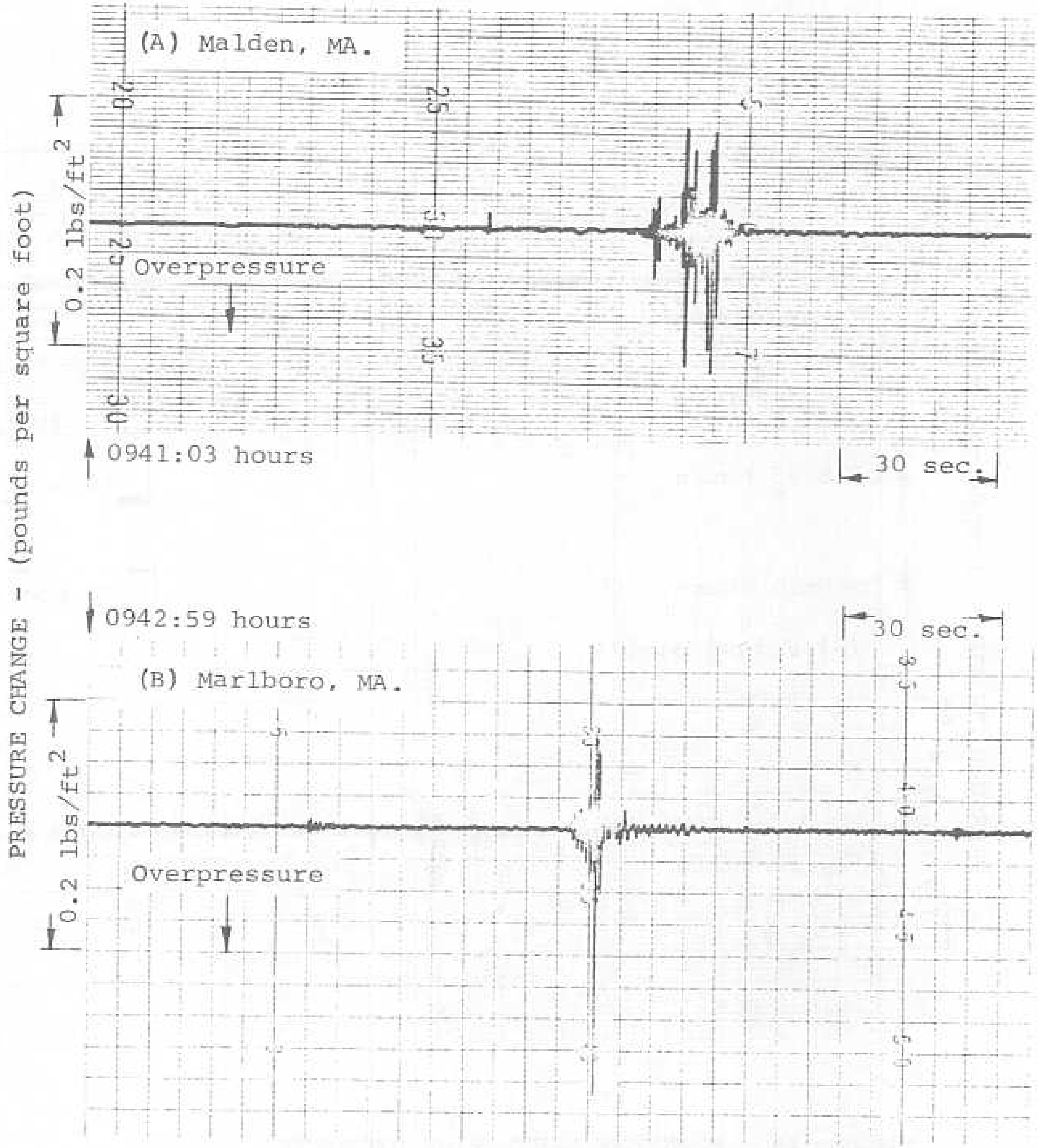


Figure 15 PRESSURE LEVEL TIME HISTORIES
Source: British Airways Flight No. BA-171
June 27, 1979

A) Malden, MA.
B) Marlboro, MA.

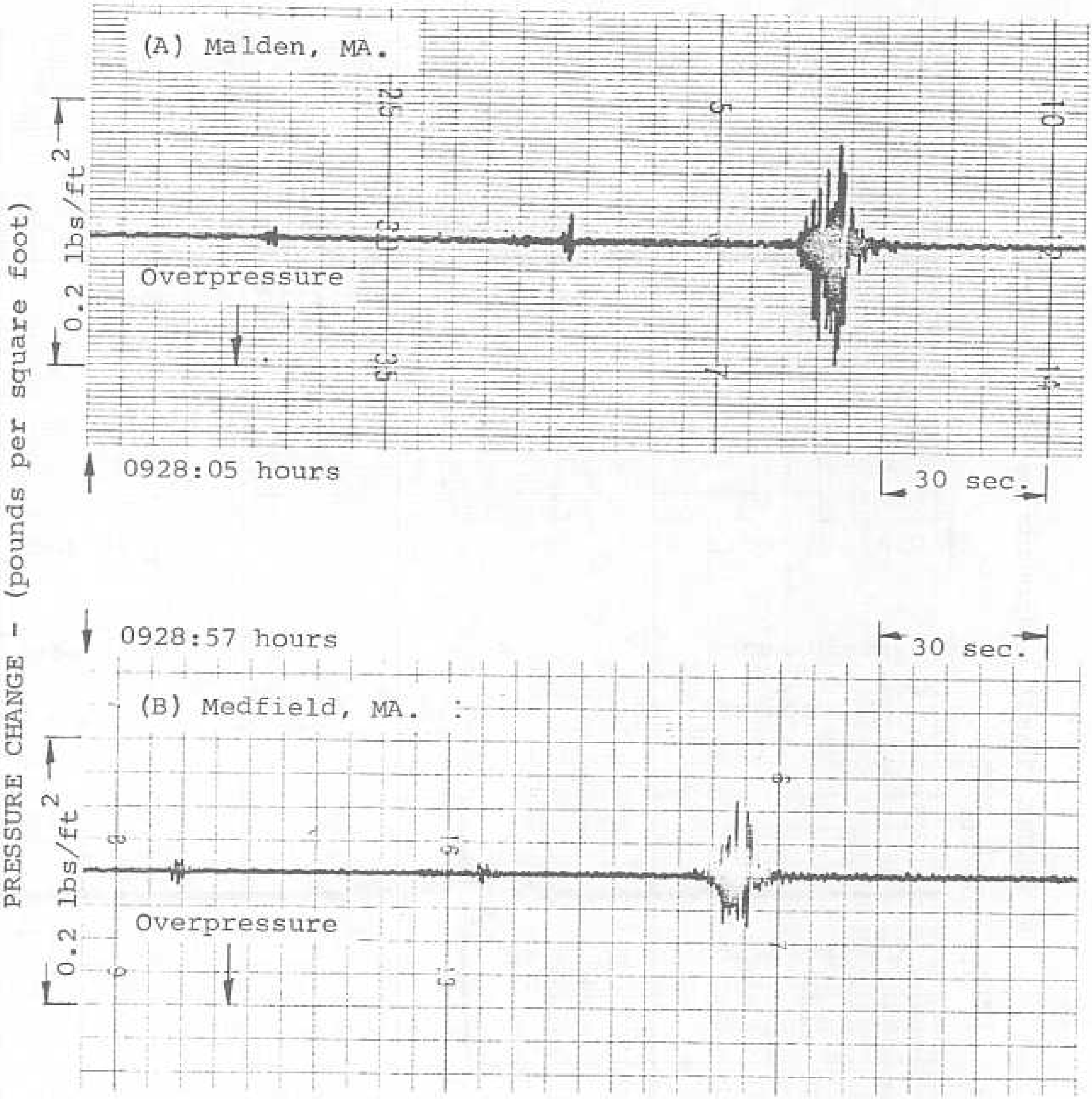


Figure 16 PRESSURE LEVEL TIME HISTORIES
Source: British Airways Flight No. BA-171
June 28, 1979

A) Malden, MA.
B) Medfield, MA.

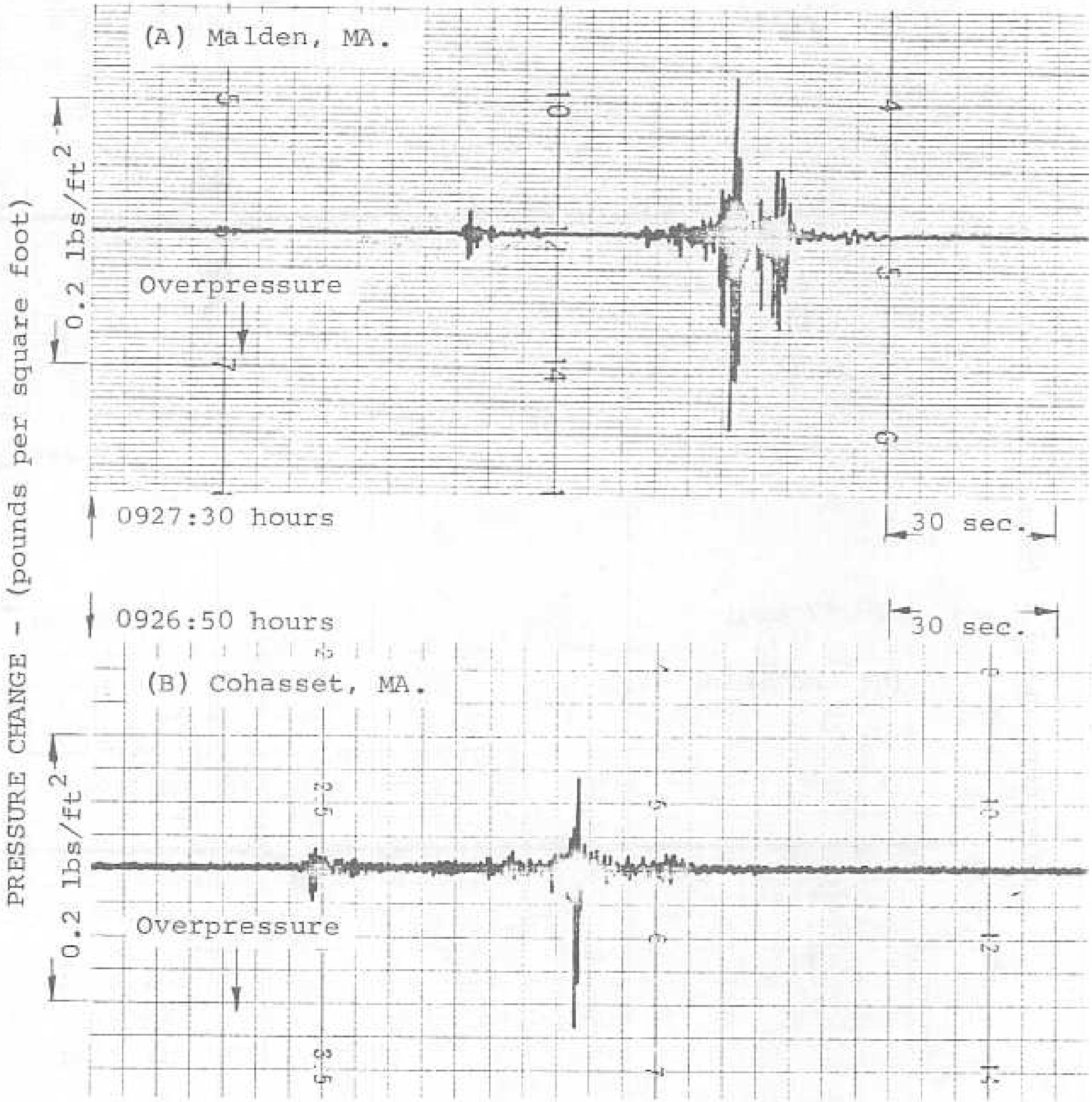


Figure 17 PRESSURE LEVEL TIME HISTORIES
Source: British Airways Flight No. BA-171
June 29, 1979

A) Malden, MA.
B) Cohasset, MA.

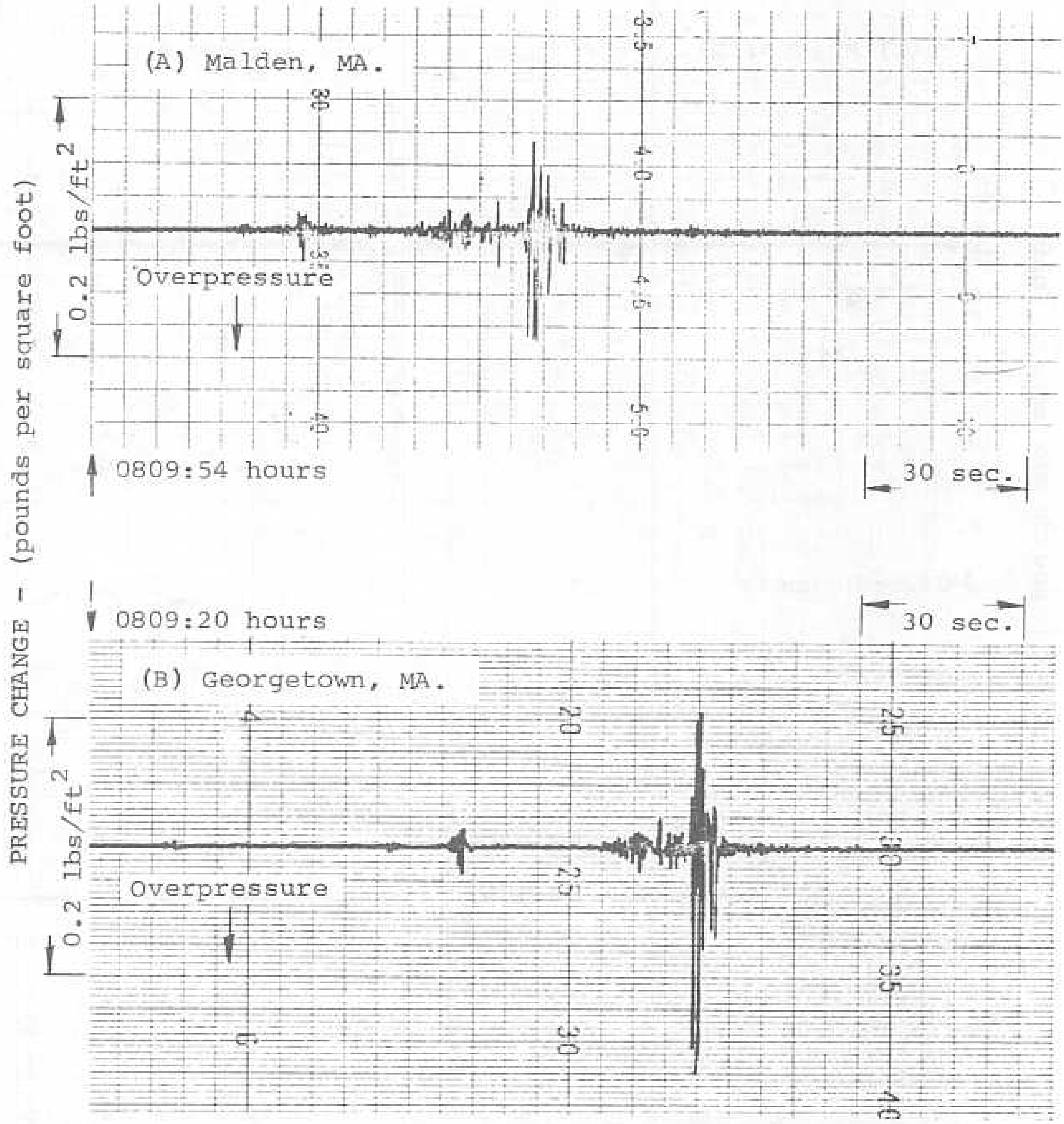


Figure 18 PRESSURE LEVEL TIME HISTORIES
Source: Air France Flight No. AF-001
July 9, 1979

A) Malden, MA.
B) Georgetown, MA.

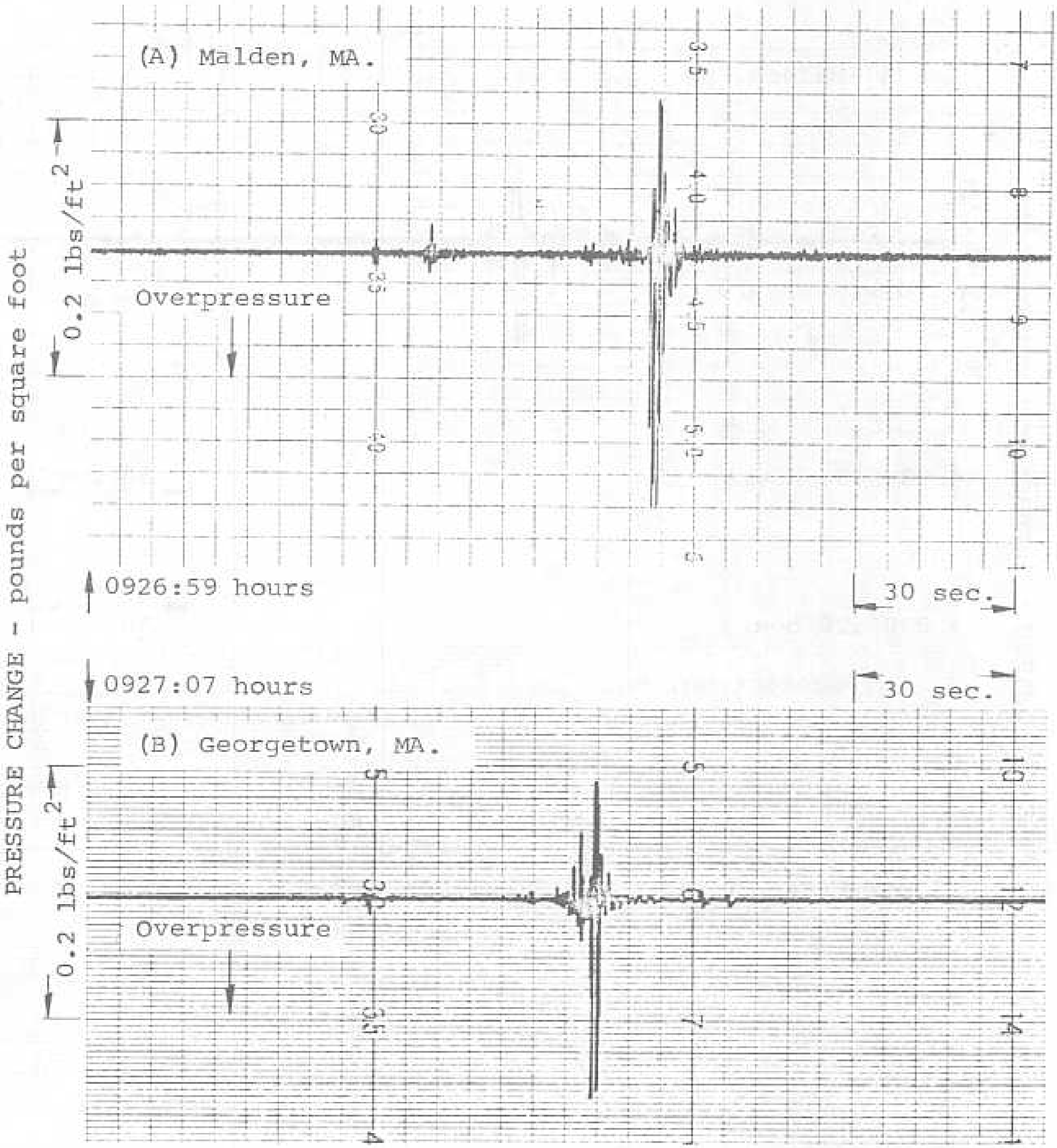


Figure 19 PRESSURE LEVEL TIME HISTORIES
Source: British Airways Flight No. BA-171
July 9, 1979

A) Malden, MA.
B) Georgetown, MA.

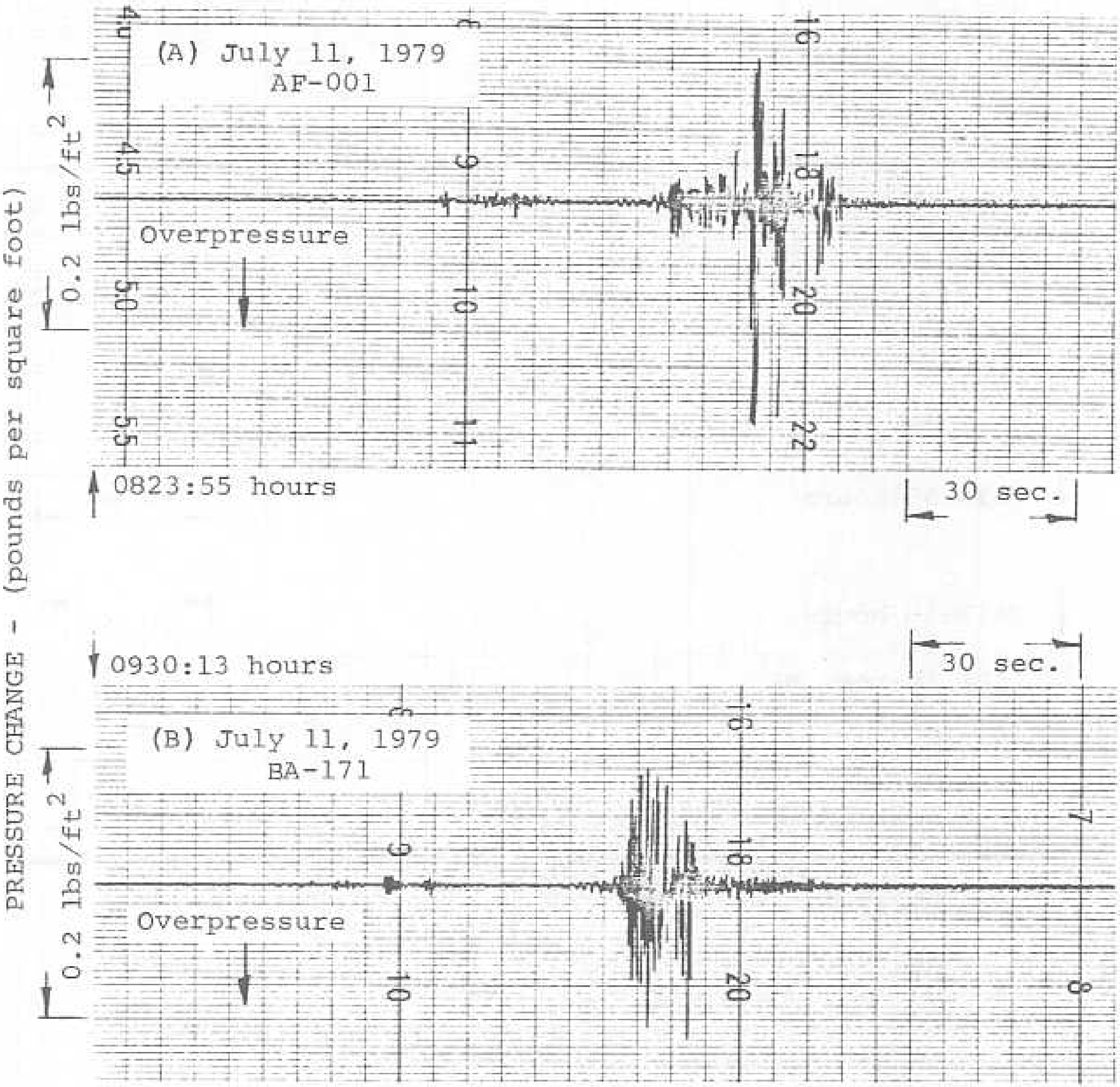


Figure 20 PRESSURE LEVEL TIME HISTORIES
Georgetown, MA.

A) Source: Air France Flight AF-001
July 11, 1979
B) Source: British Airways Flight BA-171
July 11, 1979

See figure 7 for July 11, 1979 data at Malden, MA.

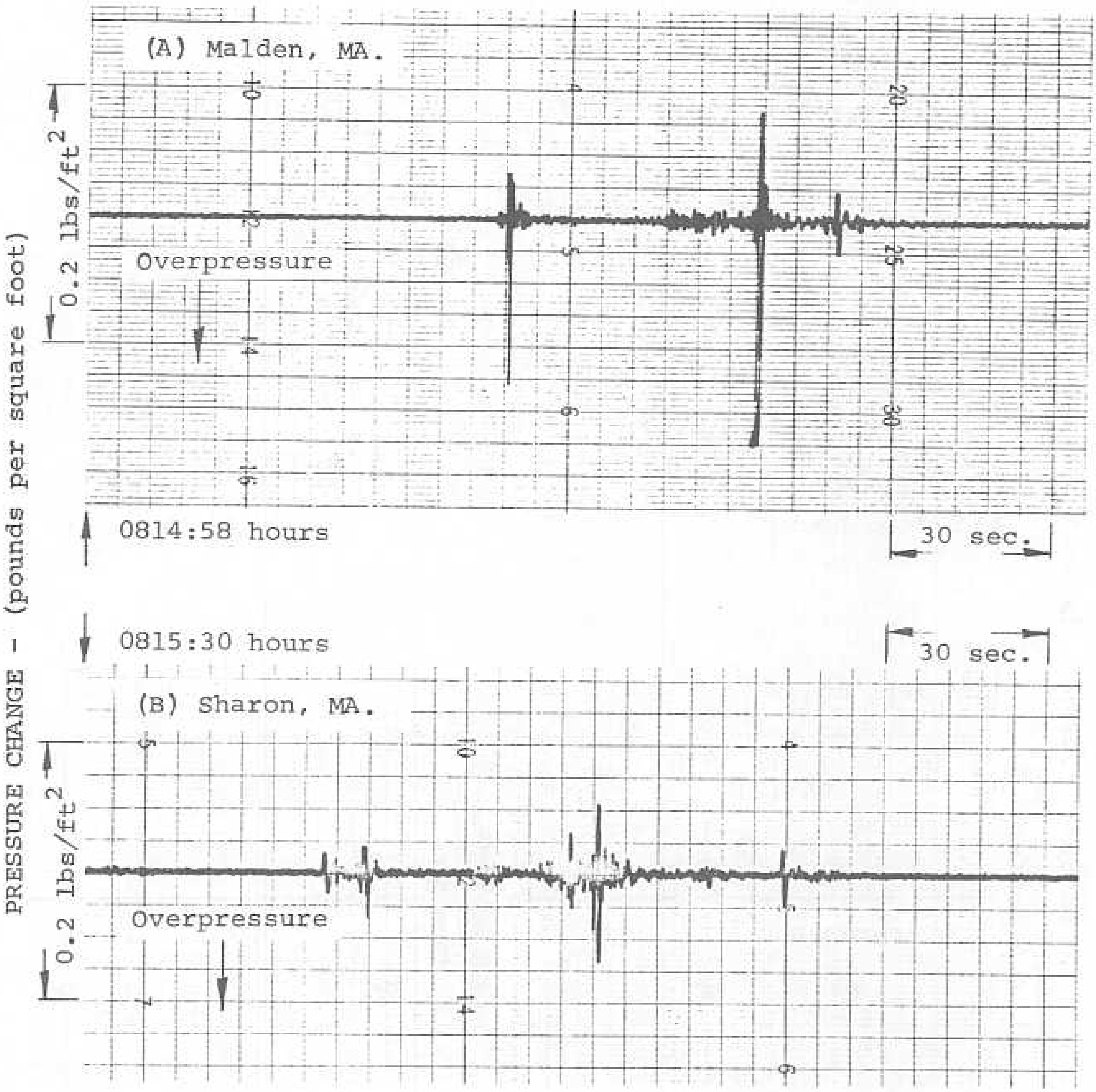


Figure 21 PRESSURE LEVEL TIME HISTORIES
Source: Air France Flight No. AF-001
August 2, 1979

A) Malden, MA.
B) Sharon, MA.

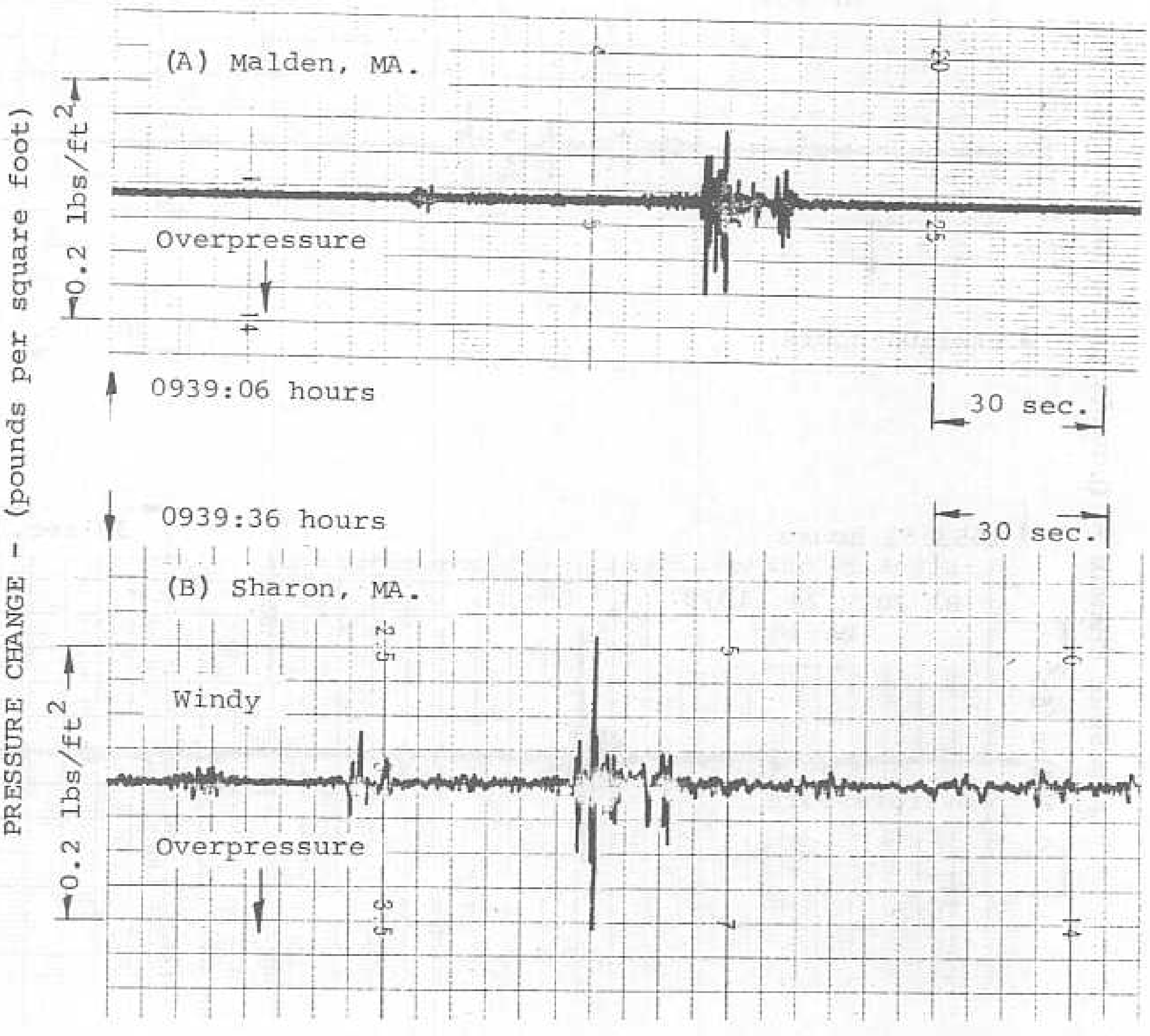


Figure 22 PRESSURE LEVEL TIME HISTORIES
Source: British Airways Flight No. BA-171
August 2, 1979

A) Malden, MA.
B) Sharon, MA.

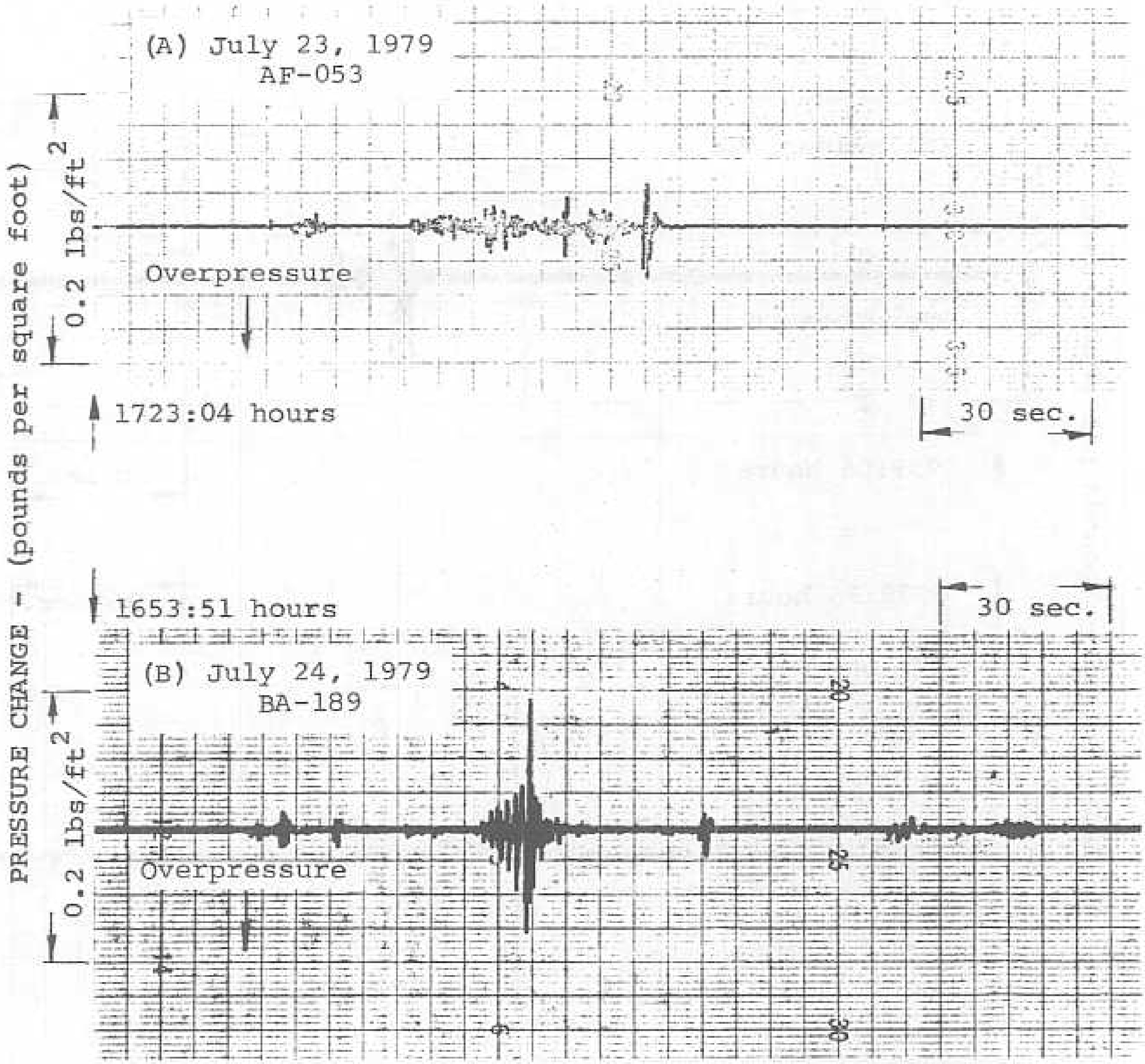


Figure 23 PRESSURE LEVEL TIME HISTORIES
Applebachsville, PA.

A) Source: Air France Flight AF-053
July 23, 1979
B) Source: British Airways Flight BA-189
July 24, 1979

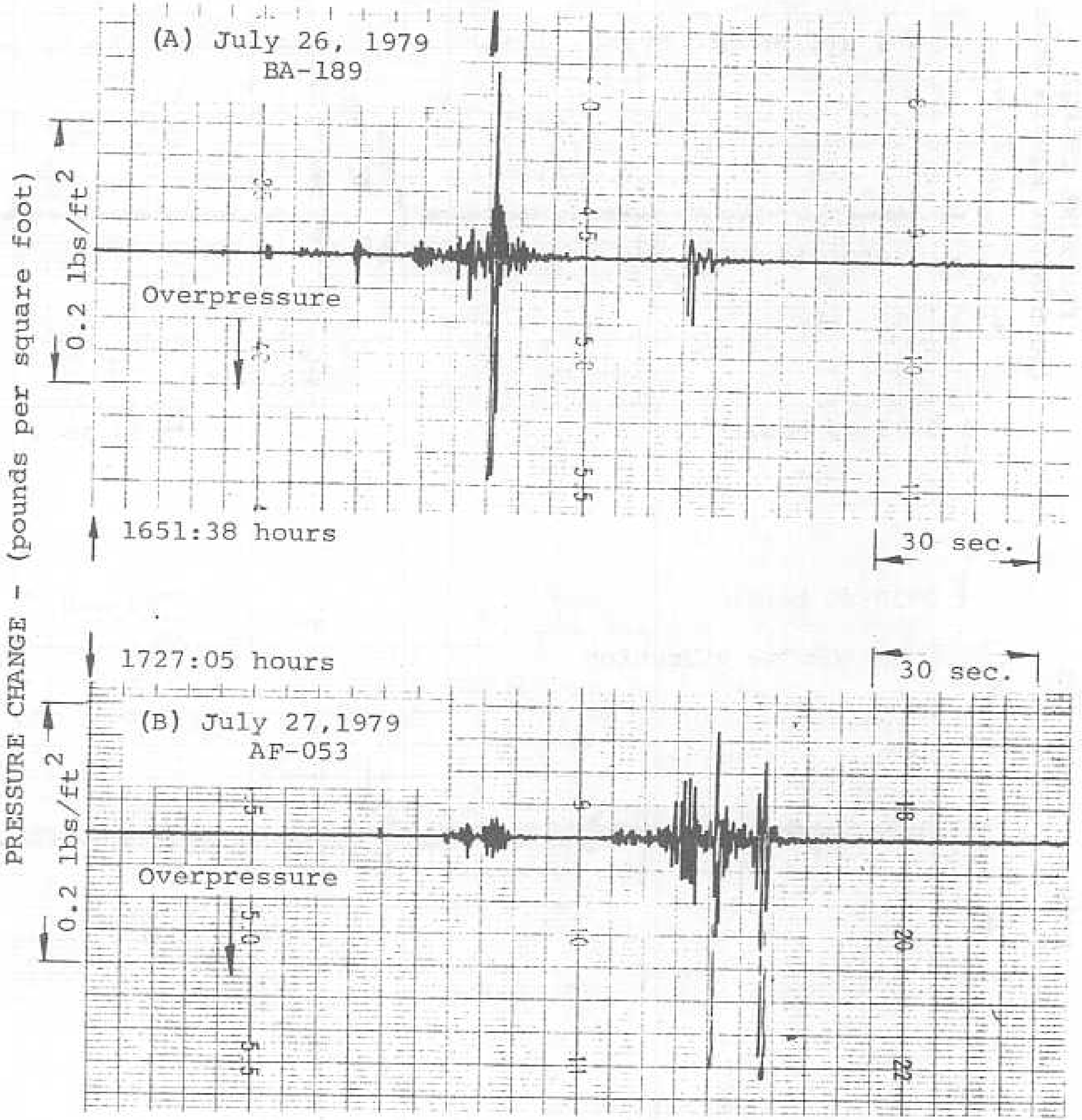


Figure 24 PRESSURE LEVEL TIME HISTORIES
Applebachsville, PA.

A) Source: British Airways Flight BA-189
July 26, 1979
B) Source: Air France Flight AF-053
July 27, 1979

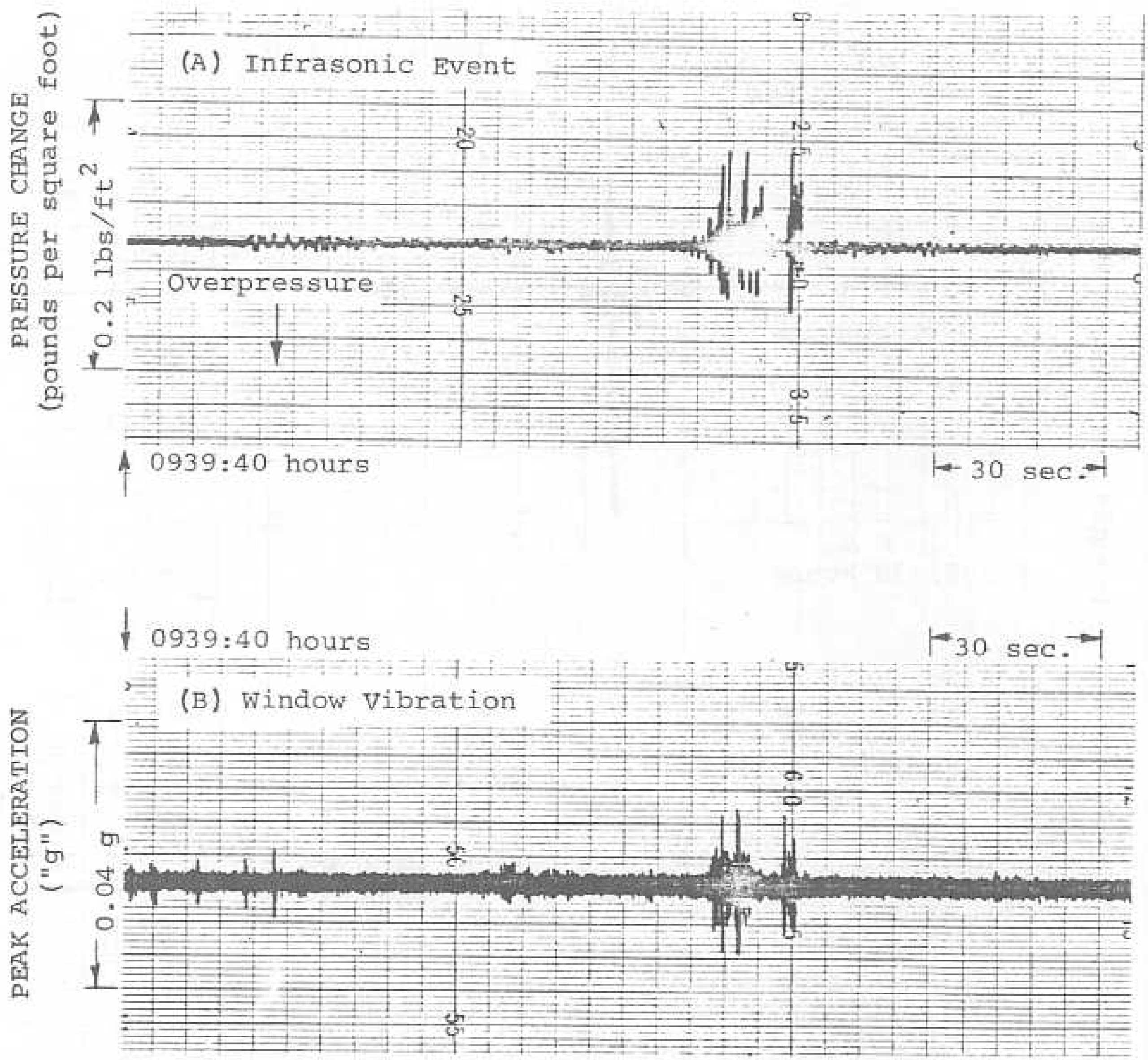


Figure 25 TIME HISTORIES
Wilmington, MA. - June 20, 1979
Source: British Airways Flight No. BA-171

A) Infrasonic Exterior Pressure Change
B) Window Vibrational Acceleration

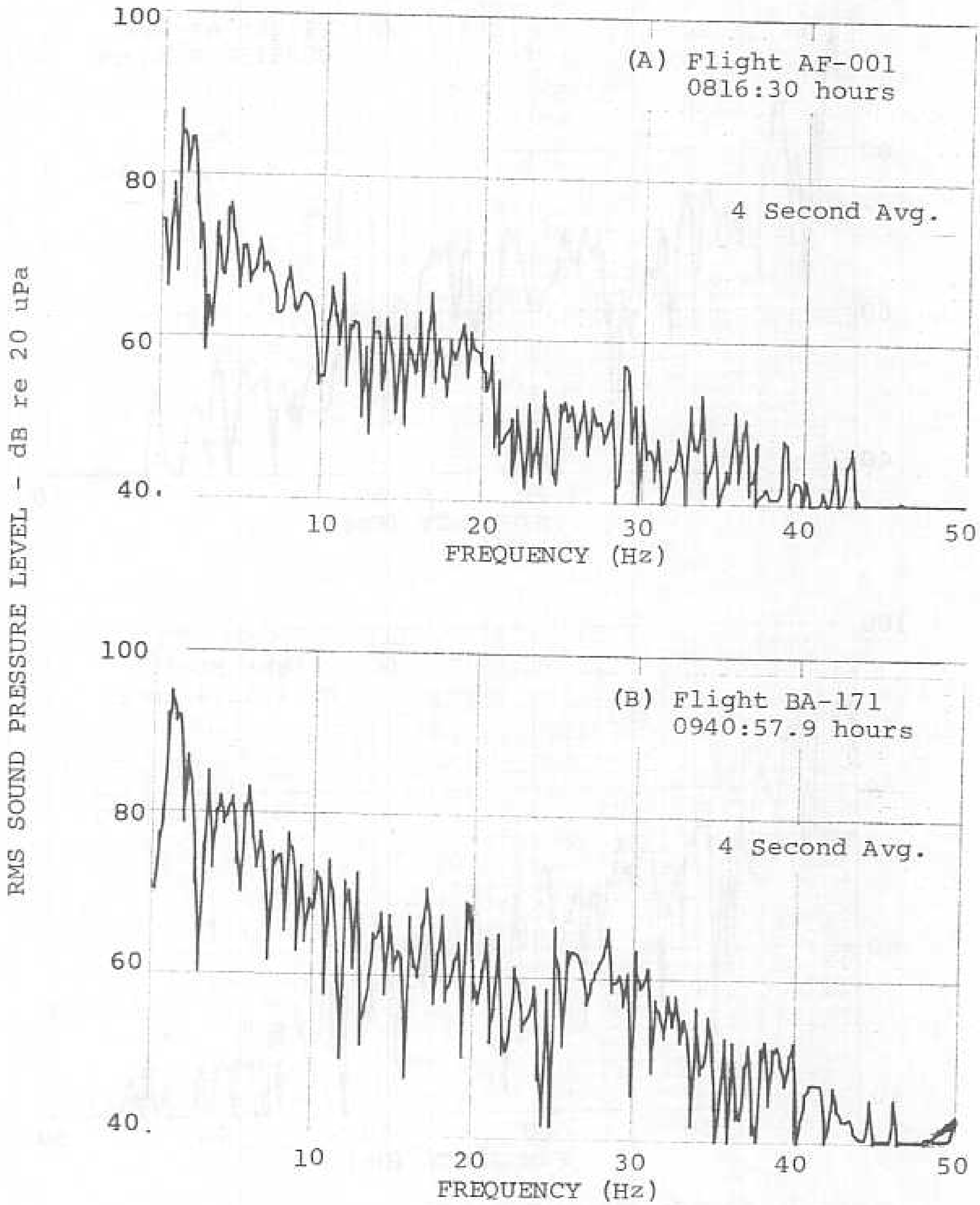


Figure 26 FREQUENCY SPECTRA

Acoustic Event, Malden, MA.
June 20, 1979

A) Source: Air France Flight AF-001
B) Source: British Airways Flight BA-171

See figure 6 for Pressure Level Time Histories

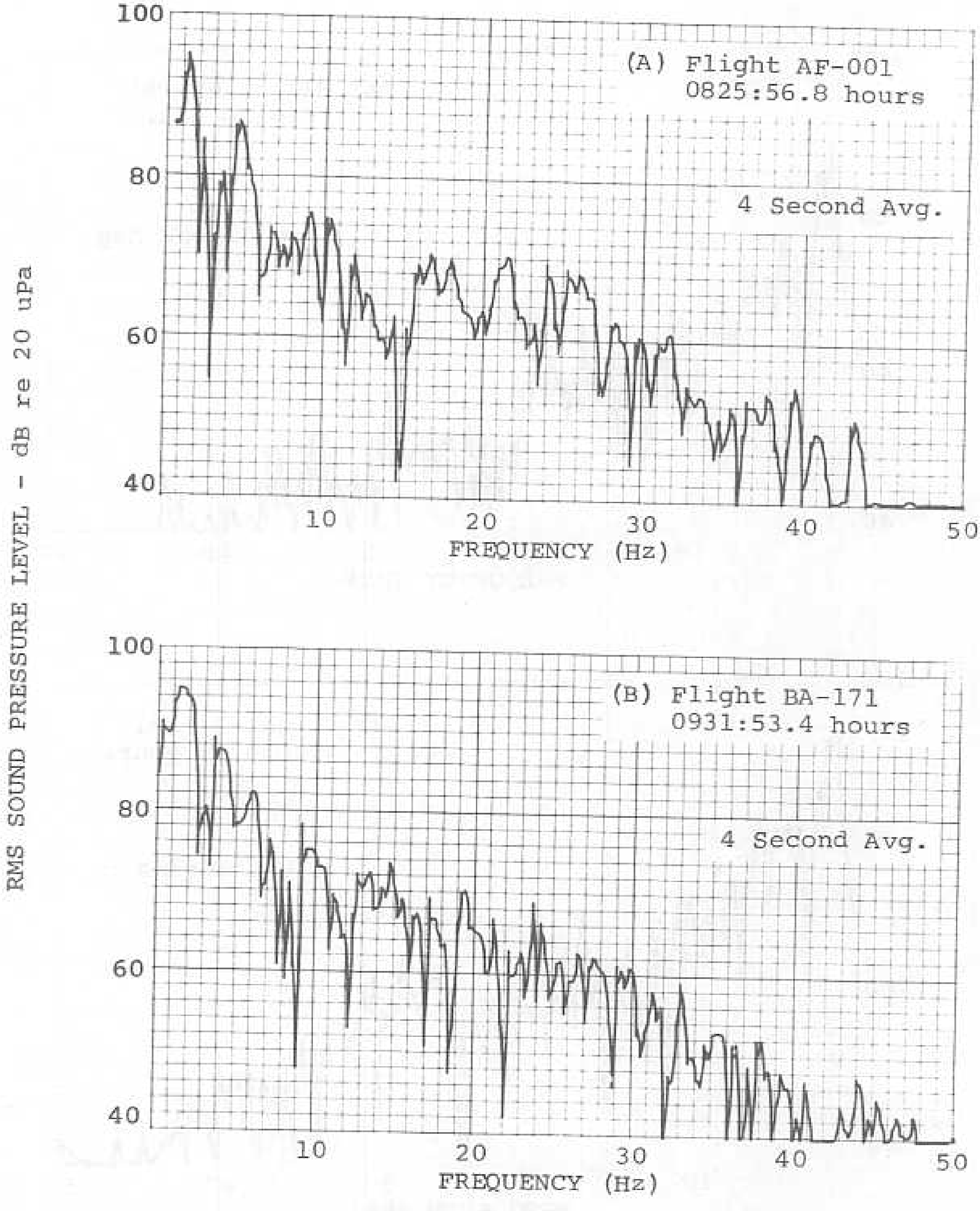


Figure 27 FREQUENCY SPECTRA

Acoustic Event, Malden, MA.
July 11, 1979

A) Source: Air France Flight AF-001
B) Source: British Airways Flight BA-171

See figure 7 for Pressure Level Time Histories

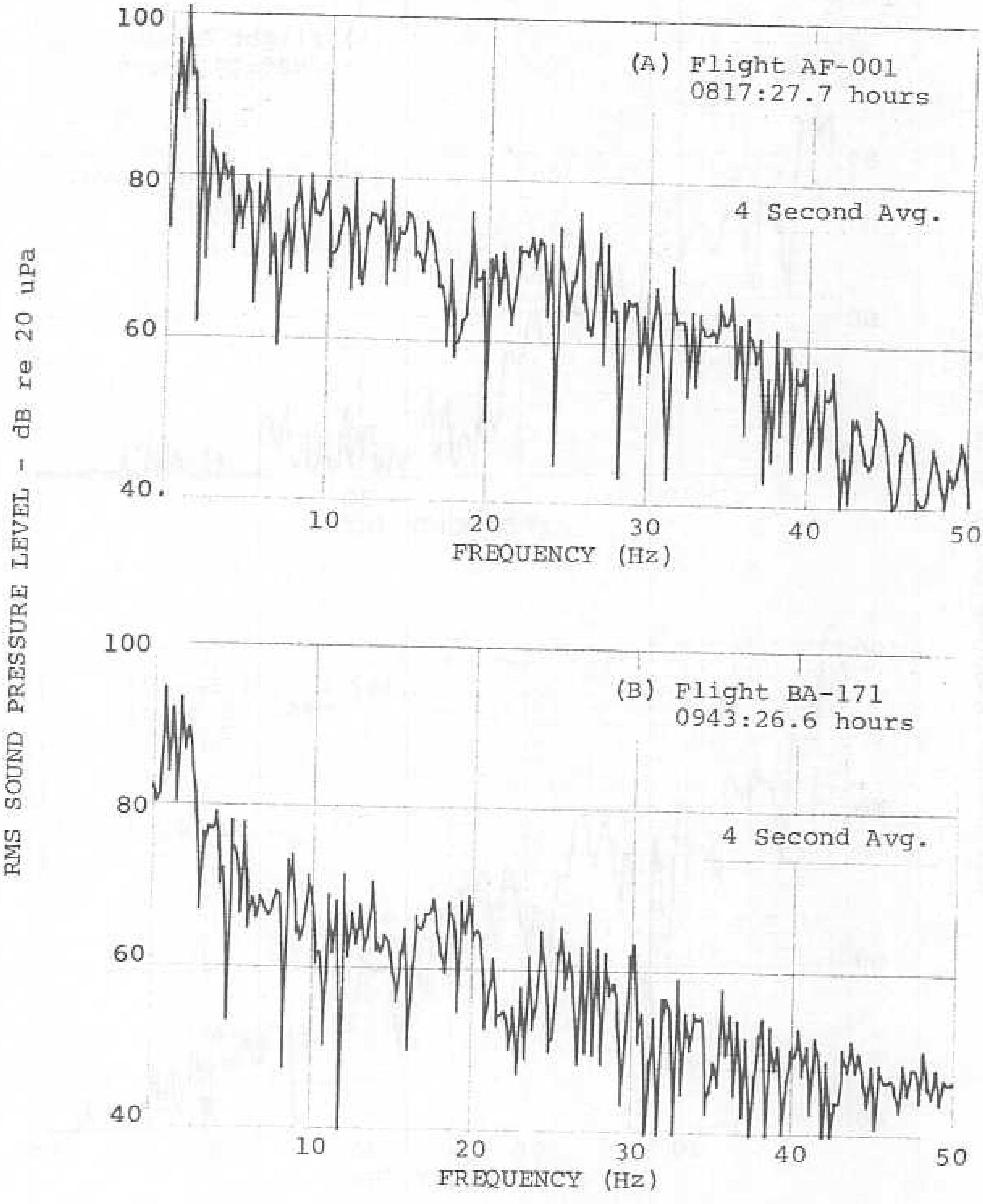


Figure 28 FREQUENCY SPECTRA

Acoustic Event, Malden, MA.
August 15, 1979

A) Source: Air France Flight AF-001
B) Source: British Airways BA-171

See figure 11 for Pressure Level Time Histories

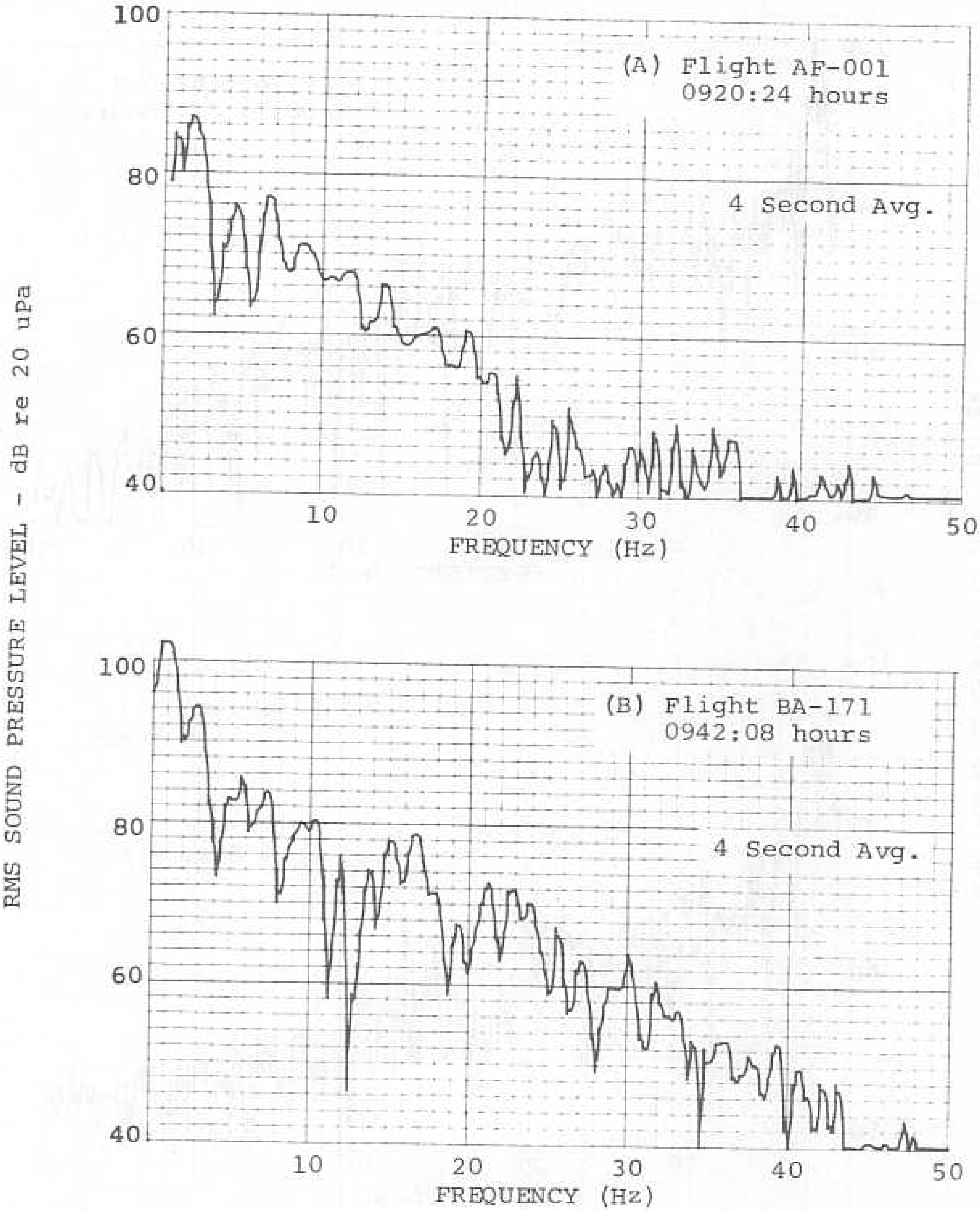


Figure 29 FREQUENCY SPECTRA

Acoustic Event, Malden, MA.
September 12, 1979

A) Source: Air France Flight AF-001
B) Source: British Airways Flight BA-171

See figure 14 for Pressure Level Time Histories

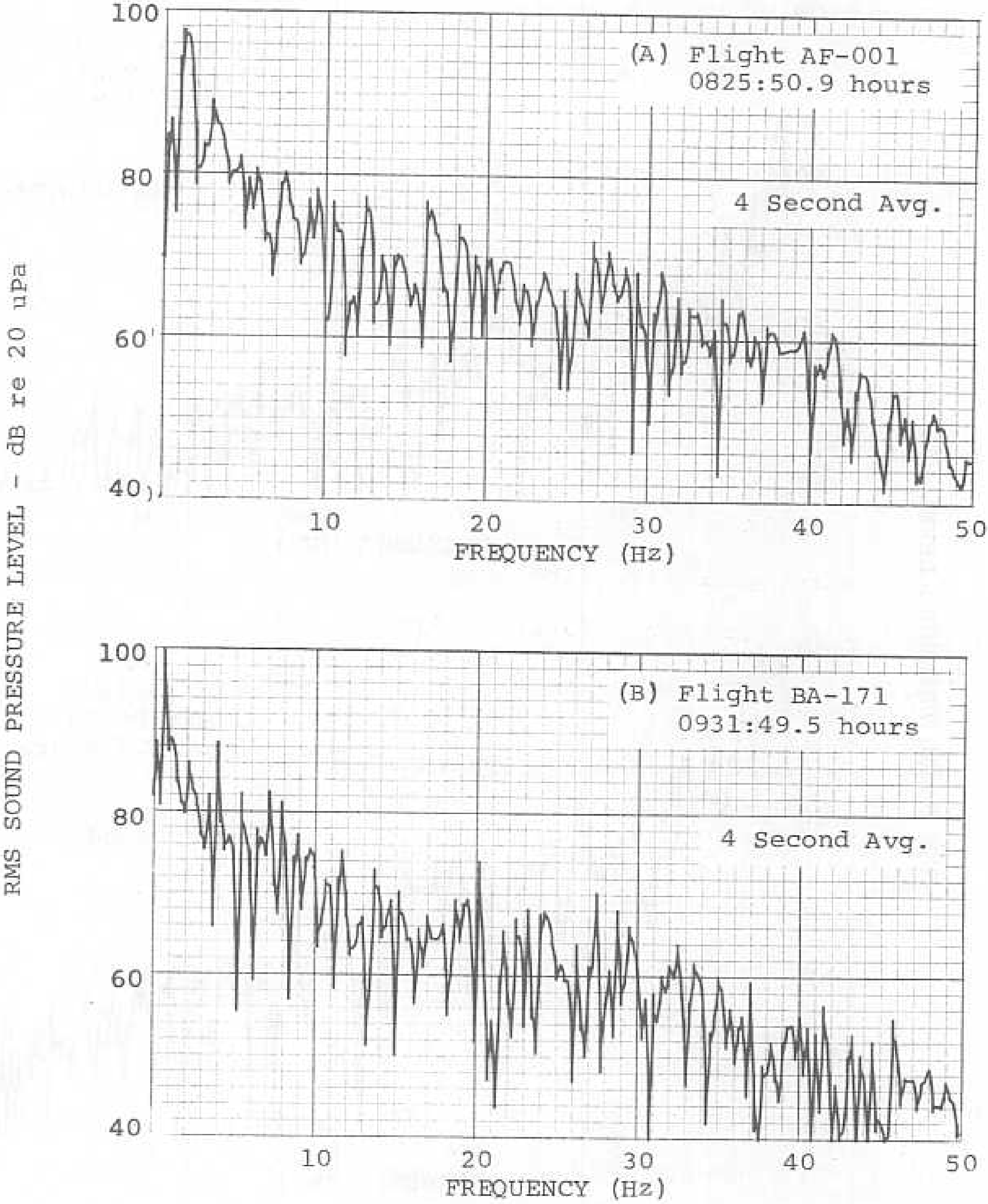


Figure 30 FREQUENCY SPECTRA

Acoustic Event, Georgetown, MA.
July 11, 1979

A) Source: Air France Flight AF-001
B) Source: British Airways Flight BA-171

See figure 21 for Pressure Level Time Histories

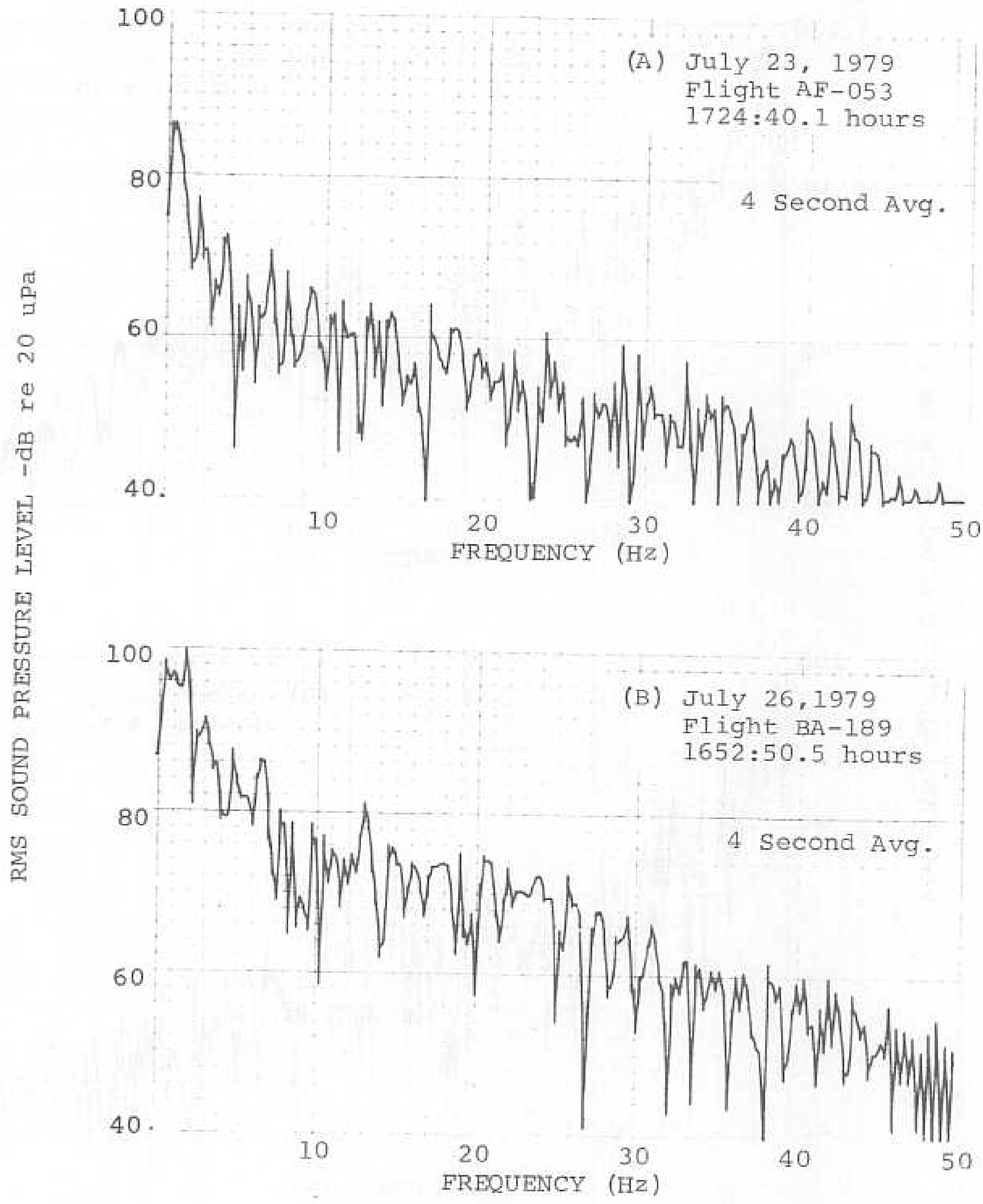


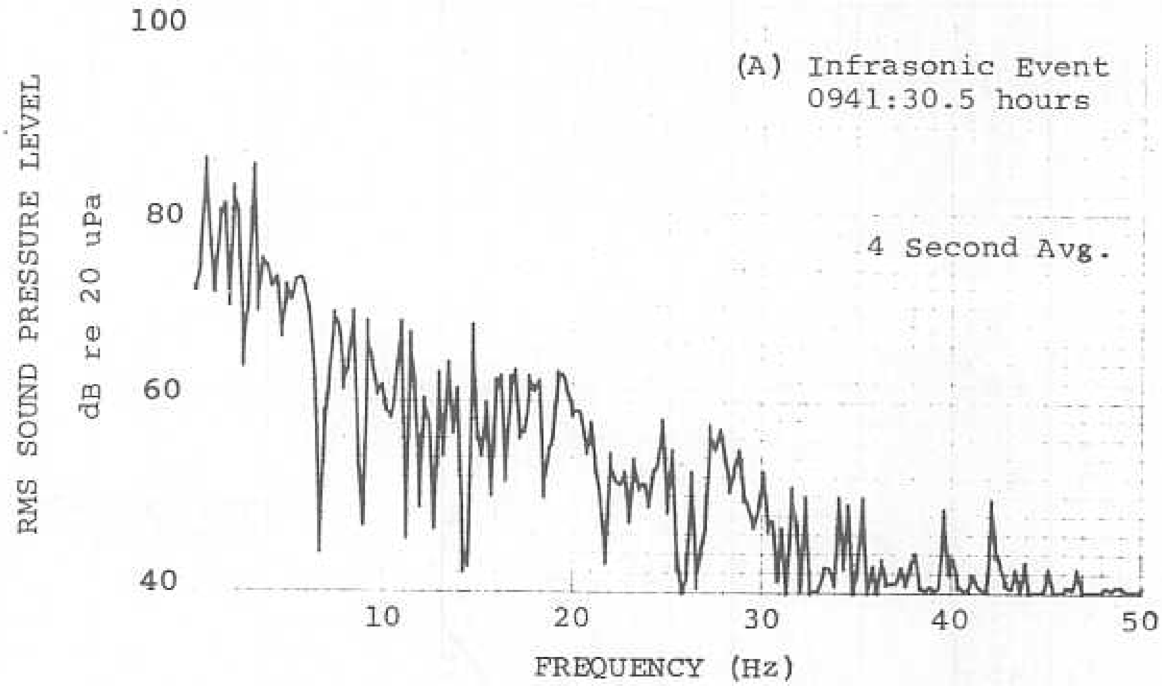
Figure 31 FREQUENCY SPECTRA

Acoustic Event, Applebachsville, PA.

A) Source: Air France Flight AF-053
July 23, 1979

B) Source: British Airways Flight BA-189
July 26, 1979

See figures 23 & 24 for Pressure Level Time Histories



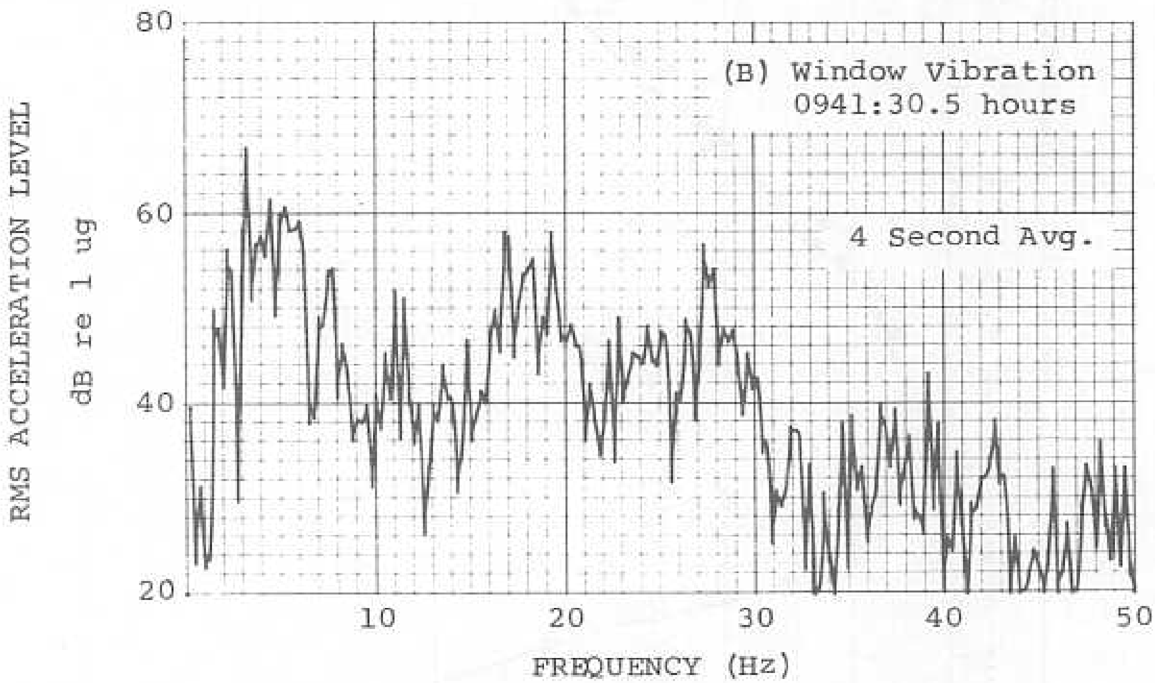


Figure 32 FREQUENCY SPECTRA

Acoustic Event, Wilmington, MA.
Source: British Airways Flight BA-171
June 20, 1979

A) Infrasonic Exterior Pressure Change
B) Window Vibrational Acceleration

See figure 25 for Level Time Histories

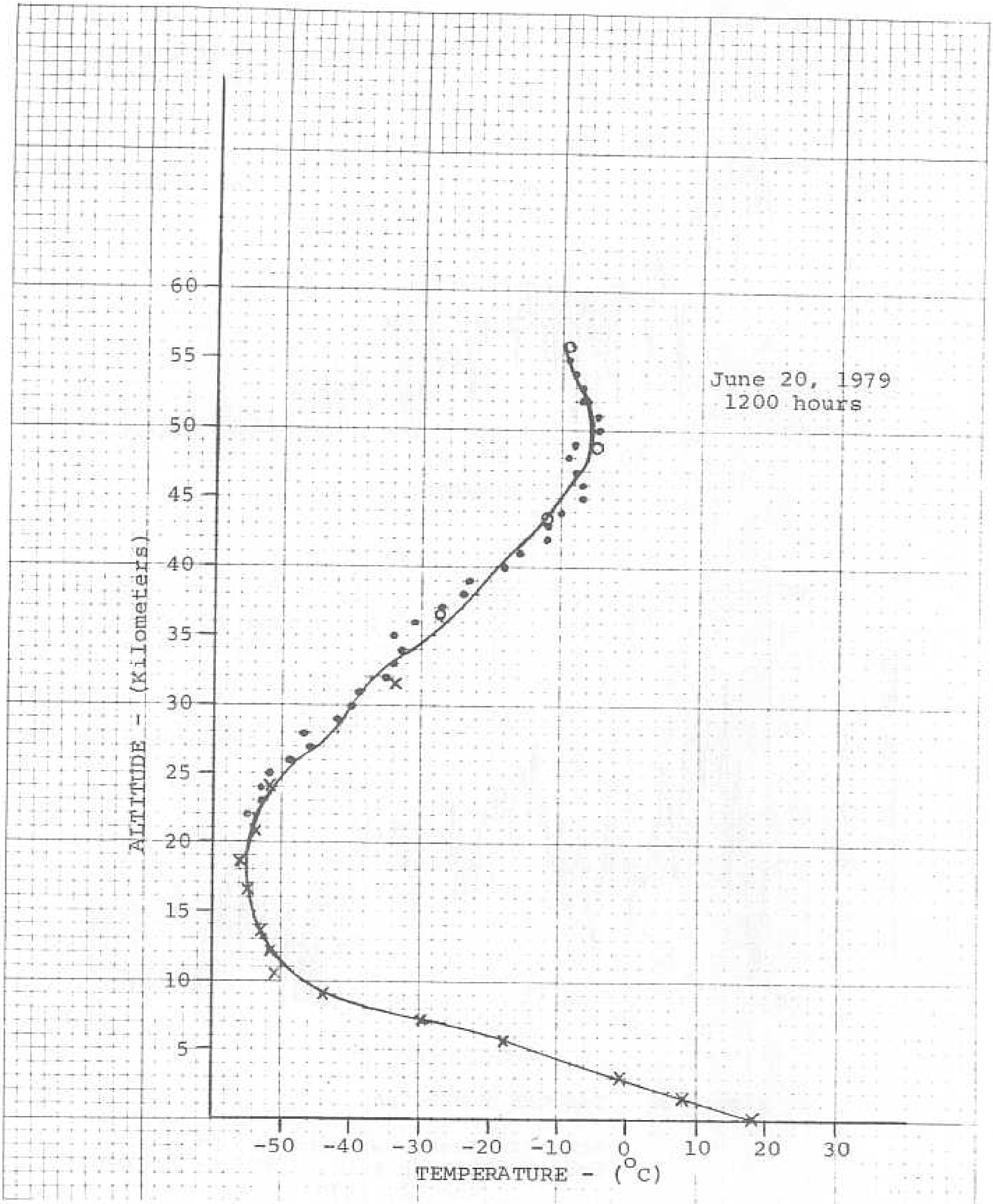


Figure 33 TEMPERATURE PROFILE
June 20, 1979

(•) Rocketsonde Data-Wallops Island, VA.
(x) Rawinsonde(Balloon borne) Data-Boston, MA.
(o) Satellite Radiance Data-Boston, MA.

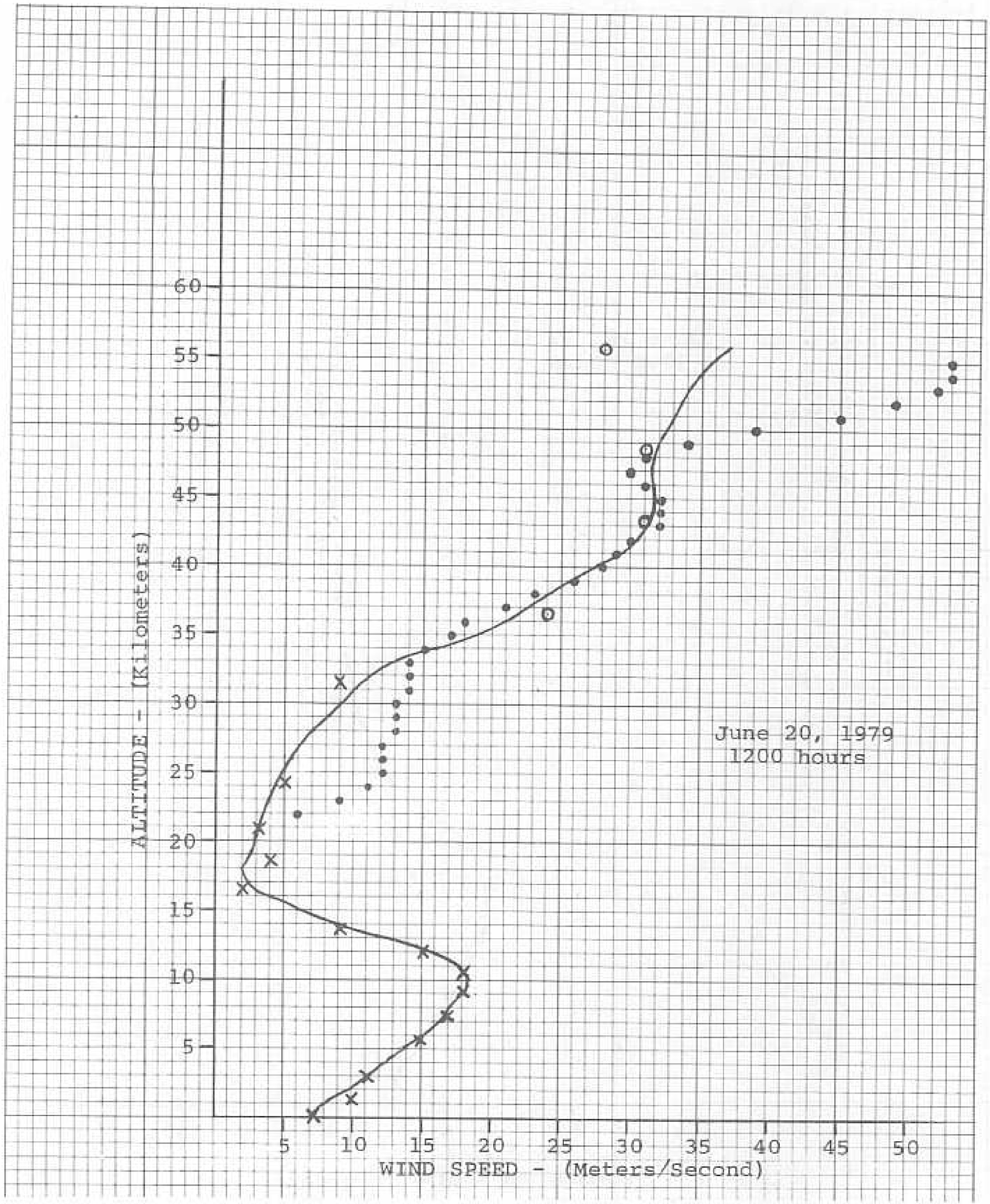


Figure 34 WIND SPEED PROFILE
June 20, 1979

(•) Rocketsonde Data-Wallops Island, VA.
(x) Rawinsonde(Balloon borne)Data-Boston, MA.
(o) Satellite Radiance Data-Boston, MA.

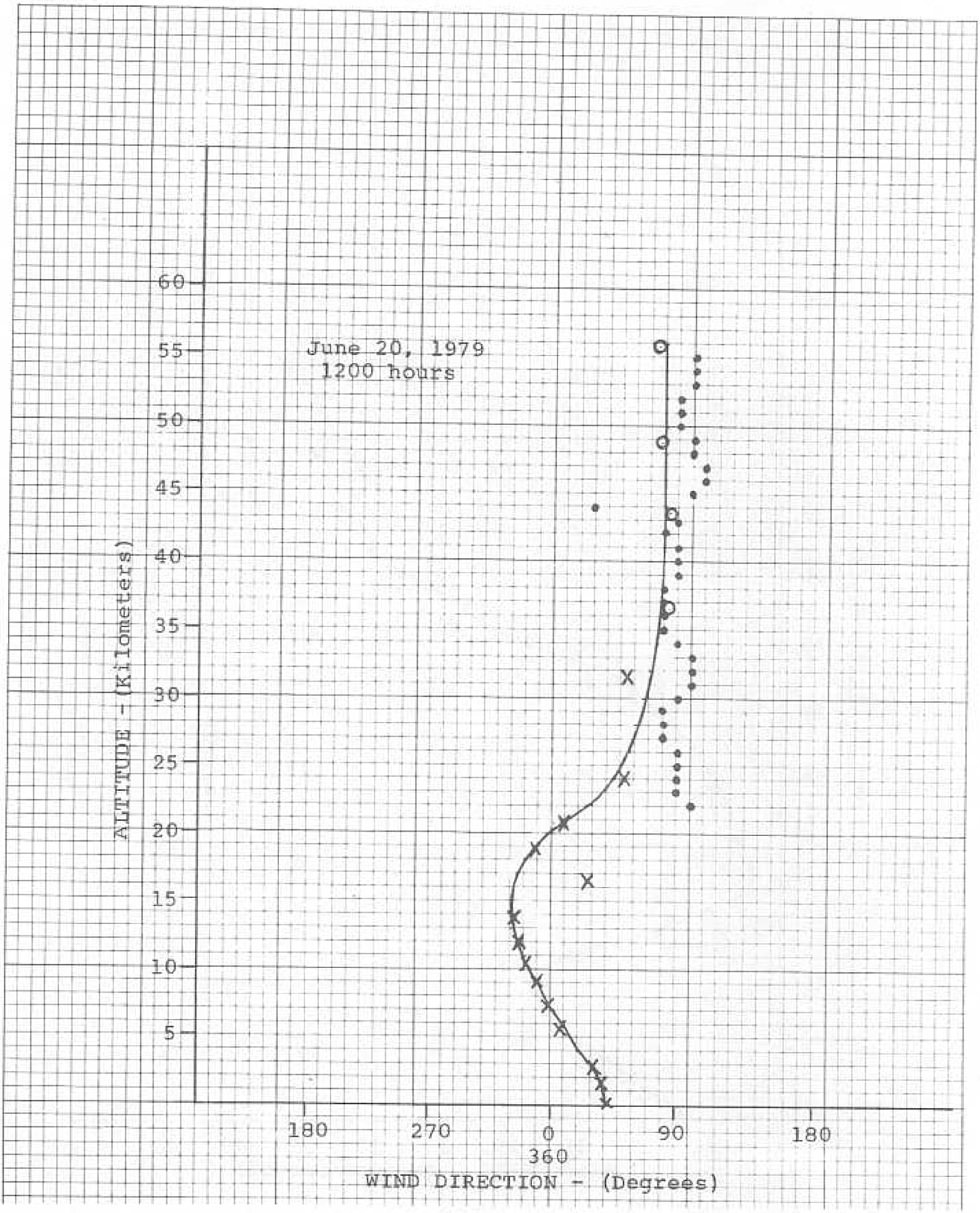


Figure 35 WIND DIRECTION PROFILE
June 20, 1979

(•) Rocketsonde Data-Wallops Island, VA.
(x) Rawinsonde(Balloon borne)Data-Boston, MA.
(o) Satellite Radiance Data-Boston, MA.

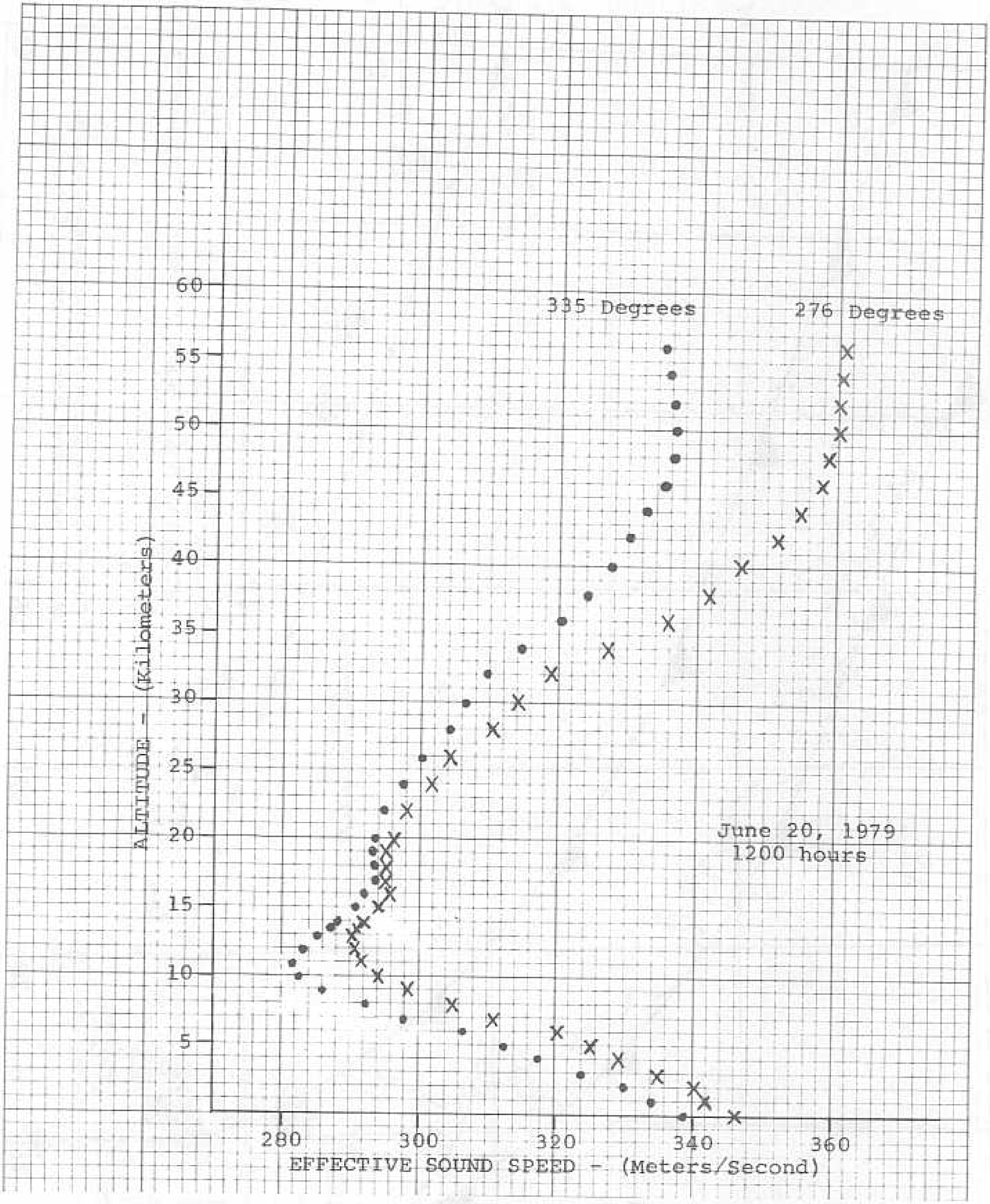


Figure 36 EFFECTIVE SOUND SPEED PROFILE
Boston, MA. - June 20, 1979

(x) Azimuth Angle 276 Degrees
(·) Azimuth Angle 335 Degrees

See Figures 33,34,35 for meteorological profiles

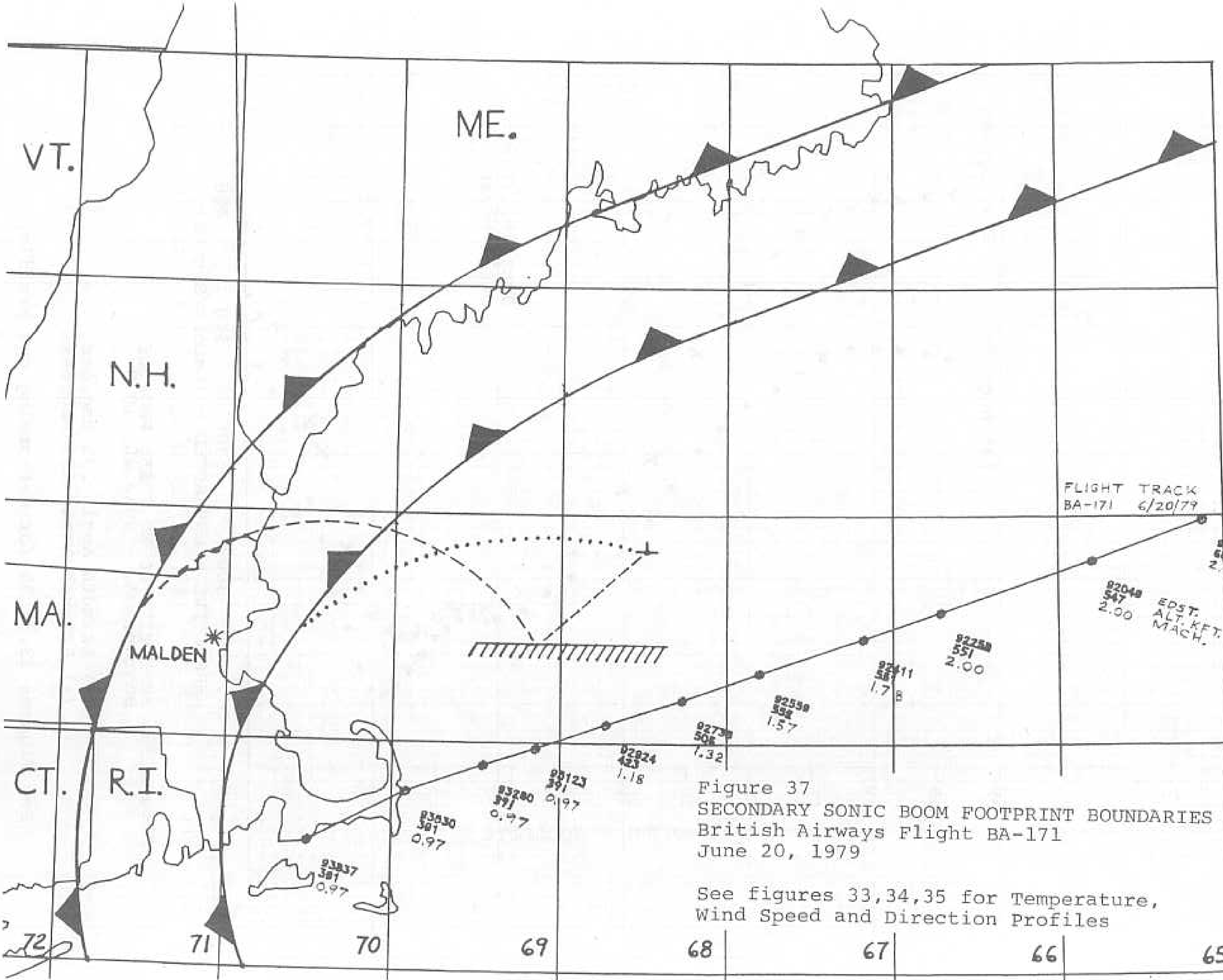


Figure 37
SECONDARY SONIC BOOM FOOTPRINT BOUNDARIES
British Airways Flight BA-171
June 20, 1979

See figures 33,34,35 for Temperature, Wind Speed and Direction Profiles