A COMPARISON OF A COAXIAL FOCUSED LASER
DOPPLER SYSTEM IN ATMOSPHERIC MEASUREMENTS

FINAL REPORT
to
National Aeronautic and Space Administration
George C. Marshall Space Flight Center
Huntsville, Alabama

by
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Prepared under

National Aeronautic and Space Administration
Contract No. NAS8-26234
Marshall Space Flight Center
Huntsville, Alabama

June 1973  CER71-72SK35
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INTRODUCTION

Measurements of fluid flow speed may be made by utilizing the Doppler shift of laser light scattered from small particles suspended in the flowing fluid. The principle of the Doppler shift is of course well known, but only recently was a technique introduced by Yeh and Cummins (1964) to utilize the Doppler shift of a laser radiation to successfully measure fluid flow speeds. Since that time there have been a number of separate investigations reported in the literature (see references). The instrument utilized in this investigation was developed by a team of scientists at NASA/MSFC (Huntsville, Alabama), Raytheon Company (Sudbury, Massachusetts) and Lockheed Missiles and Space Company (Huntsville, Alabama). Much of the technology used was originally developed in assembling a system to be used in subsonic and supersonic gas flows with large quantities of particle entrainment [Rolfe et al. (1968)]. The system used in this study involved only aerosols and particulate matter suspended naturally in the atmosphere.

Interest in application of the instrument has broadened currently (1972) to a variety of practical situations where a remote-sensing instrument has particular advantages over conventional velocimeters. Two applications currently under research is for use as an airport warning system for wake vortex detection and as an air-borne system for clear-air turbulence detection. A potentially important use of the instrument is in meteorological investigations of the atmospheric boundary layer. Further uses of the instrument could be for remote air-pollution detection and for measurement of mass and momentum fluxes in a variety of fluid flow fields.
In principle it is possible to measure "point" velocities in the flow field with complete vector directional resolution. A laboratory three-dimensional instrument is presently being investigated at NASA/MSFC (Huntsville, Alabama), where also an atmospheric three-dimensional arrangement is under research and development. The instrument used in this investigation was a one-dimensional co-axial system, using a 25-watt CO₂ laser and back-scattered radiation. The direction of wind velocity was resolved by utilizing an ordinary wind-vane direction sensor.

The purpose of this research project was to obtain measurements of atmospheric velocities and turbulence with the laser Doppler system and to compare the results with cup anemometer and hot-wire measurements in the same wind field.

**BASIC PRINCIPLES**

The frequency of laser light scattered by moving particles in a flow field is shifted by the Doppler effect. The Doppler shift is detected by optical mixing of the emitted or incident and scattered beams. A variety of optical configurations is possible to accomplish the optical mixing. In the present arrangement the back-scattered radiation along the axis of the incident beam was redirected into the laser to combine with the original laser beam. The resultant heterodyne or "beat" frequency is equal to the difference in frequencies of the emitted and scattered frequencies, and is directly proportional to the particle speed. If the scatterers are small, and no relative velocity exists between the particle and the fluid, then fluid velocity is
measured. An infrared detector was used to convert the Doppler-shifted frequency to a measurable electrical signal. The arrangement of the system is shown schematically in Figure 1.

The laser Doppler velocity measurement system (hereinafter referred to as the laser Doppler velocimeter and mnemonically denoted LDV) is almost instantaneous and has the advantage that no prior calibration is required as with other velocity instruments. The range of detectable velocities is very large. There is minimal perturbation of the fluid flow field by the laser radiation. The spatial resolution which is fixed ultimately by diffraction limitations can be controlled to a large degree by size and optical quality of the lenses and mirrors.

A nonrelativistic derivation of velocity determination from the Doppler shift frequency follows. A definition diagram relative to the derivation is shown in Figure 2. For purpose of clarity, the scattered beam is shown at an arbitrary angle $\theta$ from the direction of particle motion. In the case of a coaxial system, $\theta = \alpha$.

The emitted monochromatic laser radiation of wave length $\lambda_0$ and speed $c$ illuminates a particle having a velocity $\hat{V}$. The direction of the incident beam is defined by the unit vector $\hat{f}_o$. If the particle is motionless, the number of waves incident on the particle per unit of time is $f_0 = c/\lambda_0$, where $c$ is the speed of the laser radiation and $\lambda_0$ is the wave length.

If the particle is in motion at an angle $\alpha$ with respect to the incident beam, the frequency of the waves per unit of time relative to the moving particle is

$$f_p = \frac{c + V\cos\alpha}{\lambda_0}$$
Figure 1. Schematic arrangement of the laser Doppler velocimeter.
which is also the frequency of the scattered waves relative to the particle. The scattered radiation is directed toward a fixed point along a direction \( \hat{r}_s \) from point P. The frequency of the scattered radiation relative to the particle is \( f_p \), but to a fixed observer along \( \hat{r}_s \), the wave length appears to be

\[
\lambda_s = \frac{c - V \cos \theta}{f_p} = \frac{c - V \cos \theta}{c + V \cos \alpha \lambda_0}
\]

and the frequency of the scattered radiation appears to be

\[
f_s = \frac{c}{\lambda_s} = \frac{c}{\lambda_0} \left( \frac{c + V \cos \alpha}{c - V \cos \theta} \right)
\]

which is rearranged to give

\[
f_s = \frac{c}{\lambda_0} \left( \frac{1 + \frac{V \cos \alpha}{c}}{1 - \frac{V \cos \theta}{c}} \right).
\]
The apparent shift in frequency, the Doppler shift, is
\[ f_D = f_s - f_o \]
or,
\[ f_D = \frac{1}{\lambda_o} [V(c\cos\alpha + c\sin\theta)] \]
using the approximation that \( \frac{|V|}{c} \ll 1 \).

For backscatter along the incident laser beam, \( \theta = \alpha \), thus
\[ f_D = \frac{2V\cos\alpha}{\lambda_o} \]
and
\[ V = \frac{\lambda_o f_D}{2\cos\alpha} = \frac{c}{2\cos\alpha} \frac{f_D}{f_0} . \]

In particular the component of the particle velocity along the laser beam axis \( V_o \) is always determinable from
\[ V_o = V\cos\alpha = \frac{\lambda_o f_D}{2} = \frac{cf_D}{2f_0} . \]

The wavelength of the \( \text{CO}_2 \) laser was 10.6 microns, thus the velocity is given by
\[ V_o = 5.3 \times 10^{-6} f_D \text{ m/sec} \]
or,
\[ V_o = .53 \text{ cm/sec/KHz Doppler shift}. \]

DESCRIPTION OF THE LASER DOPPLER VELOCIMETER

The optical configuration of the LDV is shown schematically in Figure 1. It consists of a 25-watt, 10.6\( \mu \), \( \text{CO}_2 \) laser, beam splitters, mirrors and attenuators, an f8 12-inch Newtonian telescope and a liquid-helium cooled Ge-Hg infrared detector.
Based on relative power of 100 percent of the laser output (nominal 25 watts), the power at the focal region F was about 60 percent. The focal region is the sample space or volume from where the scattered signal is effectively heterodyned. The relative power at the detector was about 1 percent.

The laser radiation is focused at the desired range by a 2-in. focusing lens L. A diagonal, 1-7/8 by 2-21/32 inches mounted on a spider within the 15-in. diameter tube of the telescope, directs the beam to a 12-in. diameter schlieren mirror mounted at the end. The mirror is adjustable on a 3-point mount. Physical limitation of the focusing lens movement limited the near range of the telescope focus to about 60 feet from the mirror. The other limit of the telescope focusing range is limited to about 250 feet by the size of the diagonal. Of course if the power loss from beam "spill over" at the diagonal is not of concern the range can be extended. A curve of focal distance as a function of lens movement is shown in Figure 3. The reference position of the lens is arbitrary and made relative to 60 feet in the figure. The range of the telescope relative to "performance" is also diffraction limited [cf. Lockheed Missiles and Space Company (LMSC) progress report D162417, July 23, 1970].

**Spatial Resolution**

The spatial resolution of the system is specified in terms of the signal-to-noise, S/N, ratio. A calculation of S/N was made by LMSC (cf. Appendix A, Interim Report D225028, June 1971). It has been shown [Thomson and Dorian (1967)] that only radiation scattered from the region near the focus of the telescope contributes most significantly
Figure 3. Range positioning as a function of lens position.
to the Doppler signal. Nevertheless, there is some amount of heterodyned signal attributable to scattered returns in the whole space of illumination. The ratio of S/N from the focal region in comparison to the total S/N, then, is a method of defining the spatial resolution. A curve of spatial resolution (axial dimension) as a function of focal range is reproduced from the LMSC calculations as Figure 4.

Signal Processing

There are several options for discriminating the Doppler shift in frequency from the detector. These are:

1. Spectrum analyzer
2. Wide-band frequency discriminator
3. Filter bank
4. Doppler frequency tracker
5. Phase-locked receiver.

The merits, advantages and disadvantages are discussed by Rolfe et al. (1968). In this system principal use was made of a spectrum analyzer and to a limited extent of a frequency tracker.

Spectrum Analyzer - The Hewlett-Packard Model 8553B/8552A spectrum analyzer used in this investigation is a swept superhetrodyne receiver. A simplified block diagram is shown in Figure 5. Essentially the signal frequency is compared with a harmonic of the local oscillator frequency and the analyzer displays the signal directly in the frequency domain as a carrier with its side bands. The center frequency is tuneable, and a scan of the total band is selectable. The spectrum analyzer resolution is determined by a selectable IF bandwidth. The scan time can vary from 1 millisecond to 100 seconds for the selected scan width.
Figure 4. Spatial resolution of the 12-in. telescope.
If time intervals are too small, power output of the signal may be too small to measure. On the other hand, for large time intervals the output reflects the spectrum of particle speeds passing through the resolution focal volume of the beam, and can give therefore only a spectrum of velocities (Doppler frequencies) and not an "instantaneous" velocity as a function of time. Clearly, for "instantaneous" velocities the time interval should be consistent with the focal resolution volume, convected particle speed and S/N ratio of the spectrum analyzer.

In order to convert spectral information in frequency space to velocity, use is made of the linear variation of velocity with Doppler frequency shift. The frequency bandwidth of the spectrum analyzer is "swept" at a rate consistent with resolution of the analyzer and the power contained in the bandwidth is recorded on a conventional FM recorder in time space. Conversion from time to frequency hence to velocity in principle is simple, requiring only a reference zero frequency and known bandwidth or alternatively a calibrated external frequency. The rate at which the spectral bandwidth is swept is controlled externally to the spectrum analyzer. A schematic arrangement of the process including preconditioning of the detector signal is shown in Figure 6. A typical time, frequency trace of the power output is shown in Figure 7.
Figure 6. Block diagram of signal detection circuitry.
Doppler frequency tracker - A device which provides an output voltage proportional to a given Doppler frequency is termed a Doppler frequency tracker, or simply frequency tracker. The technique is also known as "frequency compressive feedback" or "frequency-locked loop" [cf. Rolfe et al. (1968)]. The Doppler frequency, $f_D(t)$, is heterodyned with a local oscillator frequency. The local oscillator frequency, $f_{LO}$, is varied so that the difference $f_{LO} - f_D$ is constant and equal to the center frequency of a discriminator. The driving voltage of the local oscillator is then proportional to $f_D$, hence to the velocity. A schematic representation of the tracker is shown in Figure 8.
TEST FACILITIES

The field site for the experiments was selected at the Colorado State University airport (Christman field) located approximately three miles west of the city of Fort Collins, Colorado (see Figure 9). The test site has a clear field from northwest to northeast, and from south to southwest. There are buildings and trees in the range from south to east, although the nearest building is some 1100 feet away. To the west is the foothills of the Rocky Mountains about a mile distant. The site was selected on the basis of land and power availability and proximity to the research center about 1/2 mile away. The dominant wind directions in the area are north-south, as evident from the alignment of the runway, although strong winds also blow over the foothills directly from the west.
Figure 9. Field site at Christman Field.
The site facilities included two towers and two trailer vans to house the instruments and the LDV system. The arrangement shown in Figure 10 was to provide clear wind fields to the north and south. As winds seldom blow from the east, the instrument vans were located so as to cause as little interference as possible to the wind field.

The 60-ft high tower was used to mount the wind profiling anemometers. The 40-ft tower was used to mount mirrors to direct the laser beam and also to mount the comparison instruments, a climet anemometer and wind vane, and a hot wire for turbulence measurements. Photographs of the established arrangement are shown in Figures 11 and 12.

INSTRUMENTATION

The arrangement of the various instruments in the laser instrument van is shown in the photograph of Figure 13. The total instrumentation for data taking and recording included the following:

*Spectrum analyzer* - The function and description of the spectrum analyzer was given in a previous section.

*Frequency tracker* - This instrument was also discussed in the earlier section.

*Wide band frequency generator* - A frequency generator of MHz range was used to establish a calibration point for the spectrum analyzer. Depending upon the prevailing wind speed, a calibration frequency was selected near the extreme of the wind speed range and the scan width of the spectrum analyzer was selected to contain this calibration frequency.

*Frequency counter* - A frequency counter was used to determine the calibration frequency.
Figure 10. Site arrangement for towers and instrument van.
Figure 11. Instrument vans at test facility.

Figure 12. Towers at test facility. Profile tower is at left.

Figure 13. Instrument arrangement inside laser van.
**Function generator** - A stable function generator was used to drive the sweep of the spectrum analyzer IF at a rate consistent with the spectrum analyzer scan time. A finite sweep time and "flyback" is involved. A given combination of sweep duration and scan width has its optimum IF filter bandwidth. A table of sample rates for various scan time settings is given in Table 1, and bandwidths as a function of scan width and scan time is given in Table 2. These tables were reproduced from the LMSC report No. D162840 describing the operating procedures of the LDV system.

**Mirror position indicator and drive** - The upper mirror on the 40-ft tower had a motor drive to rotate the mirror about its vertical axis. This permitted orientation of the laser beam into nominal alignment with the wind direction. The position of the mirror was indicated by a 357 degree potentiometer. There were 3 degrees of ambiguity from 357 degrees to 360 (zero) degrees. The position pot of the mirror was oriented so that zero was due east.

**Climet wind translator** - The translator presented wind direction and speed as sensed by the cup anemometer and wind direction sensor into recordable analog signals. The wind direction sensor was oriented so that zero output coincided with due east. The analog signals were then monitored on a dual channel strip chart recorder.

**FM tape recorders** - Two 14 channel FM tape recorders were used to record the analog signals, one a CP-100 Ampex unit and the second an FR-1300 Ampex recorder.

**Temperature sensor** - A standard bridge and amplifier circuit was constructed for this study to measure the deviations in temperature of the various thermistors from a reference unit.
### TABLE 1. MAXIMUM SAMPLE RATES FOR SELECTED SCAN TIMES

<table>
<thead>
<tr>
<th>Spectrum Analyzer Scan Time (Millisec/cm)</th>
<th>Maximum Sample Rate (Hz)</th>
<th>External SYNC Period (sec)</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.5</td>
<td>165</td>
<td>0.006</td>
</tr>
<tr>
<td>1.0</td>
<td>69</td>
<td>0.0145</td>
</tr>
<tr>
<td>2.0</td>
<td>40</td>
<td>0.025</td>
</tr>
<tr>
<td>5.0</td>
<td>18.2</td>
<td>0.055</td>
</tr>
<tr>
<td>10.0</td>
<td>5.0</td>
<td>0.200</td>
</tr>
<tr>
<td>20.0</td>
<td>3.3</td>
<td>0.303</td>
</tr>
</tbody>
</table>

### TABLE 2. MINIMUM BANDWIDTHS IN kHz FOR COMBINATIONS OF SCANWIDTH AND SCAN TIME

<table>
<thead>
<tr>
<th>Scan Width/cm</th>
<th>Scan Time, Millisec/Division</th>
<th>1.0</th>
<th>2.0</th>
<th>5.0</th>
<th>10.0</th>
<th>20.0</th>
<th>50.0</th>
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<tr>
<td>0.02 kHz</td>
<td></td>
<td>0.3</td>
<td>0.3</td>
<td>0.1</td>
<td>0.1</td>
<td>0.1</td>
<td>0.1</td>
</tr>
<tr>
<td>0.05 kHz</td>
<td></td>
<td>0.3</td>
<td>0.3</td>
<td>0.3</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>0.1 kHz</td>
<td></td>
<td>3.0</td>
<td>3.0</td>
<td>3.0</td>
<td>1.0</td>
<td>1.0</td>
<td>1.0</td>
</tr>
<tr>
<td>0.2 kHz</td>
<td></td>
<td>3.0</td>
<td>3.0</td>
<td>1.0</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>0.5 kHz</td>
<td></td>
<td>10.0</td>
<td>10.0</td>
<td>3.0</td>
<td>3.0</td>
<td>3.0</td>
<td>3.0</td>
</tr>
<tr>
<td>1.0 kHz</td>
<td></td>
<td>30.0</td>
<td>10.0</td>
<td>10.0</td>
<td>10.0</td>
<td>10.0</td>
<td>10.0</td>
</tr>
<tr>
<td>2.0 kHz</td>
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<td>300.0</td>
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<td>300.0</td>
<td>300.0</td>
<td>300.0</td>
<td>300.0</td>
</tr>
<tr>
<td>5.0 MHz</td>
<td></td>
<td>---</td>
<td>---</td>
<td>300.0</td>
<td>300.0</td>
<td>300.0</td>
<td>300.0</td>
</tr>
<tr>
<td>10.0 MHz</td>
<td></td>
<td>---</td>
<td>---</td>
<td>300.0</td>
<td>300.0</td>
<td>300.0</td>
<td>300.0</td>
</tr>
<tr>
<td>0.05 MHz</td>
<td></td>
<td>---</td>
<td>---</td>
<td>---</td>
<td>300.0</td>
<td>300.0</td>
<td>300.0</td>
</tr>
<tr>
<td>0.1 MHz</td>
<td></td>
<td>100.0</td>
<td>100.0</td>
<td>100.0</td>
<td>100.0</td>
<td>100.0</td>
<td>100.0</td>
</tr>
</tbody>
</table>
**Hot-wire anemometer** - A constant temperature hot-wire anemometer was used to measure the atmospheric turbulence. A 100-ft long cable was used for the probe and a cable capacitance compensator was used for the long-length cable. The hot wires were calibrated with the extra cable and compensator.

**Time code generator** - A time code generator in IRIG B format was used to synchronize the two tape recorders. Usually the times were synchronized with the National Bureau of Standards time broadcasts.

**RECORDING OF TEST DATA**

There were in all 26 separate pieces of continuous information desired for each test. Two analog 14 channel FM recorders were needed. However, two recorders were not available for all tests and some information was therefore sacrificed. The sample data recording sheet shown in Figure 14 indicates the data recorded on each channel of each recorder. They were arranged in such a way that temperature and humidity data were sacrificed when the second recorder was unavailable.

The data can be grouped into the following sets. On the 60-ft tower, six levels of wind speed were obtained to establish the vertical profile of the wind field in which comparison data were taken. These were grouped in the CP-100 Ampex recorder. Also, on the same tower, there were six levels of temperature measurements to determine the temperature profile and four levels of wet bulb temperatures to establish the humidity profile. These were grouped on the FR-1300 Ampex recorder. On the 40-ft tower the comparison instruments, the cup anemometer, the wind vane, and the hot wire were mounted. These data together with the
ATMOSPHERIC LASER DOPPLER VELOCIMETER PERFORMANCE VERIFICATION

Test Conducted Between ___ a.m./p.m. and ___ a.m./p.m. on ________ (date)

METEOROLOGICAL DATA

Air Pollution Index: ________; Visibility: _____; Good; _____; Fair; _____; Poor
Sky Condition: _____; Clear; _____; Light Clouds; _____; Medium Clouds; _____; Heavy Overcast
Temperature _____°F; Relative Humidity _____% or Dew Point _____°F
Barometric Pressure _____ mb; Anemometer(s) Location

Time into Test (min) 0 15 30 45 60
Mean Wind Speed (knots, mph, ft/sec) 
Mean Wind Direction (deg wt north)
Laser Coolant Temperature (°F)

General Weather Conditions (frontal presence, rain in past 12 hours, etc.):

OPTICAL CONFIGURATION

Mirror Orientation _____ deg (wt north)
Telescope mirror to lower tower mirror distance: _____ ft in.
Distance between top and bottom mirrors on tower _____ ft in.
Total distance from telescope mirror to focus vol: _____ ft
Laser power into telescope: _____ watts; Power at focal volume: _____ watts; He dewar check 0
Telescope mirror size: _____ in. diam.; Lens focal length: _____ in; Detector type: _____

Comments: __________________________

SPECTRUM ANALYZER/AVERAGER DATA

Sweep Rate: _____ ms/cm; Sample Rate: _____ samples/sec.
Number of sweeps averaged per sample: _____.
Frequency dispersion: _____ MHz/cm. Filter bandwidth: _____ kHz; Bandwidth: _____ kHz.

Other: __________________________

FM RECORDER DATA - MODEL CP-100 AMPEX
Label Tape Reel with Test No.
Tape No. ___________ Tape Speed _____ IPS; Response ______ Hz.

Ch. No. 1 2 3 4 5 6 7 8 9 10 11 12 13 14
Contents ______ ______ ______ ______ ______ ______ ______ ______ ______ ______ ______ ______ ______

FM RECORDER DATA - MODEL FR-1300 AMPEX
Label Tape Reel with Test No.
Tape No. ___________ Tape Speed _____ IPS; Response ______ Hz.

Ch. No. 1 2 3 4 5 6 7 8 9 10 11 12 13 14
Contents ______ ______ ______ ______ ______ ______ ______ ______ ______ ______ ______ ______ ______

AUDIO RECORD

Test Identification Number: _____ Spectrometer settings (sweep rate, number samples averaged, etc.).
Mean Wind; Distance from telescope mirror to focal volume; Visual quality of signal, and Problems and other comments.

(Signed) Test Engineer

Figure 14. Sample data sheet.
spectrum analyzer signal and appurtenant data were grouped into the CP-100 recorder. On one channel of each recorder there was an IRIG B time code for referencing the two sets of data to corresponding times. A voice channel (direct record) was reserved for verbal description of conditions and problems which occurred during a test.

Data with a frequency tracker were taken during a period when the second tape recorder was unavailable. Since two additional channels were required to record the signals from the tracker, two levels of wind speed data were sacrificed on the CP-100. These were levels 2 and 4.

**TEST PROCEDURE**

**Pre-Test Preparation**

Preparations for recording one-hour of continuous wind data and associated documentation was elaborate and time-consuming. For any given test, or attempted test, the following routine was necessary.

*Cooling the Ge-Hg detector* - The Ge-Hg detector was pre-cooled with liquid nitrogen for a period of about one hour before filling with liquid helium. This procedure was followed primarily to conserve liquid helium, which is comparatively many times more expensive than liquid nitrogen. Just prior to data-taking, after all preparations were completed, the dewar of the detector was filled with liquid helium.

*Optics alignment* - Before each test, alignment of the optics was necessary. A specific alignment procedure progressing outward from the laser to the tower was necessary. Although the beam splitters and mirrors did not require frequent adjustment, the optical beam on which
the focusing mirror was mounted required frequent adjustment. As the scattered radiation was redirected back into the laser, slight misalignment of the optical axis caused poor to no heterodyning, hence weak or no Doppler detection. Since alignment of the focusing lense mount is coupled with the diagonal and the schlieren mirror, a sequence of trial and readjustment was usually necessary.

After the optical beam was adjusted, the diagonal required minute adjustment to center the diverging radiation on the schlieren mirror. The schlieren mirror in turn required adjustment to direct the converging beam through the end of the 9-ft long tube. Thereafter, the entire mounting table required movement to center the beam on the lower external mirror near the base of the 40-ft tower. If the optics were bumped out of alignment during this process, then the entire procedure was restarted.

Once the laser beam was centered on the lower mirror, then the lower mirror was adjusted to center the beam on the upper one, and finally the upper mirror was rotated to direct the beam as closely as possible either directly into the prevailing wind direction or downwind along the wind direction, checking also to see that the beam was parallel with the ground. To establish the latter, an identification mark on the adjacent 60-ft tower was used to place the line of sight parallel to the ground, hence the axis of the laser beam was in the horizontal plane of the mean wind.

Profile tower - The thermistors on the 60-ft tower were arranged in a radiation shield, with a suction pump arranged to draw 2 ft/sec air velocity over the "dry bulb" thermistor and 30 ft/sec over the "wet bulb" thermistors. Distilled water was forced up the tower by air pressure into water wells with wicks leading to the "wet bulb" thermistors.
These thermistors were checked before each test and wicks were prewetted to insure that the distilled water would be drawn up from the wells.

*Hot-wire anemometer* - The hot-wire anemometer which was dismounted during a non-test period was remounted. The wire was placed in a vertical axis and the probe was oriented toward the wind and in a location such that there was no interference from the mirror, the cup anemometer or the tower itself.

**Pre-Test Calibration**

*Tape recorder* - The FM record amplifiers of the tape recorder are subject to slight deviations from calibrated conditions from day to day. To account for these deviations, a five-level DC signal was provided as a calibration of tape-recorded (and playback) voltage against a "true" voltage registered by a calibrated digital voltmeter (DVM). Since in the data set, a continuous square-wave signal was recorded, the calibration set did not include a sinusoidal signal of known rms value.

*Climet anemometers* - Both climet anemometer translators were calibrated for zero and full scale 1 volt outputs and recorded on the tape recorder. Prior to mounting the anemometers in the towers, all cup anemometers as well as the hot wires were calibrated in the Colorado State University wind tunnel against a pitot probe of known performance. Calibrations were performed twice, in February and June 1971.

*Mirror position* - The mirror position, with zero oriented directly east for convenience, was calibrated for zero and full scale output, with the assumption of linearity with angular position. Since the position was indicated by a potentiometer, the assumption seems justified.

*Spectrum analyzer* - Proper settings of the spectrum analyzer controls were established consistent with the prevailing wind speeds.
The sweep of the spectrum analyzer was triggered by an external square wave from a stable function generator by a change from negative to positive voltage. A known deviation frequency was input to the spectrum analyzer and the resultant signal from the IF output was recorded as the frequency band was swept. This calibration thus provided the reference for determining velocity from the Doppler shifted frequency of the back-scattered radiation.

*Noise calibration* - The final pre-test calibration was made of the background noise emitted from the detector. With the detector dewar charged with liquid helium, and the main laser beam to the telescope blocked, the output signal from the detector which consisted only of noise was recorded.

**Data Recording**

After completing the pre-test preparations and calibrations, data were recorded on the tape recorders for nominal periods of one hour duration. Constant monitoring of the data was provided, and instrument adjustments when necessary were properly recorded as to time and nature.

The turbulence range of interest extended only to a maximum of 5 Hz, thus the CP-100 tape recorder was operated at 7\(\frac{2}{3}\) inches per second (ips) and the FR-1300 recorder at 1-7/8 ips. The higher speed of the CP-100 recorder was necessary to record the Doppler signals from the spectrum analyzer. At 7\(\frac{2}{3}\) ips the recorder amplifiers are responsive to 2.5 KHz.

Anomalies in the data noticed were recorded on a voice channel (direct record) of the tape recorder, as well as on the data record sheet (Figure 14).
DATA REDUCTION PROCEDURE

All data for this investigation were analyzed digitally, the
digitizing being done in prescribed sets in simultaneous sample and
hold mode at the NASA-MSFC computer center. The digitized data were
analyzed at the Colorado State University computer center.

Selection of Digitizing Rates

The turbulent frequencies of interest in this study are less than
5 Hz, thus the digitizing frequency should be at 10 samples per second,
and also, because in general the recorded information should be related
to the same instants of time, a simultaneous sample and hold mode was
used in digitizing. The analog signals were filtered at 5 Hz (real-
time base).

The scan rate of the spectrum analyzer for Doppler frequencies was
16 Hz. Since the Nyquist frequency is equal to one-half sampling
frequency,

\[ f_N = \frac{f_D}{2} \]

the highest frequency information contained in the recorded signal is
8 Hz. However, the usual criterion of digitizing rate to obtain this
frequency information does not apply. The objective in data reduction
was to determine the location (time base) of the Doppler signal with
reference to zero frequency, hence of Doppler frequency and of wind
velocity. The bandwidth and resolution of the spectrum analyzer deter-
mines the nature of the Doppler signal. If we view the peak signal in
the bandwidth as depicting the mean velocity in the prescribed resolu-
tion interval, then the digitizing rate of the Doppler signal is
independent of the spectrum analyzer settings. Thus with a view to maximizing the frequency resolution (of the peak) in a given sweep, a choice of 250 points per sweep was made. The choice of this digitizing rate does however affect the total quantity of digitized data. Two channels of information, the external function generator and the IF output of the spectrum analyzer, were digitized at this higher rate, multiplexed on digital magnetic tape in binary format. The sampling rate for these channels was thus 4 KHz/channel and the data were filtered at 2 KHz.

Multiplexed Data Groups

The 26 channels of analog information were digitized in three separate groups.

**Group 1** - The sweep signal (square wave) and the spectrum analyzer IF(y) output were multiplexed and digitized at a rate of 4 KHz/channel.

**Group 2** - The climet anemometer and wind direction sensor, the mirror position, the hot wire output and six levels of wind speeds on the profile tower were multiplexed and digitized at a rate of 10 Hz/channel.

**Group 3** - The ten channels of thermistor data were multiplexed and digitized at a rate of 10 Hz/channel.

The remaining four channels of voice, time codes and wind direction on the profile tower were not digitized and were retained for reference. The time code information was of course used to identify the regions of the analog tape which were digitized.
Data Format

The A/D converter used at NASA/MSFC generated data words of 10 bits plus sign. The packed format of the multiplexed data therefore were written in groups of 11 bits. The CDC 6400 at Colorado State University is a 60-bit word machine, thus some tape reading problems were presented with the original format of the generated data tape. In order to reduce the reading problem, the original data tapes were reformatted to give data words which were 11 bits plus sign, or 12 bit words where a zero was inserted into the most significant bit. The packed 12-bit data words were thus conveniently separated and sorted from the 60-bit computer word.

The data included a record of header information at the beginning of each data set, and a 24-bit time word at the beginning of each data record. This time word is a reference digitizing time, and relates to real time in accordance with the ratio of record to playback tape speed. However, for records of the order of 60 minutes real time duration, the time word (expressed in milliseconds) becomes excessively large. Thus the digitizing clock which recycles after 100 seconds requires accounting of the cycles to convert digitizing time to real time as well as the ratio of record to playback speeds.

Data Reduction

Laser Doppler signals - The bulk of data reduction involved the Doppler signals. The view adopted in computer program formulation was to devise a general, automatic program. This was successful to a degree, however sufficient problems with data anomalies were encountered that some initialization is necessary. Considerable time was spent in developing this feature of a data reduction program. In retrospect,
perhaps less automatic, sequential programs would be more economical in terms of total effort. The flow chart for the program is shown in Figure 15 and a listing is given in Appendix A.

The essential technique is as follows: Data from Group 1 (identified above), and the first channel of the multiplexed data of Group 2, are necessary to convert the spectrum analyzer data to wind speed. If the mirror direction varies in the data period, that information is also required.

The cup anemometer wind speed, the hot wire data and the profile information can be processed separately, but because the two groups of data were arranged on different tapes and had to be read in "simultaneously" to analyze the Doppler signal, the program included processing of these data at the same time. It should be noted here that several alternative methods were recognized from the outset, and a one-pass automatic program seemed feasible and most desirable. Ultimately the profile data program was separated from the others and analyzed in a separate pass. The flow chart in Figure 15 reflects this variation to the original technique.

The program first determines the input-output calibration of DC voltage. This calibration enables conversion of such data as wind and mirror directions, cup anemometer speeds and hot wire turbulence velocities from tape output voltage to true voltage hence to the physical quantities. The next step in the analysis is to determine the calibration Doppler frequency. That is, the known frequency input is identified in the time space (number of points) from zero frequency, and since velocity is linear with Doppler frequency, then calibration is obtained for the velocity component along the laser axis. In order to
Figure 15. Simplified Flow Chart of Doppler Data Reduction.
distinguish the Doppler "peak" from the background noise, the noise calibration established the noise level across the entire frequency band of the spectrum analyzer. In the program the S/N ratio is a variable and may be set at any level compatible with the recorded Doppler signal.

The first step in the data analysis is to read in one record from the multiplexed Group 2 data. Each digital value is converted to velocity, and reference times for each value are calculated. The velocities and reference times are stored. The cup and hot wire data are digitized at identical times, thus one reference time serves both channels of information. Means and variances are calculated. Wind direction voltages are averaged for 10 seconds (one record) and converted to angle with respect to the laser beam. The value is temporarily stored. The mirror azimuth (direction) is averaged and checked. If no change occurred (i.e. the mirror was not rotated) the information is redundant and discarded.

The first record of Group 1 is then read in. Each spectrum analyzer scan, approximately 250 points, is searched for zero frequency (the change in voltage of the square wave from negative to positive identifies the beginning of the sweep) and the Doppler signal. The reference time for Doppler-converted velocity is referenced to the beginning of the sweep. Successive sweeps and time words at the beginning of each record references the true time of the calculated Doppler-measured velocity. The first identifiable Doppler peak is accepted as the measured velocity. To determine the peak value, comparison is made to successive points, and if the signal level (voltage) drops, the previous point is accepted as the Doppler frequency. It is possible that in a given sweep there is no
Doppler signal (signal dropout), in that event, the velocity determined in the previous sweep is recorded. The Doppler-indicated velocity is then converted to wind velocity by the 10-second average angle of the wind direction with respect to the laser beam axis (mirror direction).

There are 3000 data points (2 channels) in each record of the Group 1 data. This corresponds to 6 sweeps of the spectrum analyzer and 0.375 second in terms of real time. Successive records of Group 1 are read in and analyzed until the real time reference period exceeds the real time period of the data read in from the Group 2 data. Additional Group 2 data are then read and reduced, and the process repeated.

The stored values of velocities and reference times are periodically purged from storage and written on a magnetic tape. Thus the entire test record is converted to velocity-time history with the same reference times for the cup anemometer and hot-wire data, but a different reference time for the Doppler-indicated velocities.

The generated velocity-time history tape is then reprocessed to obtain the statistical characteristics of the turbulent wind data. These characteristics are the mean, variance (standard deviation), probability density and spectral densities (power spectrum).

*Velocity profiles* - The velocity profiles are calculated in a straightforward manner, using the other six channels of data in Group 2. Only the mean values are of concern, and ten-minute average velocities are calculated for each anemometer. The calibration data for voltages, and the prior wind-tunnel calibrations, are all that are required. A program listing is given in Appendix A.
Temperature profiles - Temperature and humidity profiles likewise, are relatively straightforward requiring manufacturer's calibration data for the thermistors and conversion of average tape voltage to true voltage. The resistances are calculated from a standard bridge equation, hence temperatures are determined. The program listing is given in Appendix A.

EXPERIMENTAL RESULTS AND DISCUSSION

Calibrations

Climet anemometers - Calibration curves of the climet anemometer, Series No. 828, are shown in Figure 16. The calibration was performed in a wind tunnel with the translator set for 1 volt output at 1896 Hz input (signal frequency generated by the cup) for the 60 scale setting on the translator. Ordinarily, the translator is adjusted to output 1 volt for specific input frequencies on each scale. However, for purpose of this calibration, adjustment was made for 1 volt output on the 60 scale only (any frequency would have served as well) and outputs read from both 30 and 60 scales. In setting the translator during an experiment, therefore, adjustment was always made only for the 60 scale. The output is linear with velocity as seen in the figure.

The CP-100 tape recorder has a low input impedance, causing a loading problem with virtually all the instruments connected to it. Thus the cup anemometers and hot wires were calibrated with the outputs connected to the tape recorder.

Hot-wire anemometer - A typical calibration curve for the hot-wire anemometer is shown in Figure 17. For purpose of this investigation, the King's law relationship is shown, and it is seen that in the region
Figure 16. Calibration curves for climet anemometer.
Figure 17. Hot-wire calibration curve
of interest, the curve was linear. A linearizer was not used with the anemometer. Instead, each digitized data point was converted to actual voltage and velocity calculated from the calibration.

**Measurements of Run 50801 (May 8, 1971)**

The data for this test were taken from 1:48 pm to 2:45 pm, covering a period of approximately one hour. At the beginning of the test the wind was blowing from the south-southeast (30 degrees east from south) which gradually changed to south-southwest (15 degrees west from south) by the end of the test period. The wind speed was reasonably constant at about 4 m/sec (9 mph) throughout the test period. Particle counts in the atmosphere were not available for this test; however, with the prevailing south wind, the pollution from Denver was evident as a blue haze along the horizon. This was also reflected in the strength of the Doppler signals on the spectrum analyzer.

**Velocity profiles** - The velocity profiles for successive 10-minute periods throughout the test are shown on Figure 18. The velocity profiles were logarithmic as expected; however, the slope of the profiles differ, indicating that the effects of accelerating and decelerating winds (gusts) are reflected in the profiles. It will be seen in the time traces of velocities that the fluctuations are of the same order of magnitude as the means, and the mean values change with time. The analysis to establish the profiles assumes piece-wise stationarity.

**Spectrum analyzer settings** - The following settings were made on the spectrum analyzer:

- Sweep rate: 5 ms/cm
- Sample rate: 16 sweeps/sec
Figure 18. Velocity profiles for test period 50801.
Frequency Dispersion: 0.2 MHz/cm
Filter Bandwidth: 10 KHz
Bandwidth: 30 KHz

The calibration frequency was 1.007 MHz (5.34 m/sec) which is pictured in Figure 19. The noise level from the detector is shown in Figure 20. The photograph is the oscilloscope trace from playback (at record time) of the recorded signal on the CP-100. The signal is inverted to avoid confusion with the square wave shown at the top part of the picture. The vertical scale is 200 mv/cm.

Typical Doppler signals are shown in Figures 21 and 22. As noted, the S/N ratio is large, but the spectral bandwidth is also large. Peaks in the signal of the kind shown in Figure 21 are relatively easy to determine; however, multiple peaks are evident in Figure 22. In these instances, the first largest peak is detected, and the others ignored. There were undoubtedly particles of different sizes in the focal region with different angularity with respect to the laser beam axis which cause the multiple peaks in a given sweep.

**Velocity time traces** - Time traces of velocity from the cup anemometer, hot wire and the LDV, for two consecutive 4.26-minute periods are shown in Figures 23 and 24. Mean velocities for each 4.26-minute interval have been subtracted; the fluctuations thus are referenced to zero for each plot.

As seen in these traces, there is reasonable conformance between the cup anemometer, hot wire and LDV outputs. It should be noted here that the cup anemometer was at a level 11.3 meters above ground, the hot wire was 0.3 meters below the cup level and the laser beam axis was at the same level as the hot wire although the focal region was 3 meters
Figure 19. Calibration frequency 1.007 MHz. Test 50801

Figure 20. Detector noise calibration. Vertical scale is 200 mV/cm. Test 50801

Figure 21. Sample Doppler signal. Test 50801

Figure 22. Sample Doppler signal. Test 50801
Figure 23. Time traces of wind velocity.
Test 50801, Interval 1
(For means and variances see Table 3)
Figure 24. Time traces of wind velocity
Test 50801, Interval 2
(For means and variances see Table 3)
farther upwind. It should be noticed in making visual comparisons that the vertical scales are different for the traces.

**Means and variances** - The means and variances from a 34-minute interval of the total record were analyzed and are shown in Table 3. The choice of a 34-minute period was based largely on the limitations of the spectral analysis program. This was also a sufficiently large period to reflect a reasonable confidence interval for the spectral densities.

**TABLE 3. MEANS AND VARIANCES FOR TEST 50801**

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<tr>
<th>4.26-Minute Intervals</th>
<th>Mean Velocities m/sec</th>
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<td>Hot Wire</td>
<td>LDV</td>
<td>Cup</td>
</tr>
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<tr>
<td>7</td>
<td>3.618</td>
<td>3.642</td>
<td>3.489</td>
<td>.623</td>
</tr>
<tr>
<td>8</td>
<td>4.212</td>
<td>4.235</td>
<td>4.073</td>
<td>.461</td>
</tr>
<tr>
<td>Averages</td>
<td>4.041</td>
<td>4.064</td>
<td>3.917</td>
<td>.472</td>
</tr>
</tbody>
</table>

The mean wind speeds detected by the LDV is in overall 3 percent agreement with the cup anemometer, and within 5 percent for any given 4.26-minute interval. The greater spread for smaller time intervals is to be expected because of the spatial spread of sampling points for the two instruments.
The variances for LDV are larger than those detected by either the hot-wire or the cup anemometer. It is surprising to note also that the variances for the hot wire are less than that for both the cup anemometer and LDV measurements. The greater variances for the LDV results are due in part to the fact that only mean horizontal angularity of the particle motion with respect to the laser axis is included in the correction. Thus there are greater variations of velocities from the mean. This is observed also in comparing the mean speeds for the three data sets. The mean is lower for the LDV as compared to cup speeds.

**Probability distributions** - The distributions of velocities about the means for the three instruments are shown in Figure 25. These data are in terms of standard deviations, and are not normalized so that straight lines are drawn from one data point to another. The distributions are skewed to the right. This skewness is governed by the nature of the turbulence in the atmosphere rather than by instrument response, as it can be seen that all three instruments respond similarly. The percentage of data near the mean is greater for the cup anemometer than for the other instruments, as was suggested in the preceding paragraph, the percent of low velocities appear to be greater for the LDV than for either cup or hot wire measurements.

**Spectral densities** - The spectral densities for measured turbulence in the atmosphere are shown in Figures 26, 27 and 28 for the cup, hot wire and LDV instruments, respectively, and a comparison of the three are shown on Figure 29.

There are apparent energy concentrations in the spectra for the cup anemometer and hot wires at 5 Hz which are also noted at 2.5 and
Figure 25. Distributions of velocities about the mean.
Test 50801
Figure 26. Spectral density distributions for cup anemometer.
Test 50801
Figure 27. Spectral density distributions for hot-wire anemometer. Test 50801
Figure 28. Spectral density distributions for LDV data.
Test 50801
1.25 Hz. These must be due to mechanical aliased frequencies from the tape recorder, for they appear in the hot-wire and cup anemometer data but not in the LDV data. Mechanical aliasing does not appear in the LDV data because of the manner in which the velocity-time history is generated (see section on data reduction).

If the aliased spectral densities are ignored, it can be seen that the hot-wire and cup anemometer have identical spectra up to 0.4 Hz. Beyond that frequency, the spectrum decreases because of the limited frequency response of the cup anemometer. The cup anemometer data may in principle be corrected by a frequency response function (see Camp 1965), but in this study the correction was not made, as the comparison spectrum for higher frequency is given by the hot-wire anemometer data. The response of the constant temperature hot wire used here is up to at least 1 KHz and the data were filtered at 5 Hz before digitizing.

As it is seen on Figure 29, the spectral densities for the LDV-measured turbulence is slightly greater for frequencies less than 1 Hz, but essentially parallel to the hot-wire data. For higher frequencies, there appears to be more energy contained in the LDV-measured turbulence. This must be aliased information because the hot-wire data do not show this trend.

The aliasing must arise from the technique used in data reduction. While the spectrum analyzer is being swept (sampled) at a rate of 16 Hz, thereby effectively establishing the Nyquist frequency, the velocity time data cannot be filtered at 8 Hz before the sampling is done. That is, turbulence of higher frequency transporting aerosol and solid particles in the atmosphere are sensed in the resolution volume of the LDV. Thus in calculating the velocity from the sampled spectrum, the aliasing
from higher frequency cannot be avoided. What is surprising, however, is to note the magnitude of the aliased spectrum in the LDV-measured turbulence indicated by the deviation beyond 1 Hz.

**Measurements of Run 32701 (March 27, 1971)**

The data for this test were taken from 3:30 pm to 4:18 pm, a period of 48 minutes. The wind was essentially steady from the north-east (60 degrees east from north) at around 12 m/sec (27 mph). Particle counts in the atmosphere were not available for this test. There was an arctic front moving in from the north and the air was "clean." Visibility was virtually unlimited. The laser beam axis was directed downwind in this test because the direction of the wind was such that the laser beam axis would have been close to a vertical leg of the tower.

**Velocity profiles** - The velocity profiles for successive 10-minute intervals are shown on Figure 30. The profiles are logarithmic and the mean velocities increased in the first 20 minutes of the 50-minute period and decreased thereafter. The spread of mean velocities for the total period varied from about 10.7 to 13 m/sec at the level of the focal region of the laser beam.

**Spectrum analyzer settings** - The settings of the spectrum analyzer were as follows:

- **Sweep rate:** 5 ms/cm
- **Sample rate:** 16 sweeps/sec
- **Frequency dispersion:** 0.5 MHz/cm
- **Filter Bandwidth:** off
- **Bandwidth:** 30 KHz
Figure 30. Velocity profiles. Test 32701
The calibration frequency was 4.009 MHz (21.2 m/sec) which is shown in Figure 31. The noise level from the detector is shown in Figure 32. The vertical scale in the oscilloscope trace is 100 mv/cm.

Typical Doppler signals are shown in Figures 33 and 34. As noted, the S/N ratio is small and the spectral dispersion is also small. There were larger periods of signal dropout, that is sweeps when there were no detectable signals. In these instances the analysis was made assuming that the velocity indicated in the current sweep was equal to that of the previously detected velocity.

*Velocity time traces* - Time traces of velocity from the three instruments are shown in Figures 35 and 36 for two representative 4-minute time intervals.

There is reasonable agreement between the cup anemometer and hot-wire traces in general trend of mean velocities. However, the turbulent fluctuations in the hot-wire signals are greater than that indicated by the cup anemometer traces. The LDV signals have several peculiarities. The fluctuations are clipped at both the upper and lower limits. These clipped signals are results of the low S/N ratio and the computer program. As indicated previously, the low particle concentration in the atmosphere often caused no detectable signal in a given sweep of the spectrum analyzer. In such instances the velocity was set equal to the immediately-previous calculated velocity. At the lower end, the signal was lost in the noise (see the noise calibration trace of the oscilloscope) and a previously higher value was then identified as the velocity for that sweep. There are noticeable high peaks in the LDV trace. It is believed that these signals are spurious, resulting from identification of high noise peaks as Doppler signals. The trend of mean
Figure 31. Calibration frequency 4.009 MHz. Test 32701

Figure 32. Noise calibration. Vertical scale is 100 mv/cm Test 32701

Figure 33. Typical Doppler signal. Test 32701

Figure 34. Typical Doppler signal. Test 32701
Figure 35. Time traces of wind velocity
Test 32701, Interval 3
(For means and variances see Table 4)
Figure 36. Time traces of wind velocity
Test 32701, Interval 5
(For means and variances see Table 4)
velocities is generally identifiable, but the comparison is not as favorable as for test 50801.

*Means and variances* - The means and variances from a 34-minute interval of the total record are given in Table 4.

**TABLE 4. MEANS AND VARIANCES FOR TEST 32701**

<table>
<thead>
<tr>
<th>4.26-Minute Intervals</th>
<th>Mean Velocities m/sec</th>
<th>Variances (m/sec)$^2$</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Cup</td>
<td>Hot Wire</td>
</tr>
<tr>
<td>1</td>
<td>12.041</td>
<td>12.152</td>
</tr>
<tr>
<td>7</td>
<td>12.417</td>
<td>12.578</td>
</tr>
<tr>
<td>8</td>
<td>11.453</td>
<td>11.551</td>
</tr>
<tr>
<td>Averages</td>
<td>12.856</td>
<td>12.961</td>
</tr>
</tbody>
</table>

The average wind speed detected by the LDV in the 34-minute period is within 1 percent of the cup and hot wire averages. There are larger variations however for the shorter 4.26-minute intervals, and as the time traces would suggest, variations become greater for even shorter periods. As noted in the preceding section, these are undoubtedly caused by the spurious signals in the velocity calculations. The mean velocities measured by the hot wire were generally larger than the cup anemometer, and the variances as expected are definitely greater because the frequency response of the cup anemometer is limited.
Over a 34-minute period, the fluctuations (variances) detected by the LDV are larger than those of the hot wire. This was also true for Test 50801 which had considerably lower mean wind speeds. Again, the spurious signals in the LDV velocities contribute significantly to variances.

**Probability distributions** - The distributions of velocities about the means for the three instruments are shown in Figure 37. Turbulence velocities are skewed to the left for all three instruments. The LDV data indicated difficulty in tracing the larger velocities. As explained previously, this could be due in part to the three dimensional nature of turbulence and only the horizontal angularity was corrected (in the mean) in these measurements. This feature of the LDV traces was noted also for test 50801.

**Spectral densities** - The spectra for the cup anemometer, hot wire and LDV data are shown in Figures 38, 39 and 40, respectively. For comparison, the three are replotted in Figure 41. Spikes of high frequency are again noted at 2.5 and 5 Hz in the cup anemometer spectra. It was noted that the time traces of the LDV data included spurious spikes of high velocity. These spikes are transformed into the spectra and are noted particularly as spikes of power near 1 and 3 Hz. These spikes in the spectra were ignored in reploting on Figure 41.

The spectra of turbulence measured by the LDV and hot wire compare favorably. This is also indicated by the comparison of variances in Table 4. The cup spectra however drops off at around 0.2 Hz because of the limited frequency response. Response corrections for the cup anemometer were not made.
Figure 37. Distributions of velocities about the mean. Test 32701
Figure 38. Spectral density distributions for cup anemometer data.
Test 32701
Figure 39. Spectral density distributions for hot-wire anemometer.
Test 32701
Figure 40. Spectral density distributions for LDV data.
Test 32701
Figure 41. Comparison of spectral density distributions for Test 32701.
Measurements of Run 101401 (October 14, 1971)

The data for this test were taken from 9:16 pm to 9:55 pm, a period of 39 minutes. The wind was from the north-northwest across the clear grassland. The mean wind speed varied from about 4 m/sec at the start of the test to about 5.7 m/sec at the end. The wind direction remained constant. With a northern weather front moving in, the air was clear, (little pollution), and visibility was good.

_Spectrum analyzer settings_ - The settings of the spectrum analyzer were as follows:

- **Sweep rate**: 5 ms/cm
- **Sample rate**: 16 sweeps/sec
- **Frequency Dispersion**: 0.2 MHz/cm
- **Filter Bandwidth**: 10 KHz
- **Bandwidth**: 30 KHz

The calibration frequency was 1.691 MHz, which is shown in Figure 42. The noise level is shown in Figure 43. It will be noted that reference zero frequency is shifted slightly from the pulse rise of the square wave, resulting from a horizontal axis shift of the spectrum analyzer. An accounting of this shift was made in data analysis.

A sample trace of one sweep of the spectrum analyzer is depicted in Figure 44. The S/N of the Doppler trace is small but was sufficient to discriminate from noise. There were drop outs in Doppler signature as indicated by the time traces of wind speeds.

_Velocity time traces_ - Time traces of wind speeds from the cup and hot wire anemometers and the LDV are shown for representative 4-minute intervals in Figures 45 and 46. As with the two previous tests, the mean trends correspond with apparent differences in turbulence.
Figure 42. Calibration frequency 1.691 MHz. Test 101401

Figure 43. Noise Calibration. Test 101401

Figure 44. Sample Doppler signal. Test 101401
Figure 45. Time traces of wind velocity.
Test 101401, Interval 1
(For means and variances see Table 5)
Figure 46. Time traces of wind velocity.
Test 101401, Interval 5
(For means and variances see Table 5)
fluctuations. The large number of low points in the LDV signature resulted from the low S/N ratio; particularly by having to set a low level trigger in the computer program. The spurrious high peaks are believed to be caused by extraneous signal in the Doppler sweep. There are not enough of these to cause difficulty with the statistical analysis.

Means and variances - Means and variances for the entire 34-minute test period are given in Table 5 for each 4.26-minute segment.

<table>
<thead>
<tr>
<th>4.26-Minute Intervals</th>
<th>Mean Velocities m/sec</th>
<th>Variances (m/sec)^2</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Cup</td>
<td>Hot Wire</td>
</tr>
<tr>
<td>1</td>
<td>5.150</td>
<td>5.154</td>
</tr>
<tr>
<td>2</td>
<td>5.535</td>
<td>5.543</td>
</tr>
<tr>
<td>3</td>
<td>5.425</td>
<td>5.479</td>
</tr>
<tr>
<td>4</td>
<td>6.052</td>
<td>6.092</td>
</tr>
<tr>
<td>5</td>
<td>5.381</td>
<td>5.406</td>
</tr>
<tr>
<td>6</td>
<td>6.417</td>
<td>6.426</td>
</tr>
<tr>
<td>8</td>
<td>5.958</td>
<td>5.996</td>
</tr>
<tr>
<td>Averages</td>
<td>5.792</td>
<td>5.819</td>
</tr>
</tbody>
</table>

The average wind speed indicated by the LDV measurements is about 5 percent greater than that indicated by the cup anemometer. This is comparably about the same as for Test 50801. The variance for the LDV is greater than for the anemometers. Also, the variance for the hot wire is less than that for the cup anemometer as was the case also for Test 50801.
**Probability distributions** - The distributions of velocities about the means for the three instruments are shown in Figure 47. The turbulent fluctuations are more normally distributed about the mean than was the case for the previous two tests. As before, the probability distributions compare favorably one instrument to another.

**Spectral densities** - A comparison of the spectral density distributions with frequency for the three instruments is shown in Figure 48. The spectral distribution for the cup anemometer drops off slightly at about 0.5 Hz, the hot wire spectrum decreases on a constant slope and the LDV spectrum tends to level off for higher frequencies. The 2.5 and 5 hertz spikes were not included in drawing these spectra. The comparisons are reasonable to about 1 Hz frequency.

**Frequency tracker** - Considerable difficulty was experienced in tracking the LDV output with the frequency tracker. The tracker required frequent adjustments during the test, and tracking was often lost. Consequently the tape recorded output was too intermittent and analysis was difficult.

From observations during the test, it was noted that when tracking was achieved, the D.C. output (although slightly nonlinear) corresponded with the mean Doppler frequency, hence with the indicated wind speed. The A.C. output however did not correspond very well with the turbulent fluctuations. For example, in Figure 49, is shown a simultaneous trace of the hot wire and the A.C. output from the tracker for Test 101401. The hot wire leads the laser focal volume by about 3 meters and the average wind speed was about 6 meters per second. The horizontal sweep on the oscilloscope was 0.2 sec/cm.
Figure 47. Distribution of velocities about the mean.
Test 101401
Figure 48. Comparison of spectral density distributions.
Test 101401
The A.C. output (top trace) resembles noise rather than turbulence, while the hot wire output is clearly that which traces the turbulence. The intermittency of the tracker signal created considerable difficulty with digital data analysis. After considerable effort, this part of the data analysis was abandoned. The particular frequency tracker used in these tests (1971) should be modified to provide long-term uninterrupted velocity-time histories. This of course is related to Doppler S/N ratio and to the concentration of aerosols which provide the Doppler shifted signals. With no Doppler signature (signal drop out) there can be no tracking regardless of the quality and design of the frequency tracker.

Measurements of Run 102501 (October 25, 1971)

Test time was from 2:04 pm to 2:45 pm. The wind was from the south-southeast at about 5 m/sec. There were no active weather fronts in the vicinity and the sky had been clear for the day. Some pollution was evident in the air, but visibility was good.
Spectrum analyzer settings - The settings were as follows:

- Sweep rate: 5 ms/cm
- Sample rate: 16 sweeps/sec
- Frequency Dispersion: 0.2 MHz/cm
- Filter Bandwidth: 10 KHz
- Bandwidth: 30 KHz

The calibration frequency was 1.678 MHz as shown in Figure 50.

The noise level from the detector is shown in Figure 51. The vertical scale is 200 mv/cm. A sample Doppler trace of one sweep is shown in Figure 52. As is observable, the S/N ratio is small which made data analysis difficult.

Velocity time traces - Time traces of velocity from the cup and hot wire anemometers and the LDV are shown in Figures 53 and 54. There was much more variability of wind speeds during this test than in previous tests. The smaller scale turbulence is superimposed on larger scale variations. Thus, it should be expected, as will be seen later, that the power spectra would indicate greater power at the lower frequencies. Some amount of dropout in signals is indicated for the LDV. In general comparisons of the time traces appear satisfactory.

Means and variances - The means and variances for 8 segments of a 34-minute time period are given in Table 6.
Figure 50. Calibration frequency 1.678 MHz. Test 102501

Figure 51. Noise Calibration. Vertical scale is 200 ms/cm. Test 102501

Figure 52. Sample Doppler signal. Test 102501
Figure 53. Time traces of wind velocity.
Test 102501, Interval 1
(For means and variances see Table 6)
Figure 54. Time traces of wind velocity.  
Test 102501, Interval 2  
(For means and variances see Table 6)
TABLE 6. MEANS AND VARIANCES FOR TEST 102501

<table>
<thead>
<tr>
<th>4.26-Minute Intervals</th>
<th>Mean Velocities m/sec</th>
<th>Variances (m/sec)^2</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Cup</td>
<td>Hot Wire</td>
</tr>
<tr>
<td>1</td>
<td>4.397</td>
<td>4.444</td>
</tr>
<tr>
<td>2</td>
<td>4.154</td>
<td>4.169</td>
</tr>
<tr>
<td>3</td>
<td>6.025</td>
<td>6.010</td>
</tr>
<tr>
<td>4</td>
<td>4.943</td>
<td>5.000</td>
</tr>
<tr>
<td>5</td>
<td>5.307</td>
<td>5.315</td>
</tr>
<tr>
<td>6</td>
<td>4.713</td>
<td>4.748</td>
</tr>
<tr>
<td>7</td>
<td>5.082</td>
<td>5.102</td>
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<tr>
<td>8</td>
<td>5.278</td>
<td>5.284</td>
</tr>
<tr>
<td>Averages</td>
<td>4.987</td>
<td>5.009</td>
</tr>
</tbody>
</table>

The average wind speed indicated by the LDV is within 5 percent of the cup and hot wire averages. The comparison is reasonably good.

**Probability distributions** - The distributions of velocities about the means for the three instruments are shown in Figure 55. Turbulence velocities are skewed to the right. The distributions are about the same as for the other tests.

**Spectral densities** - The spectral distributions of turbulence are shown in Figure 56. As was noted earlier the lower frequency variations of velocities produced greater power spectral densities at the lower frequencies. The cup anemometer response drops off at about 0.5 Hz, and the LDV tends to level off for frequencies greater than about 2 Hz. The comparison of spectral distributions is reasonably good.
Figure 55. Distribution of velocities about the mean. Test 102501
Figure 56. Comparison of spectral density distributions. Test 102501
OBSERVATIONS AND CONCLUSIONS

As a consequence of the comparisons presented, the following observations can be made regarding the one-dimensional LDV system.

1. The gross features of atmospheric phenomena in the boundary layer are measured by the LDV system. The time traces show reproduction of these gross features and comparison with other anemometers are favorable.

2. Mean values determined from the LDV data are in general within 5% of other anemometer data for long (34-minute) time periods. The variations are larger for shorter time periods, chiefly because of larger variations in measured velocities. That the LDV measures larger velocities is also indicated by the probability (percent) distributions of the data and by the spectral distributions with frequency.

3. The confidence of measuring high frequency turbulence (greater than 2 Hz in atmosphere) is not yet established.

4. The technique for data reduction of the LDV data is cumbersome in its present form. Immediate improvements can be made by including on-line analog to digital equipment including a special purpose minicomputer to calculate the velocities from the digitized data. Alternatively an analog system to detect Doppler signals such as an improved frequency tracker could be used. The frequency tracker used in this study required very fine tuning, and dependable frequency lock was not achieved.
REFERENCES


APPENDIX A

A-1 Computer Program for Analysis of Doppler Signals

A-2 Computer Program for Determination of Velocity Profiles

A-3 Computer Program for Determination of Temperature and Humidity Profiles
APPENDIX A-1

Computer Program for Analysis of Doppler Signals
**PROGRAM LASDOPI**

```
PROGRAM LASDOPI

COMMON/BLOCK1/LENARR1*WINDHE(100)+NRECD1*NLFILE1*

COMMON/BLOCK2/LENARR2*SYNC(1500)+YLASER(1500)+NRECD2*NLFILE2*

COMMON/BLASER*/NFLYBACK*NOISREC*TIMECHG*TIMEHW*ACTVOL

COMMON/BHFLA1/NCALRECall*NCALVAL*VARIT

COMMON/BHUFLA2/NCLOCK2*TEXTIME*NCALREC*NRECD

COMMON/HVOLTAD/ISCALE

COMMON/4SPFEU/SUMVEL*SUMVOLT*CHANNE1*CHANNEL2

COMMON/HNOISE1/FLYBACK*NOISREC*TIMECHG*TIMEHW

COMMON/HCOicTM/NAVFMIR*CREMC*HGE

COMMON/BAVEwlt4/JSA,P,PLEt*SUMNIN*MULTIM*AVEWD*3000

COMMON/BBUMPUP/TIMEI*ICOMWRU*IJATWRD*1000

READ(59S) TIMAUJ1,TIMAUJ2,TIMAUJ3,TIMAUJ4,TIMAYJ,*NREC2,NREC3

FORMAT(5F11.4,5F6.0,2F6.0,5F4.0,5F6.0)

READ(5.5) TIME1*TIME2*TIME3*TIME4*TIME5

FORMAT(4A3,4A3,4A3)

WRITE(6.2) VOltCHGRIDAT2, CALLAS*180

WRITE(16.10) IUNNO

READ(15.5) TIMAUJ1,TIMAUJ2,TIMAUJ3,TIMAUJ4,TIMAYJ,*NREC2,NREC3

FORMAT(114A,1114,5F6.0,7F6.0,3F6.0,3F6.0,3F6.0,3F6.0)

READ(15.5) TIMAUJ1,TIMAUJ2,TIMAUJ3,TIMAUJ4,TIMAYJ,*NREC2,NREC3

FORMAT(114A,1114,5F6.0,7F6.0,3F6.0,3F6.0,3F6.0,3F6.0)

WRITE(16.10) IUNNO

FORMAT(114A,1114,5F6.0,7F6.0,3F6.0,3F6.0,3F6.0,3F6.0)

WRITE(16.10) IUNNO

READ(15.5) TIMAUJ1,TIMAUJ2,TIMAUJ3,TIMAUJ4,TIMAYJ,*NREC2,NREC3

FORMAT(114A,1114,5F6.0,7F6.0,3F6.0,3F6.0,3F6.0,3F6.0)
```

**CQC 6400 FTN V3.0-P261 OPTsO**

02/10/72 13.01.02  PAGE 1
PROGRAM LAS00P TRACE

FRSTSPD = 3HYES
NTAPE2 = 1
NEXTPTS = 0
NAVWD = 0
NDATAP2 = 1
JCLK1 = 0
JCLK2 = 0
IND = 1
IPOINT = 1

JCOUNT = 0
IF (IDENT1 .EQ. 3HYES) CALL HEADER1
IF (IDENT2 .EQ. 3HYES) CALL HEAD2
IF (FRSTAPE .EQ. 3HOK) GO TO 20
NFLSKP1 = 0
NRCSKP1 = 0
CALL SKPEOF1

IF (CALTAPE .EQ. 3HYES) CALL TAPECAL
IF (CALTAPE .EQ. 3HNE) READ(SI11) (SLOPE(I)ZEROTAP(I)I=12)

IF (NFILE1 .GT. NTAPFII) GO TO 21
NFLSKP1 = 1
NRCSKP1 = 0
CALL SKPEOF1

IF (CALINST .EQ. 3HYES) CALL INSTCAL
IF (CALINST .EQ. 3HNE) READ(SI11) SLOPEW,SLOPEW,WINTER,WINTER
IF (NFILE1 .GT. NINSFII) GO TO 23
NFLSKP1 = 1
NRCSKP1 = 0
CALL SKPEOF1

IF (FRSTLAS .EQ. 3HOK) GO TO 24
NFLSKP2 = 0
NRCSKP2 = 1
CALL SKPEOF2

IF (CALNOSL .EQ. 3HYES) CALL LASCAL
IF (CALNOSL .EQ. 3HNE) READ(SI12) CALVELO,NPTSWP

FLYBACK = FLYBACK - DFLYBAC
IF (NFILE2 .GT. NLASFII) GO TO 25
NFLSKP2 = 1
NRCSKP2 = 0
CALL SKPEOF2

IF (FRSTNOS .EQ. 3HOK) GO TO 26
NFLSKP2 = 0
NRCSKP2 = 1
CALL SKPEOF2

IF (CALNOIS .EQ. 3HYES) CALL NOISCAL
IF (CALNOIS .EQ. 3HNE) READ(SI12) KLEVEL2(I)I=1,202)

FLSKP2 = 1
NRCSKP2 = 0
CALL SKPEOF2

CALL VOLTAOJ
IF (MRCONST .EQ. 3HYES) CALL CONSTMR
IF (MRCONST .GT. 3HNE) GO TO 75
PROGRAM LASOOP TRACE

READ(5,14) CHGMIR,TIMEMIR
READ(5,13) DIRECMR
13 FORMAT(FI0.3)
14 FORMAT(A3*F6.2)
15 FORMAT(I90,S5*ANGMA*CHGMIR,**A3* TIMEMIR **F10.3)
170 JLOCK1 = 0
175 ZEROTM1 = 0.0
176 JLOCK2 = 0
177 ZEROTM2 = 0.0
178 JOATAM1 = 1
179 MULTIM1 = 1
180 LASTIME = 1
181 MULTIME = 1
PRINT 16
16 FORMAT(1M1)
100 CALL SPEED
CALL AVEWIND
145 IF(PRINTOK.EQ.3*YES) WRITE(n,7)NTAPE2
7 FORMAT(I8*LASER VELOCITIES*FILE*12,5X*TAPE*12/10X*TIME*SEC*10X*VELOCITY*10X*RECORD*)
150 CALL BUFLAS2
IBEGIN = 1
175 DO 200 =IBEGIN,LENARR2
200 CONTINUE
GO TO 150
300 JCOUNT = JCOUNT + 1
301 N = M + 1
302 IF (N .LE. LENARR2) GO TO 500
400 CALL BUFLAS2
N = 1
500 IF (YLASER .GE. FLYBACK) GO TO 300
501 IF (JCOUNT .GT. 15) GO TO 600
502 JCOUNT = 0
IBEGIN = M
503 IF (N .LE. LENARR2) GO TO 175
504 GO TO 150
650 N = M - IBEGCHK - 1
660 IF (M .LE. LENARR2) GO TO 650
CALL BUFLAS2
N = M - LENARR2
655 JCOUNT = 0
210 LAST = NPTSWP-FLYBACK
215 DO 800 =IBEGCHK9 LAST
220 IF (YLASEH .GE. XLEVEL(I)) ZLGO TO 900
221 M = M + 1
222 CONTINUE
IBEGIN = M
224 IF (FKSPT .EQ. 3*YES) GO TO 175
225 VELOLAS(IPOINT) = VELOLAS(IPOINT - 1)
TIME2(IPOINT) = TIME2(IPOINT-1) + (NTS/2*CHANNE2*TIMRAT2/DIGRAT2)
IF TIME2(IPOINT) GT ITIME = (TIME2(IPOINT) + IWIND) * IWIND = IWIND + 1
IF (AVEW0(IWIND) .NE. 0) GO TO 820
IF (EXIT .EQ. 3) GO TO 926
IF (WRITE .EQ. 3) CALL LA5WRIT
IPOINT = 1
810 CALL SPEED
CALL AVEWINO
IF (PRINTOK .EQ. 3) WRITE (6,7) NFILE2, NTAPE2
GO TO 825
820 IWIND = IWIND + 1
IF (AVEWD(IWIND) .EQ. 0) GO TO 820
825 IF (PRINTOK .EQ. 3) WRITE (6,7) NFILE2, NTAPE2
IF (EXIT .EQ. 3) GO TO 926
IF (PRINTOK .EQ. 3) WRITE (6,7) NFILE2, NTAPE2
875 IPOINT = IPOINT + 1
GO TO 175
900 IF (YLASER(I+1) LT YLASER(I)) GO TO 925
I = 1 + 1
M = M + 1
GO TO 900
925 TIME2(IPOINT) = TIMRAT2*(((TIME2-ZEROT2)/10000 + (M * CHANNE2)/
DIGRAT2)

FSTPT = Y Hz
IF (TIME2(IPOINT) - GE. FSTPT) A. CHNGIR .EQ. 3) CALL CONSTMR
IF (TIME2(IPOINT) - GT. FSTPT) IWIND = IWIND + 1
IF (AVEWD(IWIND) .NE. 0) GO TO 930
IF (EXIT .EQ. 3) GO TO 930
IF (WRITE .EQ. 3) CALL LA5WRIT
IPOINT = 1
926 CALL SPEED
CALL AVEWINO
IF (PRINTOK .EQ. 3) WRITE (6,7) NFILE2, NTAPE2
GO TO 935
930 IWIND = IWIND - 1
IF (AVEWD(IWIND) .EQ. 0) GO TO 930
935 W0IREC = AVEW0(IWIND) = DIREC
W0IREC = DIREC * 2 * 3.14/ 360.
VELAS = (IPOINT) - (1 + 4) * (CALVELCOS(W0IREC))
IF (PRINTOK .EQ. 3) GO TO 1000
960 WRITE (6,8) TIME2(IPOINT), VELAS(IPOINT), NTAPE2
3 FORMAT (1, 8(E8.3*15E6.3))
1000 IPOINT = IPOINT + 1
IBegin = M
IF (M LE. LENARR2) GO TO 175
GO TO 150
END
SUBROUTINE TAPECAL
COMMON/BTAPECA/NCHANTPNCALVAL.VARITPACTVOLI (5)
COMMON/BLOCKI/LENARR1.WINDIRE(100),NRECOR1,NFILE1,
* ZEROTM1,DIHMIsQR(100).VOLT(2,100IWRIOAT)
COMMON/BCALR/SLOPE(2).ZERUTAP(2),SLOPEANANINTERSLOPEHW9
* SLOPEWDqWDINTEQ*SLOePEMODMINTER
DIMENSION SUMCAL(2).*SUMTAP(2).SOVALUE(2),SU4ACT(2),ACT

IMPLICIT 0
NSAMPLE = 0
LASTCAL = 0
ICALVAL = 1
DO 100 I=NCHANTP
SU’4EAN(I) = 0.0
TEMPSUMM 0.0
SUMCALMI = 0.0
SUMACTMI = 0.0
SU’4TAP(I) = 0.0
SOVALUE(!) 0.0
ACTX TAPMI = 0.0
TEPMEANIl) = 0.0
RECMEAN(I) = 0.0
DO 100 J=1.NCALVAL
2A
SUMP4(1,J) = 0.0
NSAMPLE = 0
CALL BUFLASI
IF (ICALVAL .EQ. NCALVAL) LASTCAL = LASTCAL + 1
DO 120 I=1,NCALVAL
SUMCAL(I) = SUMCAL(I) + VOLT(1+K)
100 SUMSO(I) = SUMCAL(SUMCAL(1)/LENARR1)
IF (ical VAL = 1) GO TO 151
NSAMPLE = NSAMPLE + 1
DO 140 I=1,NCALVAL
SUMP4(1,J) = SUMCAL(I)/LENARR1
IF (NSAMPLE .EQ. 1) GO TO 125
IF (ICALVAL .GT. NCALVAL .A. LASTCAL .GT. 3)
GO TO 180
DO 125 K=1,LENARR1
SUMCAL(I) = SUMCAL(I) + VOLTS1.*Z
SUMMEAN(I) = SUMMEAN(I) + RECMEAN(I)
SUMCAL(I) = 0.0
TOTMEAN(I) = SUMMEAN(I)/NSAMPLE
IF (I .EQ. 1) WRITE(6)1HX.RECMEAN(1),TOTMEAN(I),ICALVAL .A. VARI TP .A. RECMEAN(I)
X.TT.RECMEAN(I),ICALVAL .A. VARI TP .A. RECMEAN(I)

140 WRITE(6,2)1,ICALVAL,NSAMPLE FOR CUMULATIVE MEAN
2 FORMAT(16,1X,RECMEAN(1),TOTMEAN(I),ICALVAL)NSAMPLE
GO TO 110
150 NSAMPLE = NSAMPLE - 1
ICALVAL = ICALVAL + 1
151 IF (ICALVAL .GT. NCALVAL .A. LASTCAL .GT. 3) GO TO 180
SUBROUTINE TAPECAL TRACE

ICHECK = ICHECK + 1
WRITE(6,5)IREC10,ICALVAL,ACTVOLT(ICALVAL)
5 FORMAT(10D5.1,5X,TMPVALEN*RECORD NUMBER*14,1X,_CALIBRATION NUMBER*14,1X,INPUT VALUE *12,5X,INPUT VALUE *FS.1/11X,CHANNEL*10X,MEAN)
60 DO 170 I=1,NCALTP
RECMEAN(I) = SUMCAL(I)/LENARR1
WRITE(6,91)ICHECK
91 FORMAT(1H0,12X,MEANS*CALIBRATION
5 FORMAT(IIHO.SX*TEMPORARY MEANS*dX*KECORO
NUMBER44,IX*CALIBRATION *@I2.4X*INPUT VALUE
*FS.1/11X*CHANNEL0XRM5*)
70 DO 170 1=1,NCHAN
SUNCAL(I) = 0.0
75 IF (ICHECK .EQ. 1) GO TO 160
DO 155 K=1,LENARR
155 SUMSO(I,ICALVAL) = SUMSO(I,ICALVAL) + VOLT(I,K)**2
TEMPSUM(I) = TEMPSUM(I) + RECMEAN(I)
160 IF (RECMEAN(I) .GT. 0.1+RECMEAN(I) + VARITP .GT. RECMEAN(I))
CONTINUE
70 CONTINUE
IF (ICHECK .LE. 3) GO TO 180
IF (GOTOEF .LE. 3) GO TO 110
DO 175 I=1,NCALTP
175 SUMSO(I,ICALVAL) = 0.0
ICHECK = 0
ICALVAL = ICALVAL + 1
GO TO 110
180 IF (END = ICALVAL) I=1
180 WRITE(6,8)IEND,ACTVOLT(IEND)
8 FORMAT(10D5.1,5X,STANDARD DEVIATIONS*10X,_CALIBRATION*12,5X,INPUT VA
LUE*FS.1/11X,CHANNEL*10X,MEAN*)
DO 190 I=1,NCALTP
190 STANDEV(I) = SQRT(SUMSO(I,END)/NSAMPLE*LENARR1) -
TOMEAN(I)/IEND**2
190 CONTINUE
WRITE(6,9)IEND,STANDEV(I)END)
9 FORMAT(1H0,12X,STANDARD DEVS*NSAMPLE=ICHECK = 1
DO 195 I=1,NCALTP
TOMEAN(I,ICALVAL) = TEMPUSM(I)/NSAMPLE
195 IF (ICALVAL .LE. NCALVAL) GO TO 110
WRITE(6,10)NSAMPLE,ICALVAL
10 FORMAT(1H0,12X,ACTUAL VS TAPE VOLTAGE*10X,CALCULATIONS*NSAMPLE*NU
BER RECORDS USED FOR CALCULATIONS*13)
DO 210 I=1,NCALTP
DO 200 J=1,NCALVAL
SUNTAP(I) = SUMTAP(I) + TOMEAN(I,J)
SOVALUE(I) = SOVALUE(I) + TOMEAN(I,J)**2
200 SUMPACT(I) = SUMPACT(I) + ACTVOLT(J)
ACT X TAP(I) = ACT X TAP(I) + TOMEAN(I,J)*ACTVOLT(J)
105 SUMPACT(I) = SUMPACT(I) + ACTVOLT(J)
ACT X TAP(I) = ACT X TAP(I) + TOMEAN(I,J)*ACTVOLT(J)
SLOPE(I) = (SUMPACT(I)*SUMTAP(I) - NCALVAL*ACT X TAP(I)) /
(SUMPACT(I)**2 - NCALVAL*SOVALUE(I))
ZEROPTAP(I) = (SUMPACT(I)*ACT X TAP(I) - SUMTAP(I)*SOVALUE(I)) /
(SUMPACT(I)**2 - NCALVAL*SOVALUE(I))
WRITE(6,111)ACTVOLT(J),TOMEAN(I,J),J,NCALVAL
11 FORMAT(1H0,10X,C X H A N N E L X J,15X,VALUES USED FOR LEAST SQUARE C
SUBROUTINE TAPECAL TRACE

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CALCULATIONS #10X INPUT VALUE #5X TAPE VALUE #/109X.1.X11X.3I)
210 WRITE(6,12)SLOPE(I)+ZEROTAP(I)
12 FORMAT(1X0,15X VALUES OBTAINED FROM LEAST SQUARE CALCULATIONS 7X
 .SLOPE#X INTERCEPT#/68X.51X5F.3J)
PRINT 13
13 FORMAT(1H1)
RETURN
END
SUBROUTINE INSTCAL

COMMON/BINSTCA/NINSCAL,VARIIN,FULSCAWZEROWOFULSCAM9ZEROM

* FRSTINT

COMMON/BLOCK/LENARRI,WINDIRE(100),NRECORI,NFILE1.

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DIMENSION SUMSQW(3),SUMSQD(3),TMEANW(3),TMEANMD(3),STDEVW(3),

STDEVMD(3)

LEVEL = IGHZERO INPUT
NRECORI = 0
IF (FRSTINT .EQ. 3HYES) NRECORI = 1
SUMW = 0.0
SUMMD = 0.0
SUMAVEW = 0.0
SUMAVEMD = 0.0
NSAMPLE = 0
INSCAL = 1
TEMPW = 0.0
TEMPMD = 0.0
ICHECK = 0
DO 100 1 = I,INSCAL

SUMW(I) = 0.0
100 SUMMD(I) = 0.0
IF (NRECORI .EQ. 1) GO TO 175
175 CALL BLFLASI
GOTO 150
IF (NFILEI .GT. 1) 60
100
30 SUMW = SUMW + WINDIRE(K)
200 SUMMD = SUMMD + WINDIRE(K)
AVEW = SUMW/LENARRI
AVEMD = SUMMD/LENARRI
SUMW = 0.0
SUMMD = 0.0
IF (NRECOR1 .EQ. 1) GO TO 300
IF (ICHECK .GT. 0) GO TO 600
IF (AVEW .GT. TMEANW(INSCAL) + VARIIN) GO TO 500
300 SUMAVEW = SUMAVEW + AVEW
SUMAVEMD = SUMAVEMD + AVEW
NSAMPLE = NSAMPLE + 1
TMEANW(INSCAL) = SUMAVEW/NSAMPLE
TMEANMD(INSCAL) = SUMAVEMD/NSAMPLE
WRITE(6,1)NRECORI,LEVEL,AVEW,TMEANW(INSCAL),TMEANMD(INSCAL),NSAMPLE,AVEW,

TMEANMD(INSCAL) = NSAMPLE
40 FORMAT(1H0.5K INSTRUMENT CALIBRATION*##RECORD MEANS##RECORD 13*

5X*INPUT##10X*INSTRUMENT##10X*RECORD MEAN##10X*CUMULATIVE MEAN*

10X*NUMBER OF RECORDS IN CUMULATIVE MEAN##7X*MINOR DIRECTION*6X

5X*6.3, 19XF6, 3, 30X12

100 DO 400 K = 1,LENARRI

SUMSQW(INSCAL) = SUMSQW(INSCAL) + WINDIRE(K)**2
400 SUMSQD(INSCAL) = SUMSQD(INSCAL) + WINDIRE(K)**2
GO TO 150
500 INSCAL = INSCAL + 1
600 ICHECK = ICHECK + 1
IF (ICHECK.LT.2) GO TO 150
TEMPWO = TEMPWO + AVEWD
TEMPMD = TEMPMD + AVEMD
IEND = ICHECK - 1
LEVEL = 10*FULL SCALE
WRITE(6,9) IENDD, AVEWD, TEMPMD, IEND, AVEWD, TEMPMD, IEND
2 FORMAT(10X*TEMPORARY SUM*10X*RECORD*10X*INPUT*10X*AVEW*10X*INS
*TRUNCATION*10X*RECORD MEAN*10X*SUM OF RECORD MEANS*10X*NUMBER OF RECO
*RS IN SUM*7X*ERROR DIRECTION*9X*F6.3*20X*F6.3*325X12*8X*WIND DIR
*CTION*10F6.3*320F6.3*25X12)
DO 700 K=1,LENARR
SUMSQWD(INSCAL) = SUMSQWD(INSCAL) + WINDIREK**2
700 SUMSQWD(INSCAL) = SUMSQWD(INSCAL) + DIREK**2
800 IF (AVEWD.GT. TMEANWD(INSCAL) + VARWD(INSCAL)) GOTOBUF 3HYES
IF (ICHECK .GT. 3) GO TO 900
IF (GOTOBUF .EQ. 3HYES) GOTO 150
SUMSOMD(INSCAL) = 0.0
SUMSOMD(INSCAL) = 0.0
ICHECK = 0
REGION = 0.0
TEMPMD = 0.0
INSCAL = INSCAL - 1
GO TO 150
850 INSCAL = INSCAL + 1
900 IEND = INSCAL - 1
LEVEL = 10*ZERO INPUT
IF (IEND .LE. 2) LEVEL = 10*FULL SCALE
STDEVMD(IEND) = SQRT(SUMSQD(IEND)/(NSAMPLE*LENARR)) -
* TMEANWD(IEND)**2
STDEVWD(IEND) = SQRT(SUMSQD(IEND)/(NSAMPLE*LENARR)) -
* TMEANWD(IEND)**2
WRITE(6,9) IEND, LEVEL, STDEVMD(IEND), STDEVWD(IEND)
3 FORMAT(10X*STANDARD DEVIATIONS*10X*CALIBRATION*10X*INPUT *
10X/10X*INSTRUMENT*10X*NS*/7X*ERROR DIRECTION* 6X*F5.3*8X*WIND D
*ITION*7F6.3)
LEVEL = 10*FULL SCALE
NSAMPLE = ICHECK - 1
SUMAVEW = TEMPWO
SUBAVE = TEMPMD
TMEANWD(INSCAL) = SUMAVEW/NSAMPLE
TMEANMD(INSCAL) = SUMSUB/NSAMPLE
TEMPD = 0.0
TEMPMD = 0.0
ICHECK = 0
100 IF (INSCAL .LE. MJNSCAL) GO TO 150
SLOPEWD = (FULLSCA-ZEROW0D)/TMEANWD(2)-TMEANWD(1))
SLOPEMD = (FULLSCA-ZEROMD/TMEANMD(2)-TMEANMD(1))
OMINTER = FULLSCA - SLOPEMD*TMEANMD(2)
WININTER = FULLSCA - SLOPEWD*TMEANWD(2)
WRITE(6,9) IEND, TMEANWD(1), TMEANMD(1), TMEANWD(2), TMEANMD(2), FULLSCA, SLOPEMD, SLOPEWD, WININTER
4 FORMAT(10X*INSTRUMENT CALIBRATION*5X*NUMBER OF RECORDS USED*13/
10X*ERROR DIRECTION*15X*VALUES USED FOR CALIBRATION*10X*INPUTS
,5X*TAPE VALUE*5X*ACTUAL VALUE*/5X*ZEROS*6X,F6.3*10X,F7.3*9X*FULL
, SCALE*4*F6.3*10X,F7.3*15X*VALUES OBTAINED*22X*SLOPE*5X*INTERCEPT*/
SUBROUTINE INSTCAL  TRACE

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*5*X*6*X*7.3/10*X*WIND DIRECTION*/  15*X*VALUES USED FOR CALIBRATION*
*ON*10*X*INPUT*5*X*TAPE VALUE*5*X*ACTUAL VALUE*/5*X*ZERO*6*X*6*X*10*X*7
*3*/49*X*FULL SCALE*4*X*6.3*10*X*7.3/15*X*VALUES OBTAINED*22*X*SLOPE*5*X
*INTERCEPT*/5*X*7.3*6*X*7.3)

RETURN
END
SUBROUTINE LASCAL
COMMON/BLASCAL/NCALREC,NWPREC,IBEGCHK,CALEVEL,CALVELO,NWLEN
COMMON/BLOCK2/LENARR2,SYNC(1500),YLASER(1500),NRECOR2,NFILE2
COMMON/BLASER/NFLYBAC,NPTSWP
DIMENSION NPTRIG(20)
NEXT = 0
NPTSWP = 0
SLASTPT = 10.0
CALVELO = 0.0
NSAMPLE = 0
NSWPS = 0
LASTPT = 0
GO = 3M NO
LEFTOVR = 0
100 CALL BUFLAS2
IF (NRECOR2 .GT. NCALREC) GO TO 900
150 NTRIG = 1
DO 50 J = 1, 20
50 NPTRIG(J) = 0
DO 500 K = 1, LENARR2
IF (K .GT. 1) GO TO 200
IF (SYNC(K) .GT. 0.0) .AND. (SLASTPT .LT. 0.0) GO TO 300
GO TO 500
200 IF (SYNC(K) .GT. 0.0) .AND. (SYNC(K-1) .LT. 0.0) GO TO 300
GO TO 500
300 IF (GO .EQ. 3M NO) GO TO 400
NPTSWP = NPTSWP + K - LASTPT + LEFTOVR - 1
NSWP = NSWPS + 1
LEFTOVR = 0
400 NPTRIG(NTRIG) = K - 1
NTRIG = NTRIG + 1
LASTPT = K - 1
GO = 3MYES
500 CONTINUE
SLASTPT = SYNC(LENARR2)
LEFTOVR = LENARR2 - NPTRIG(NTRIG-1)
LASTPT = 0
NEXT = 0
NTRIG = 1
NAVEPTS = NPTSWP / NSWPS
600 ISTART = NPTRIG(NTRIG) + IBEGCHK
LAST = NPTRIG(NTRIG) + NAVEPTS - NFLYBAC
IF (LAST .GT. LENARR2) NEXT = LAST - LENARR2
IF (LAST .GT. LENARR2) LAST = LENARR2
DO 700 I = ISTART,LAST
IF (YLASER(I) .GT. CALEVEL) NFAT = 0
IF (YLASER(I) .GT. CALEVEL) GO TO 800
700 CONTINUE
IF (NEXT .EQ. 0) GO TO 750
CALL BUFLAS2
DO 725 J = 1, NXT
IF (YLASER(J) .LE. CALEVEL) GO TO 725
I = J + LENARR2
SUBROUTINE LASCAL
TRACE

GO TO 800
CONTINUE
IF (NRECOR2 .GT. NCALREC) GO TO 900
GO TO 150

750 NTRIG = NTRIG + 1
IF (NPTRIG(NTRIG) .GT. 0) GO TO 600
IF (NRECOR2 .GT. NCALREC) GO TO 900
GO TO 100

800 IF (YLASEM(I+1) .GT. YLASEM(I)) I = I + 1

CALVELO = CALVELO + 1 - NPTRIG(NTRIG)
NSAMPLE = NSAMPLE + 1
NTRIG = NTRIG + 1
IF (NRECOR2 .GT. NCALREC) GO TO 900
IF (NEXT .GT. 0) GO TO 150
GO TO 100

CALVELO = CALVELO/NSAMPLE
NSWP = CALVELO/NSWP
WRITE(6,5)NRECOR,CALVELO,NSWP

5 FORMAT (I5,N5,R15.4)

CALVELO = (WAVLEN*DEVFREQ)/(2*CALVELO)
WRITE(6,6)CALVELO

6 FORMAT (I5,10X,F5.4)
RETURN
END
SUBROUTINE NOISCAL
COMMON/BNOISCAL/FLYBACK,NOISREC,XLEVEL(175)
COMMON/BLASER/FLYBACK,NOISREC,XLEVEL(175),NFILE2
DIMENSION SUMPTS(300)
100 SUMPTS(I) = 0.0
150 CALL BUFBLAS2

DO 200 I = 1, LENARRZ
175 IF (YLASER(I) .GT. FLYBACK) GO TO 300
200 CONTINUE

DO 400 J = 1, LENARRZ
300 JCOUNT = JCOUNT * 1
400 CONTINUE

DO 600 M = 1, NPTSWP
500 ISTART = J - 1
550 DO 600 K = ISTART, LENARRZ
600 CONTINUE

DO 800 I = 1, LAST
700 NSAMPLE = NSAMPLE + 1
750 NSAMPLE = NSAMPLE + 1
800 XLEVEL(I) = SUMPTS(I) / NSAMPLE
850 WRITE (bl1) (XLEVEL(I), I=1, LAST)
900 FORMAT (INO, *NOISE LEVELS*, /, 11X, 15(F8.3))
950 1 FORMAT (INO, *NOISE LEVELS*, /, 11X, 15(F8.3))
1000 XLEVEL(I) = 40.0
1050 RETURN
END
SUBROUTINE BUFLAS1

COMMON/BBUFLA1/NITOTFIl,JCLOCK1,EXIT,TIMADA,NREC
COMMON/BLOCKI/LENARR,WINDRE(100),NRECOR!,NFILE!
    ,ZEROTM!,DIMARR(100),VOLT(2,100),WRIDATI
COMMON/BSPKED1/LPACDA1,,IDENT!,NFLSKP!,NRCSPK!
COMMON/UNPK1/ITIME1,IWRD(I201),IUNIT1=10001
CONT(I) = 3M = NO
100 BUFFER IN(1,1) (ITIME1+IWRD(I201))
    IF (UNIT(I)) & 200, 400
110 WRITE(I6+1) NRECOR!,NFILE!
    1 FORMAT(IH0,* THRE! ARE*15 RECORDS ON FILE*13 UNIT 1. ENCOUNTERE
    0 IN BUFLAS1!
    NRECOR = 0
    NFILE! = NFILE! + 1
    IF (NFILE! GT. NITOTFIl) GO TO 300
    IF (IDENT! ,EQ. 3HYES) CALL HEADER1
    GO TO 150
300 EXIT= 3HYES
RETURN
400 NRECOR! = NRECOR! + 1
    LEN = LENGTH(1)
    WRITE(I6+2) NRECOR!,NFILE!,LEN
2 FORMAT(IHO,* PARITY ERROR ON NEXT DATA. RECORD=15* FILE=14,5* NU
    .BER OF COMPUTER WORDS=14)
    IF (LEN >NL, LPACDA1) GO TO 100
    CALL UNPAK1
    CALL SORT1
    IF (WRIDAT!, ,EV. 3M NO) CALL DATWR1
    GO TO 600
500 NRECOR! = NRECOR! + 1
    LEN = LENGTH(1)
    IF (LEN NE. LPACDA1) GO TO 700
    CALL UNPAK1
    CALL SORT1
35 IF (NRECOR! ,EQ. 1) ZEROTM! = ITIME1
    IF (ITIME1 GT. 9999949 GT. -12000) CONT(I) = 3HYES
    ITIME1 = ITIME1 + JCLOCK1 + 9999994 + TIMADA/(NREC-1)*(NRECOR!-1)
    IF (CONT(I), ,EQ. 3HYES) JCLOCK1 = JCLOCK1 + 1
RETURN
600 IF (NRECOR!, ,EQ. 1) ZEROTM! = ITIME1
    IF (ITIME1 GT. 9999949 GT. -12000) CONT(I) = 3HYES
700 WRITE(I6,3) NRECOR!,NFILE!,LEN
3 FORMAT(IHO,* RECORD ENCOUNTERED OF IMPROPER LENGTH ON UNIT 1. REC
    O*G*14* FILE=12* NUMBER OF COMPUTER WORDS=14)
    GO TO 100
800 RETURN
END
SUBROUTINE HEADERI
COMMON/BLOCK1/LENARRI1,WINDIRE(100)*NRCDORI1,NFILEI1*
ZEROTM1,HARMINR(100)*VOLT(2),100+WRIDAT1*
COMMON/BHEADI1/ID(9)
50 BUFFER IN(1,0)(1D(1)+ID(9))
IF (UNIT(1)=300+200+100
200 PRINT 1+NFIL11
1 FORMAT(1HO,** EOF READ IN HEADER ON FILE*12* UNIT 1*)
GO TO 50
10 PRINT 2+ NFIL11
1 FORMAT(1HO,** PARITY ERROR IN HEADER ON FILE*12* UNIT 1*)
300 LEN = LENGTH(1)
PRINT 3+ NFIL11,(ID(1)+1)+LEN
3 FORMAT(1HO,** IO ON UNIT 1+ FILE*12* IS *2A10* NUMBER OF COMPUTER W
1E ,CROS+1+)
RETURN
END
SUBROUTINE SORTI
COMMON/BSORTI/IBE6SK1, ISKIP, EFACTORI
COMMON/BLOCKI/LENARR1, WINDIRE(100), NRECOR1, NFILE1,
  ZEROTM1, DIRMIRR1(100), VOLT(12*100), WRIDATI
COMMON/UNPKI/ITIME1, ITIME1, ICNTWRD(201), IOATWRD(1000)
M = IBE6SK1
DO 100 I = 1, LENARR1
  WINDIRE(I) = IDATWRD(M) * EFACTOR1
  VOLT(1+I) = IDATWRD(M+1) * EFACTOR1
  DIRMIRR1(I) = IDATWRD(M+2) * EFACTOR1
  VOLT(2+I) = IDATWRD(M+3) * EFACTOR1
100 M = M + [SKIP]
IF (WRIDATI.EQ. 3*YES) CALL NAWRI1
RETURN
END
SUBROUTINE DATWRII TRACE

COMMON/BLK1/LENARR1, WINDIRE(100), NRECOR1, NFILE1
COMMON/ZEROH1, IORM1, VAR4(10), VOLT1(2,100), WRIDAT1
COMMON/UNPKI/ITIME1, WATWRD(100), DATWRD(1000)

WRITE (6+1) NRECOR1, ITIME1
1 FORMAT (1H) 'RECORD NUMBER' 
2 WRITE (6+2) (VOLT(1)+1)+1, LENARR)
WRITE (6+2) (VOLT(2)+1)+1, LENARR)
WRITE (6+2) (WATWRD(I)+1), LENARR)
WRITE (6+2) (DATWRD(I)+1), LENARR)
RETURN
END
SUBROUTINE BUFLAS2
COMMON/BBUFLA2/JCLOCK2*1ETIME*1REC2*1REC3*1REC4*1TIMADJ2*1TIMADJ3*1TIMADJ4
* TIMADJ3*TIMADJ4
COMMON/BBLOCK2/LENARR2*SYNC(1500)†YLASER(1500)†1REC2*1FILE2
* NREC2*1NTAPE‡
COMMON/BBUFA2/ZEROTM2*WRIDAT2*NTAPE2
COMMON/BSKPEO2/LPACDA2*NTAPE2*1TIMADJ2*1TIMADJ2*1TIMADJ3*1TIMADJ4
COMMON/BSPEEO2/NTOTF2*IDENT2*1FILE2*1NTAPE2
COMMON/BSSPE2/NTOTAPE†EXIT2*1TIMADJ2*1TIMADJ2
COMMON/Bwaze2/ITIME2*1VELeLAS†500)*IPOINT2
COMMON/UNPK2/LTIME2*LCOMWRU2*1POINT2
COMMON/UNPK2/ITIME2*LCOMWRU2(LPACDA2)
CORTIM2 = 3H NO
100 BUFFER INV2*11ITIME2*LCOMWRU2(LPACDA2)
IF (UNIT2) 400*200.300
200 WRITE(6.1) NREC2*1FILE2*NTAPE2
1 FORMAT (1HO* THERE ARE*16* RECORDS ON FILE*13* TAPE*12)
 NFIE2 = NFILE2 + 1
 NREC2 = 0
 IF (NFILE2 .GT. NTOTF2) GO TO 250
225 IF (IDENT2 .EQ. 3HYES) CALL HEADER2
 GO TO 100
250 NTAPE2 = NTAPE2 + 1
 IF (NTAPE2 .GT. NTOTAPE) GO TO 600
 IF (NFILE2 .EQ. NTOTF2) CALL UNLOAD2
 JCLIENT2 = O
 IETIME2 = 1STORM
260 GO TO (220.230.240)*NTAPE2
220 NTOTREC2 = NREC2
 TIMADJ2 = TIMADJ2
 GO TO 225
230 NTOTREC2 = NREC3
 TIMADJ2 = TIMADJ3
 GO TO 225
240 NTOTREC = NREC4
 TIMADJ2 = TIMADJ4
 GO TO 225
300 NREC2 = NREC2 + 1
 LEN = LENGTH2
 WRITE (6.3) NREC2*1FILE2*NTAPE2*LEN
3 FORMAT (1HO* PARITY ERROR ON RECORD*16* FILE*13* TAPE*12* NUMBER
 OF COMPUTER WORDS*14)
 IF (LEN .NE. LPACDA2) GO TO 100
 CALL UNPAK2
 CALL S092
 IF (UNIT2 .EQ. JH NO) CALL DATWR2
 GO TO 300
400 NREC2 = NREC2 + 1
 LEN = LENGTH2
 IF (LEN .NE. LPACDA2) GO TO 450
 WRITE(6.3) LEN*1REC2*1FILE2*1TIMADJ2*1TIMADJ4
4 FORMAT (1HO* ENCOUNTERED RECORD OF IMPROPER LENGTH. LENGTH WAS*13*
 OF COMPUTER WORDS. THIS OCCURRED ON RECORD*15* FILE*12* TAPE*12* ON
SUBROUTINE BUFLAS2 TRACE

UNIT 2*)
GO TO 100
450 CALL UNPAK2
CALL SORT2
500 IF (NTOTREC .EQ. 0) RETURN
IF (NRECOR2 .EQ. 1) ZEROTM2 = ITIME2
IF (ITIME2 = 999999 .GT. -935) CORTIM2 = 3HYES
ITIME2 = ITIME2 + JCLK2*999999*(TIMADJ/(NTOTREC-1))*(NRECOR2-1)
* IEXTIME
550 IF (CORTIM2 .EQ. 3HYES) JCLOCK2 = JCLOCK2 + 1
ISTORTM = ITIME2
IF (NRECOR2 .LE. NTOTREC) RETURN
WRITE(6,2) NRECOR2+NTAPE2
2 FORMAT(1X,5X*REACHED RECORD#15* ON TAPE*12* WITHOUT EOF*)
GO TO 200
600 IF (WHITAPE .NE. 3HYES) CALL EXIT
LENARR2 = 1
CALL LASWHIT
700 ENDFILE 3
75 ENDFILE 3
ENDFILE 3
ENDFILE 3
REWIND 3
CALL EXIT
RETURN
END
SUBROUTINE HEADER2
COMMON/BLOCK2/LENARR2*SYNC(1500)+YLATER(1500)+NRECOR2*NFILE2+
* ZEROTM2*WRDAT2*NTAPE2
* COMMON/BHEAD2/ID(9)
50 BUFFER IN(2,0) (ID(1),ID(9))
1 IF (UNIT(2)) 300,100,200
100 PRINT 1+NFIE2+NTAPE2
1 FORMAT(1HG,* EOF IN HEADER ON FILE*12* TAPE*12* ON UNIT 2,*1)
GO TO 50
10 PRINT 2+ NFIE2+NTAPE2
2 FORMAT(1HG,* PARITY ERROR IN HEADER ON FILE*12* TAPE*12* UNIT 2,*1)
300 LEN = LENGTH(2)
3 PRINT 3+ NFIE2+ NTAPE2+(ID(1),I*1,2)+LEN
3 FORMAT(1HG,* 10 ON FILE*12* TAPE*12* UNIT 2 IS *2A10* NUMBER OF CO
*PUTER WORDS*I=1)
RETURN
END
SUBROUTINE SORT2
COMMON/BSORTZ/IBEGSK2+ISKIP2
COMMON/BLOCKZ/LENARR2+SYNC(1500)+YLASER(1500)+NRECOR2+NFIL22
COMMON/LOCKU/LENARR2+SYNC(1500)+YLASER(1500)+WFILEZ2
ZENOTM2+WRDATZ+MTAPEZ
COMMON/JUNKZ/TIMEZ+LCONWRD+LOATWRD(1661)+LOATWRD(3000)
M=IBEGSK2
DO 100 I=1+LENARR2
SYNC(I) = LOATWRD(M)
YLASER(I) = LOATWRD(M+1)*(-1.4)
100 M=M+ISKIP2
IF (WRDATZ .EQ. 3YES) CALL OATWRZ
RETURN
END
SUBROUTINE OATWRIZ

COMMON/BLOCK2/LENARR2,SYNC(1500),YLASER(1500),NRECOR2,NFILE2,
ZEROTH2,WRIAT2,NPA2

COMMON/UNPK2/ITIME2,LCOMWRD1,NDATE2,NCITE2

WRITE (691) NRECOR2,ITIME2
I FORMAT (19** RECORD NUMBER=I9*)
WRITE (6.2) (SYNC(I),I=1,LENARR2)
2 FORMAT (1M0.1,F10.5,F10.5)
WRITE (6.2) (YLASER(I),I=1,LENARR2)
10 RETURN
END
SUBROUTINE SKPEOFI
COMMON/BLOCK1/LENARR1,VINDIR(100),NRECOR1,NFILE1,
* ZEROTM1,DIRM1(100),VOLT(1,100),WRD(1,100)
COMMON/UNPK1/ITIME1,COMWRD(1,10),ATWRD(1,10)
COMMON/BSKPEOF1/LPACDA1,IDENT1,NFLSKP1,NRCSP1
NREC = 0
IF (NFLSKP .LE. 0) GO TO 500
NFLSKP = 1

100 BUFFER IN(1)(ITIME1)COMWRD(LPACDA1)
IF (UNIT(1)) .LE. 0, GO TO 100
NREC = NREC + 1
NRECOR = NRECOR + 1
WRITE(6.2) NRECOR1,NFILE1,NFLSKP1,NREC,LEN
2 FORMAT(1H0,* PARITY ERROR IN RECORD*10* FILE*12* ON UNIT 1. ENCOUNTERED WHILE SKIPPING FILE*13*, LENGTH OF RECORD*14*, COMPUTER WORDS*)
GO TO 100

100 LEN = LENGTH(1)
NREC = NREC + 1
NRECOR = NRECOR + 1
WRITE(6.3) LPACDA1,LEN,NRECOR1,NFILE1
3 FORMAT(1H0,* A RECORD WAS ENCOUNTERED WITH LENGTH NOT EQUAL TO*14*, COMPUTER WORDS, LENGTH WAS*14*,/5X NUMBER RECORDS SKIPPED*13*,
* NUMBER OF RECORDS TO BE SKIPPED*12*, LENGTH OF RECORD*14*, COMPUTER WORDS*)
GO TO 100

400 WRITE(6.4)NFLSKP1,NRECOR1,NFILE1,NFLSKP1,NRCSP1
4 FORMAT(1H0,* THERE WERE*15* RECORDS ON FILE*12* UNIT 1.*5X13* RECORDS SKIPPED ON THIS FILE. TOTAL NUMBER OF FILES SKIPPED*12* TOTAL NUMBER TO BE SKIPPED*12*)
NFLSKP = NFLSKP + 1
NREC = 0
NRECOR = 0
IF (IDENT..EQ. +YES) CALL HEADER1
IF (NFLSKP .LE. NFLSKP1) GO TO 100
IF (NRCSP .GT. 0) GO TO 500
RETURN

500 DO 900 I=1,NRCSP1
BUFFER IN(1)(ITIME1)COMWRD(LPACDA1)
IF (UNIT(1)) .LE. 0,700,600
600 LEN = LENGTH(1)
NREC = NREC + 1
NRECOR = NRECOR + 1
WRITE(6.5) NFLSKP1,NRECOR1,NFILE1,NRCSP1,LEN
5 FORMAT(1H0,* PARITY ERROR IN RECORD*14* FILE*12* ON UNIT 1.*5X LENGTH OF RECORD WAS*14* COMPUTER WORDS*)
GO TO 900

700 WRITE(6.6) NFLSKP1,NRECOR1,NFILE1
6 FORMAT(1H0,* EOF REACHED WHILE TRYING TO SKIP*10* RECORDS.*16* RECORDS*5X HAVE BEEN SKIPPED. RECORD NUMBER*14* FILE*12* ON UNIT 1*)
GO TO 900

800 NREC = NREC + 1
SUBROUTINE SKPEOFI TRACE

NREC = NREC + 1
LEN = LENGTH(I)
IF (LEN .NE. LPACDAI) WRITE(6,3)LPACDAI,LEN,NREC,NFILE+
NREC
900 CONTINUE
WRITE(6,7) NREC,NRECKIP,NREC,NFILE+
7 FORMAT(1HO,* COMPLETED SKIPPING*14* RECORDS. NUMBER OF RECORDS TO
, HAVE BEEN SKIPPED*14/S* RECORD NUMBER*15* FILE*12* ON UNIT 1*)
RETURN
END
SUBROUTINE SKPEOF2
COMMON/BSKPEO2/LPACDA2,
COMMON/BUFLA2/LJCOLL2/IPTIME2/NREC2/NREC3/TIMADJ2
 COMMON/BBUFLA2/JCLOCK2/IEXTIME/NREC2/NREC3/TIMAOJ
 COMMON/BLK/LENARR2/SYNC(1500)
 COMMON/UNT/ITIME2/LCOMWR(LPACDA2)
 COMMON/UNPK2/ITIME2/LCOMWR(LPACDA2)
 NREC = 0
 IF (NFLSKP .LE. 0) GO TO 600
 NFILSKP =1
 100 BUFFER IN(2,1) ITIME2/LCOMWR(LPACDA2)
 IF (UNIT(2)) .GT. 300, GO TO 200
 200 NREC = NREC + 1
 NRECOR2 = NRECOR2 + 1
 WRITE(6,2) NFIL2+NTAPE2+NRECOR2+NREC+LEN
 2 FORMAT(10), = PATTERN ERROR OCCURRED WHILE SKIPPING RECORDS ON FILE
 LENGTH OF A RECORD WAS NOT EQUAL TO 14* COMPUTER WORDS
 TOTAL NUMBER OF RECORDS SKIPPED ON THIS FILE
 GO TO 100
 300 NREC = NREC + 1
 NRECOR2 = NRECOR2 + 1
 LEN = LENGTH(2)
 IF (LEN .LT. LPACDA2) WRITE(6,3) LPACDA2+LEN+NRECOR2+NTAPE2+NFILE2
 3 FORMAT(10)+ LENGTH OF A RECORD WAS NOT EQUAL TO 14* COMPUTER WORDS
 TOTAL NUMBER OF RECORDS SKIPPED ON THIS FILE
 GO TO 100
 400 WRITE (6,4) NRECOR2+NFILE2+NTAPE2+NRECOR2+NFILSKP+NFILE2
 4 FORMAT (10),X$ RECOR2 IS NOT SKIPPED ON THIS FILE
 TOTAL NUMBER OF FILES SKIPPED
 GO TO 100
 500 NFILE = NFILE2+1
 IF (NFILE .LE. NTOTFIZ) GO TO 500
 NTAPE2 = NTAPE2 + 1
 IF (NTAPE2 .LE. NTOTAPE) GO TO 450
 IEXIT2 = 3*YES
 RETURN
 450 NTOTF2 = 1
 CALL UNLOADW(2)
 NFILE = 2
 NRECOR2 = 0
 NREC = 0
 GO TO 480
 480 NTOTREC = NRECOR2
 TIMADJ = TIMADJ2
 GO TO 495
 485 NTOTREC = NRECOR2
 TIMADJ = TIMADJ3
 GO TO 495
SUBROUTINE SKPEOF2  TRACE

490 NTOTREC = NREC4
TIMADJ = TIMADJ4
495 IF (IDENT2 .EQ. 3YES) CALL HFADER2
IF (NFLSKP .LE. NFLSKP2) GO TO 100
IF (NRCSKP2 .GT. 0) GO TO 600
RETURN
500 NRECOR2 = 0
NREC = 0
IF (NFLSKP .LE. NFLSKP2) GO TO 475
IF (NTOTREC .LT. NREC) CALL HFADER2
IF (NRCSKP2 .LE. NFLSKP2) GO TO 100
IF (NRCSKP2 .GT. 0) GO TO 600
RETURN
600 DO 1000 I=NRCSKP2, NFLSKP2
BUFFER IN(2,1) (ITIME2+LCOMWD(LPACDA2))
IF (UNIT(2)) 800, 700
700 LEN = LENGTH(2)
NREC = NREC + 1
NRECOR2 = NRECOR2 + 1
WRITE(6,5) NRECOR2, NFLSKP2, NTAPE2, NREC, LEN
5 FORMAT(I0, 5X, PARITY ERROR OCCURRED WHILE SKIPPING RECORDS. RECORD
NUMBER=I5, FILE=I2, TAPE=I2 ON UNIT 2.*5X14 RECORDS HAVE BEEN
SKIPPED. LENGTH OF RECORD WAS I4 COMPUTER WORDS.*)
GO TO 1000
800 WRITE(6,6) NREC, NRECOR2, NFLSKP2, NTAPE2
6 FORMAT(I0, 5X, AN EOF WAS ENCOUNTERED WHILE SKIPPING RECORDS.* I5= RE
CORDS HAVE BEEN SKIPPED.*5X RECORD NUMBER=I5 OF FILE=I2 ON TAPE
ON UNIT 2.*)
GO TO 1000
850 NREC = NREC + 1
NRECOR2 = NRECOR2 + 1
LEN = LENGTH(2)
IF (LEN .NE. LPACDA2) WRITE(6,3) LPACDA2, LEN, NREC, NFLSKP2, NTAPE2,
NRECOR2
3 FORMAT(I0, 5X, SKIPPED RECORD NUMBER=I5 OF FILE=I2 ON TAPE=I2 ON
UNIT 2.*)
GO TO 1000
900 CONTINUE
WRITE(6,7) NREC, NRCSKP2, NRECOR2, NFLSKP2, NTAPE2
7 FORMAT(I0, 5X, COMPLETED SKIPPING I4 RECORDS. NUMBER OF RECORDS TO
HAVE BEEN SKIPPED=I4 RECORD NUMBER=I5 OF FILE=I2 ON TAPE=I2 ON UN
UNIT 2*)
950 RETURN
END
SUBROUTINE CONSTMR TRACE

SUBROUTINE CONSTMR
COMMON/CONSTM/NAVEMIR,DIRECMR,DCHMIR,TIMEMIR
COMMON/BLOCK1/LENARR1,WINDIRE1(100),NRECOR1,NFILE1

COMMON/BCONSTM/NAVEMIR,DIRECMR,DCHMIR,TIMEMIR
COMMON/BLOCK1/LENARR1,WINDIRE1(100),NRECOR1,NFILE1

COMMON/BCALIBR/SLOPE(2),ZEROTAP2,SLOPEAN,ANINTER,SLOPEMW,
SLOPEW,DMINTER

AVEMIR = 0
NRECOR1 = 0
CALL BUFILAI
100 CALL BUFILAI

AVEMIR = AVEMIR + DCHMIR(K)
IF (NRECOR1 .LE. NAVEMIR) GO TO 100
DIRECMR = AVEMIR/LENARR1*NAVEMIR

LAST = NAVEMIR + 1
DO 300 I = 1, LAST
BACKSPACE 1
BACKSPACE 1
CONTINUE
READ(5+1), DCHMIR,TIMEMIR

1 FORMAT (A3,F6.2)
WRITE(5+2),NRECOR1,DIRECMR,SLOPEMW,DMINTER
2 FORMAT (1X,5X,MIRROR DIRECTION*5X,NUMBER OF RECORDS USED FOR AVERAGE
AVERAGE VOLTAGE*SA*SLOPE*SA*INTERCEPT*SA*DIRECTION*DEGR
.ES*14,FT,3,*F7.3F7.3F7.3)
3 FORMAT (1X,5X,MIRROR DIRECTION*DMINTER ,180
DIRECMR = SLOPEMW*DIRECMR + DMINTER + 180
WRITE(6+3),DIRECMR
4 FORMAT (1X,5X,5X,F7.3)
NRECOR1 = 0
RETURN
300 CONTINUE
END
SUBROUTINE VOLTADJ
COMMON/BVOLTAD/ISCALE
COMMON/BCALIBR/SLOPE(2),ZEROTAP(2),SLOPEAN,ANINTER
SLOPEMD,WINTERP,SLOPEMD,WINTERP
GO TO (100,200,300)*ISCALE
100 SLOPEAN = 47.736
ANINTER = -0.411
WRITE(6,1)ISCALE,SLOPEAN,ANINTER
1 FORMAT(1X,5X*ANEMOMETER VALUFS*5X*SCALE*I2/10X*SLOPE*5X*INTERCEP
100 100 100 100
200 SLOPEAN = 93.021
ANINTER = 0.451
WRITE(6,1)ISCALE,SLOPEAN,ANINTER
300 SLOPEAN = 0.0
ANINTER = 0.0
WRITE(6,1)ISCALE,SLOPEAN,ANINTER
RETURN
END
SUBROUTINE SPEED
COMMON/BSPEED/SUMVELO=ISAMPLE, IDATAHW, SUMVOLT+TIMRAT+CHANNL
  DIGRAT+TIMECHG+VOLTCMH+MULTIME+DCSUPRE
+FSIPS0=WRITAPE+PRINTK
COMMON/BUMPUP/TIME1(702)+VELOC2(702)
COMMON/BLOC1/LENAR1=INJIRE(100)+NRECOR1+NFIL1
  ZEROTM=ITIMR1+100+VOLTS+100+WRDATA
  COMMON/BCALIBR/SLOPE(2)+ZEROTAP(2)+SLOPEAN+INTER=SLOPEHW
  SLOPE WDINT+SLOPE+SINTER
COMMON/UNPKI/TIME1=ITIME1+100+TIME1(100)+VELOC1(100)
COMMON/BUFFALAT/HDFIL+JLOCK1+EXITTIMAM+RECOR1
PRINTOK = 3H NO
FIRST = 1
IF (FIRSTP .EQ. 3HYES .A. NRECOR1 .NE. 0) GO TO 25
CALL BUFFALAT
IF (EXIT. .EQ. 3HYES) GO TO 200
DO 100 IDATAWS = KFIRST+LENAR1
  VELOC1(IDATAWS) = SLOPE(1)*VOLT(1.IDATAWS) + ZEROTAP(1)
  VELOC2(IDATAWS) = (SLOPE+VELOC1(IDATAWS) + ANINTER) *0.3947
  VELOC2(IDATAHW) = SLOPE(2)*VOLTCMH + ZEROTAP(2) + DCSUPRE
IF (FRSTSPD .EQ. 3HYES) GO TO 50
SUMVELO = SUMVELO + VELOC1(IDATAWS)
ISAMPLE = ISAMPLE + 1
SUMVOLT = SUMVOLT + VELOC2(IDATAHW)
50 TIME1(IDATAHW) = TIMRAT1*((ITIME1-ZEROTM/10000 + (IDATAWS)
  *CHANNL1)/DIGRAT1)
IF (TIME1(IDATAHW) .GE. TIMECHG .A. VOLTCHG .EQ. 3HYES)
  CALL VOLTAJ
IF (TIME1(IDATAHW) .GE. MULTIME+TIMEHW) GO TO 200
100 IDATAHW = IDATAHW + 1
  FSIPS0 = 3H NO
  START = IDATAHW - LENAR1 + KFIRST - 1
  DO 115 I=KFIRST+LENAR1
    WRITIME(I) = TIME1(I+1)
115  START = START + 1
  IF (NRECOR1 .EQ. 2 .A. NRECOR1 .LE. 0) GO TO 125
  I = NRECOR1 - 1
  IF (MOD(I.30) .EQ. 0) GO TO 125
125 GO TO 140
125 PRINT 3+NRECOR1
  FORMAT (140, + ANEMOMETER VELOCITY, RECORD NUMBER=I4/2S1+TIME=SEC,
  *S5X+ VELOCITY+SEC+II=TIME=SEC+5X+ VELOCITY+SEC+II=TIME=SEC
  +S5X+ VELOCITY+SEC/) PRINTK = 3H YES
  WRITE (1,1) 4 * TIMRAT1+VELOC11+I+LENAR11
1 FORMAT (14.1)XF8.3+11XF6.3+15FX8.3+11XF6.3+15FX8.3+11XF6.3
3 IF (/WRITAPE .NE. 3HYES) RETURN
160 WRITE (6,12) NRECOR1
12 FORMAT (140+ NRECOR1=15)
  BUFFER OUT (3+1) (:4TIME1()+VELOC1(100)
  IF (UNIT(3) .EQ. 180) 140
180 WRITE(6,6) NRECOR1+NFIL1
6 FORMAT (140+ EOF ON RECORD NUMBER=I10+ FILE NUMBER=13)
55 GO TO 400
SUBROUTINE SPEED

AVERAGE VELOCITY = (SUM VELOCITY/NUMBER OF SAMPLES) / 0.3048
AVERAGE VOLTAGE = (SUM VOLTAGE/NUMBER OF SAMPLES)

MULTIPLIER = MULTIPLIER * 1

SLOPE [(AVG VELOCITY - SLOPE) * AVG VOLTAGE] * 2

DO 350 I = 1, IDATAHW
  VELOC2(I) = ((SLOPE * VELOC2(I)**2 * WINTER)**2) * 0.3048
  IF (NRECORD > 2 AND NRECORD <= 8) GO TO 305
  I = NRECORD - 1
  IF (MOD(I, 30) == 0) GO TO 305
  GO TO 310
330 WRITE(6, 10) NRECORD, FILE, M, N
  FORMAT(IH, ** PARITY ERROR ON HW VELOCITY FILE* * FILE*, MN=*, N=*)
GO TO 370
370 WRITE(6, 11) NRECORD, FILE, M, N
  FORMAT(IH, ** EOF ON HW VELOCITY FILE*, MN=*, N=*)
GO TO 370
380 BUFFER OUT(3, I) (TIME(I), TIME(I))
  IF (UNIT(3) .EQ. 3) WRITE(6, 10) NRECORD, FILE, M, N
  IF (EXIT .EQ. 3) RETURN

100 WRITE(6, 7) NRECORD, FILE
  FORMAT(IH, ** PARITY ERROR INPUT ON RECORD NUMBER* FILE NUMBER, N=*)
  GO TO 400

60 AVERAGE VELOCITY = (SUM VELOCITY/NUMBER OF SAMPLES) / 0.3048
AVERAGE VOLTAGE = (SUM VOLTAGE/NUMBER OF SAMPLES)

PRIORITY DATA = IDATAHW + 1

DO 250 JK = 1, IDATAHW
  WRITIME(JK) = TIME1(IDATAHW - JK)

65 SUM VELOCITY = 0.0
SUM VOLTAGE = 0.0
NUMBER OF SAMPLES = 0
MULTIPLIER = MULTIPLIER * 1
SLOPE = SLOPE + 1

DO 300 I = 1, IDATAHW
  VELOC2(I) = ((SLOPE * VELOC2(I)**2 * WINTER)**2) * 0.3048
  IF (NRECORD > 2 AND NRECORD <= 8) GO TO 305
  I = NRECORD - 1
  IF (MOD(I, 30) == 0) GO TO 305
  GO TO 310
300 WRITE(6, 8) NRECORD, FILE, M, N
  FORMAT(IH, ** PARITY ERROR ON HW TIME, RECORD* FILE*, MN=*, N=*)
GO TO 370
310 N = 1

PRINT 13, NRECORD, IDATAHW
13 FORMAT(IH, ** NUMBER OF WORDS = **)
LAST = 2
IF (IDATAHW .LE. 301) LAST = 1
DO 370 I = 1, LAST
  N = N + 300
IF (I .EQ. LAST) N = IDATAHW
370 BUFFER OUT(3, I) (TIME(I), TIME(I))
  IF (UNIT(3) .EQ. 3) WRITE(6, 10) NRECORD, FILE, M, N
  IF (EXIT .EQ. 3) RETURN

280 WRITE(6, 10) NRECORD, FILE
  FORMAT(IH, ** PARITY ERROR ON HW TIME, RECORD* FILE*, MN=*, N=*)
GO TO 370
300 WRITE(6, 10) NRECORD, FILE
  FORMAT(IH, ** EOF ON HW TIME, RECORD* FILE*, MN=*, N=*)
GO TO 370
310 WRITE(6, 10) NRECORD, FILE
  FORMAT(IH, ** EOF ON HW VELOCITY FILE*, MN=*, N=*)
GO TO 370
330 WRITE(6, 10) NRECORD, FILE
  FORMAT(IH, ** EOF ON HW VELOCITY FILE*, MN=*, N=*)
GO TO 370
350 WRITE(6, 10) NRECORD, FILE
  FORMAT(IH, ** EOF ON HW VELOCITY FILE*, MN=*, N=*)
GO TO 370
370 WRITE(6, 11) NRECORD, FILE
  FORMAT(IH, ** EOF ON HW VELOCITY FILE*, MN=*, N=*)
SUBROUTINE SPEED TRACE

370 M = M + 30
IDATAHW = 1
IF (IEXIT .EQ. 3) RETURN
IF (KFIRST .GT. LENARR1) GO TO 120
GO TO 25
400 RETURN
END
SUBROUTINE AVEWIND

COMMON/BAVEWIN/JSAMPLE, SUMWIND, MULTIM1, TIMAVW, AVEW0(3000)
   + LASTIME
COMMON/BSPRED/SUMVELO, ISAMPLE, IDATAMH, SUMVOLTS, TIMRAT1, CHANNEL1
   + OIGRAT1, TIMECMG, VOLTCMG, MULTIM1, TIMEHW, DCSUPRE
   + FRTSPC, WRITAPE, PRINTOK
COMMON/BBUMPP/TIME(702), VEL(702)
COMMON/BBLOCK/LENARN1, WINDIRE(100), WATERN1, NTIME1
   + ZERNOM(100), VOLT1(100), WATIEM(100), VRATI1
COMMON/BCALIBR/SLOPE(2), ZENOTP(2), SLOPEAN, ANINTER, SLOPEHW,
   + SLOPEW, WDINTER, SLOPEMD, WDINTER

J = IDATAMH + LENARN1 - 1
DO 100 K = J, LENARN1
   J = J + 1
   JSAMPLE = JSAMPLE + 1
   SUMWIND = SUMWIND + WINDIRE(K)
   IF (K .LT. LENARN1) GO TO 100
150 AVEW0(MULTIM1) = SUMWIND/JSAMPLE
   AVEW0(MULTIM1) = SLOPE00*AVEW0+MULTIM1” + WDINTER
200 MULTIM1 = MULTIM1 + 1
   SUMWIND = 0.0
   JSAMPLE = 0
100 CONTINUE
   IF (WRITAPE .EQ. 3HYES) RETURN
   WRITE (6,1) TIMAVW, MULTIM1, AVEW0(11)+LASTIME+MULTIM1
   1 FORMAT(1H1, * IND DIRECTIONS IN DEGREES OF MEANS OF DATA FOR 5.1
   + SEC INTERVALS. THIS IS INTERVAL NUMBER I4/10.31)
   LASTIME = MULTIM1
   RETURN
END
SUBROUTINE LASWRIT
COMMON TIME(200).VEL(200).IPOINT
COMMON/BLOCK2/LENARR2.SYNC(150).T(150).NRECOR2. NFIL2
* ZEROM2.WRITED2.NTAP2
5 WRITE(6+5) NRECOR2.IPOINT
5 FORMAT(1H10.**,NRECOR2=I10** NUMBER OF WORDS =I10)
50 N = IPOINT - 1
BUFF OUT(3,1) (TIME2(N),TIME2(N))
100 WRITE(6+5) NRECOR2. NFIL2.M+N
I FORMAT(1H10.* PARITY ERROR ON LASER TIME RECORD NUMBER*FILE NUM
.RER=I3* M=I5* N=I5)
GO TO 300
15 200 WRITE(6+2) NRECOR2. NFIL2.M+N
2 FORMAT(1H10.* EOF ON LASER TIME RECORD*FILE*M=I5* N=I5)
300 BUFFER OUT(3,1) (VEL(1).VEL(1))
100 WRITE(6+3) NRECOR2. NFIL2.M+N
3 FORMAT(1H10.* PARITY ERROR ON LASER VELOCITY, RECORD*FILE*13*
.RER=I3* M=I5* N=I5)
GO TO 600
500 WRITE(6+4) NRECOR2. NFIL2.M+N
4 FORMAT(1H10.* EOF ON LASER VELOCITY, RECORD*FILE*13* M=I5* N=*
.I5)
600 TIME2(I) = TIME2(IPOINT)
VEL(1) = VEL(IPOI)
RETURN
END
IDENT UNPAKI

* INSERT LENGTHS OF PACKED AND UNPACKED ARRAYS

312 LENGTHA SET 202
1759 LENGTHB SET 1000

* USE /UNPAKI/

0 NE BSS LENGTHA
312 B BSS LENGTHB

ENTRY UNPAKI

0 717000001
1 710000400 SET X7 10
2 43214 SET X14 16
3 616000031 C SET X3 1000
4 617000261 C SET X4 1000
5 615600060 SET X5 40
6 611000074 SET X6 60
7 67515 GET60 X7 41+1 GET A(I)
8 67515 GET12 X6 41+1

* 11621 BX6 X2*X1 MASK OUT 12 BITS

9 67515 SB5 41-85
10 611000011 DEC A(I)
11 15660 SB1 60

* 11760 BX7 X6*X0 CK FOR SIGN BIT

12 56660 SB6 96

* 14660 56660

* 21601 AX6 1 DELETE ZERO-BIT RIGHT-FILL

* 56660 SB6 40

* 646700000 SET EQ 39+97

13 615000060 SET SB5 40

* 43214 SET MA 12

14 040000005 SET EQ GET60

15 040000006 SET ED GET12

* 0 DONE EQU UNPAKI

END

46302 STORAGE USED

6400 ASSEMBLY

44 STATEMENTS

0.338 SECONDS

10 SYMBOLS

23 REFERENCES
IDENT UNPAK2

INSERT LENGTHS OF PACKED AND UNPACKED ARRAYS

LENGTHA SET 1132
LENGTHB SET 5670

USE /UNPAK2/
NE BSS LENGTHA
B BSS LENGTHB
USE ENTRY UNPAK2

0 7170000001
1 7100000000
2 3214
3 6160001131 C
4 6100000060
5 6110000001
6 6166000001
7 67515
8 11760
9 14666
10 21601
11 35
12 12
13 3214
14 20260
15 0
16 43417

STORB BSS 0
AX6 1
DELETE ZERO-BIT RIGHT-FILL

56600
56660
5467000000
0450000014
6150000060
0400000005
6155777763
0400000006
0 DONE

END

43417 STORAGE USLD 6400 ASSEMBLY 44 STATEMENTS 10 SYMBOLS 4.39 SECONDS 23 REFERENCES
<table>
<thead>
<tr>
<th>IDENT</th>
<th>UNLOADW ENTRY</th>
<th>UNLOADW USE</th>
<th>DATA</th>
</tr>
</thead>
<tbody>
<tr>
<td>246</td>
<td>CIOC VFD</td>
<td>18/3LCIO+21.4/0</td>
<td></td>
</tr>
<tr>
<td>247</td>
<td>MSGC VFD</td>
<td>18/3LSMG+42/0</td>
<td></td>
</tr>
<tr>
<td>250</td>
<td>ABTS VFD</td>
<td>18/3LAMH+6130/0</td>
<td></td>
</tr>
<tr>
<td>251</td>
<td>ABTC VFD</td>
<td>18/3LABT+42/0</td>
<td></td>
</tr>
<tr>
<td>252</td>
<td>MERC VFD</td>
<td>18/3LEMH+42/0</td>
<td></td>
</tr>
<tr>
<td>253</td>
<td>RELC VFD</td>
<td>18/3LPCF+42/0</td>
<td></td>
</tr>
<tr>
<td>254</td>
<td>0516450000000000000 ENDC VFD 18/3LENC+42/0</td>
<td></td>
<td></td>
</tr>
<tr>
<td>255</td>
<td>CNTCC VFD</td>
<td>18/3LACE+2122/0+18/CNTCCB</td>
<td></td>
</tr>
<tr>
<td>256</td>
<td>0000000000000000000 CNTCCB DATA 0.10 READ FORWARD 488 FOR BACKSP</td>
<td></td>
<td></td>
</tr>
<tr>
<td>257</td>
<td>011145552701235522 MSG1 DATA CFILE WAS HELCOME BEFORE RETURN</td>
<td></td>
<td></td>
</tr>
<tr>
<td>263</td>
<td>MSG2 DATA C UNLOAD ON NON-TAPE FILE</td>
<td></td>
<td></td>
</tr>
<tr>
<td>266</td>
<td>MSG3 DATA C UNLOAD ON UNDEFINED FILE</td>
<td></td>
<td></td>
</tr>
<tr>
<td>271</td>
<td>MSG4 DATA C PROGRAM CONTINUED</td>
<td></td>
<td></td>
</tr>
<tr>
<td>274</td>
<td>MSG6 DATA C RUN ABORTED WITH SPEC PROCESSING</td>
<td></td>
<td></td>
</tr>
<tr>
<td>300</td>
<td>MSG6 DATA C RUN ENTIRELY ABORTED - DUMP</td>
<td></td>
<td></td>
</tr>
<tr>
<td>304</td>
<td>MSG7 DATA C RUN ABORTED WITHOUT DUMP</td>
<td></td>
<td></td>
</tr>
<tr>
<td>307</td>
<td>MSG9 DATA C WAITING FOR NEXT REEL - GO TO CONTINUE</td>
<td></td>
<td></td>
</tr>
<tr>
<td>314</td>
<td>MSGH DATA C RUN ENDED WITH NO DUMP - NORMAL CC STREAM</td>
<td></td>
<td></td>
</tr>
<tr>
<td>321</td>
<td>SAVEW DATA 0 USE</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**CALLPP MACRO**

```
A
IFC NE,##AP+1
SAS I
NZ AS+1
SAS A5
NZ AS+1
SAS A5
NZ AS+1
ENDM
```

**CLOSER MACRO**

```
LOCAL LOPE
SA3 82+2
SA4 A3+1
IXS X3-X4
2R X5+LOPE IN EQ OUT
LXO 18
LXO 10
SA3 82
BX7 -X0*X3
BX4 X0*A3
S41 JH
eX3 -X1*X4
```
FILE NOT OPENED
WRITE MASK
NOT OPEN FOR WRITE

SPECIAL FUNCTION CODE
WRITE CODE
ADD PARITY BIT
ADD LOGICAL FILE NAME
RESET FIRST WORD FET

ADD FET ADDR TO CALL WORD
END INSTRUCTION IN MACRO

SAVE FILE NAME
REWIND CODE
ADD PARITY BIT
ADD FILE NAME

GET WAIT DAYFILE MESSAGE
GET PP CALL WORD
ADD ADDRESS TO CALL WORD
UNLOADW

SAO  100008
SAS  BX6 X5 X0
SA6  A5
SA5  A5
SA2  RCLC

CALLPP  2
SA5  '00
B05  A5*X0
NZ  X5*LOP
ENDM

3

UNLOAD MACRO CLOSER
SA5  u2
M18  18
L20  18
B20  -X0*X5
SA0  28
H45  X5*X0
SA4  088
B05  X4*X5
BA0  X0*X0
SA6  u2
SA6  u2
SA5  CIOC
BX7  X5*X6
CALLPP
ENDM

40

PMSG MACRO A
SA6  A
SAG  MSGC
BX7  X6*X5
CALLPP
ENDM

0

UNLOADW BSSZ  1
SA2  AI+1
0  0302000003 +
SA2  X2+1
BX7  X2
3  10722

55

LIST -R
0  50210000001
1  0302999993 +
5  10722
APPENDIX A-2

Computer Program for Determination of Velocity Profiles
PROGRAM ANEVEL  TRACE  CDC 6400 F930-P261 OPT=O  02/10/72 12.53.49.

PROGRAM ANEVEL (INPUT, OUTPUT, TAPE5=INPUT, TAPE6=OUTPUT, TAPE1=OUTPUT, TAPE5=INPUT, TAPE6=OUTPUT, TAPE1=FILEMLP)
COMMON TIME(101), VELOC(16,100), NCHANN, LENARR, NFILE, INRECOR, EXIT
COMMON /BCAI8R/ NCALVAL, ACTVOLT(6), SLOPE(6), ZEROPTAP(6), STANDEV(6), VARI
COMMON /BBUFANE/ IDENT, IPARITY, TAPDAT, EOFMUL, NTOFIL, PLOT
COMMON /BUXTD/ TAPDAT, SKIP, FACTOR
COMMON /VOLTAD/ ICHANGE, SCALE(6), ZEROTAP(6), VOLCHG, TIMECHG, ISCALE(6)
COMMON /BPLOTE/ ELEV(6), SUMAVE(6), TIMECHG, LABELY(4), LTITLE(4), MULTIME, ILOTAP
COMMON /3SORT/ IEGSKP, INRIIDAT, TSkip, VACTOR
COMMON /8VOL/ TAD, ICANGE, SCALE(6), VOLTCHG, ISCALE(6)
COMMON /BPLOTE/ ELEV(6), SUMAVE(6), TIMECHG, LABELY(4), LTITLE(4), MULTIME, ILOTAP
COMMON /RSKIP/ NFILE, NFILSKP
COMMON /1TIME/ ICOUNT, SCALE(6), TIMECHG, INSTCAL, TAPECAL
DATA LABELY /4OH VELOCITY, M/SEC
DATA LABELY /4OH FLowATION, M/SEC
DATA LABELY /4OH VELOCITY PROFILE
REWIND 1 IDENT, WRITAP, EOFMUL, RITDAT, WRITAP, PLOT, VOLCHG
LCALDAT+NCHANN=NCALVAL+ISKIP+I8EGSKP+LENARR+NTOFIL
PLOTME=AVERATIME+ISCALE(1)=1.16, (ELEV(1)=1.6)+VARI
DIGHAT=FACTVOLT(1)=1.5, TIMERAT=CHANNEL+TIMECHG
INSTCAL, TAPECAL
WRITE(6,3) IDENT, WRITAP, EOFMUL, RITDAT, WRITAP, PLOT, VOLCHG
LCALDAT+NCHANN=NCALVAL+ISKIP+I8EGSKP+LENARR+NTOFIL
PLOTME=AVERATIME+ISCALE(1)=1.16, (ELEV(1)=1.6)+VARI
DIGHAT=FACTVOLT(1)=1.5, TIMERAT=CHANNEL+TIMECHG
INSTCAL, TAPECAL
3 FORMAT (3X,16A3,**INDEX, 16A3, **IDUR, 16A3, **LABEL, 16A3, **EOFMUL, 16A3, **WRITDAT, 16A3, **WRITAP, 16A3, **PLOT, 16A3, **VOLCHG, 16A3, **LCALDAT+NCHANN=NCALVAL+ISKIP+I8EGSKP+LENARR+NTOFIL
PLOTME=AVERATIME+ISCALE(1)=1.16, (ELEV(1)=1.6)+VARI
DIGHAT=FACTVOLT(1)=1.5, TIMERAT=CHANNEL+TIMECHG
INSTCAL, TAPECAL
4 IF (IDENT.EQ. '3YES') CALL HEADFH
EXIT = 3M NO
CORTIME = 3M NO
J CLOCK = 0
ZEROPTIM = 0.0
ICHANGE = 0
FACTOR = SQRT(12.1/12.09-1.0)
MULTIME = 1
NRECOR = 0
BADDATA = 3M NO
NEXTPTS = 0
NFILE = 1
IPARITY = 0
ISAMPLE = 0
OD 100 = 1, NCHANN
100 SUMAVE(1) = 0.0
IF (TAPECAL .NE. '3YES') CALL CALIBRA
IF (INSTCAL .NE. '3YES') GOTO 102
NFILE = 1
NJECSPK = 0
5 CALL SKIPEOF
102 CALL VOLTADJ
103 CALL BUFANE
   IF (IEXIT .EQ. 3HYES) TIME(IDATAPT-1) = TIME(IDATAPT-1) + 0.1
   IF (IEXIT .EQ. 3HYES) CALL PLOTVEL
60   IF (INREC .EQ. 1 AND TIME .NE. 0) ZEROTIM = ITIME
   IF ((ITIME = 999999) .GT. 12000) CONTIME = 3HYES
   ITIME = ITIME + JCLOCK = 999999
   IF (CONTIME .EQ. 3HYES) JCLOCK = JCLOCK + 1
65   CONTIME = 3H NO
   IDATAPT = 1
105 DO 110 I=1,NCHANNC
   VELOC(I,IDATAPT) = SLOPE(I)*VELOC(I,IDATAPT) + ZEROTAP(I)
110 VELOC(I,IDATAPT) = VELOC(I,IDATAPT)*SCALE(I) + ZERACT(I)*0.3048
   TIME(IDATAPT) = TIMERAT*(ITIME-ZEROTIM)/10000.*(IDATAPT-IDATAPT-1)
   IF (TIME(IDATAPT-1) + TIME(IDATAPT)*NE. TIME(IDATAPT-1)) CALL VOLTADJ
   IF (AVETIME*MULTIME.LT. TIME(IDATAPT-1)) ANO. PLOT
   IF (I,IDATAPT .LE. LENARR) GO TO 105
   IF (WRITAP .EQ. 3HYES) GO TO 135
   GO TO 103
120 DO 130 I=1,NCHANNC
130 ISAMPLE = ISAMPLE + 1
   IF (TIME(IDATAPT-1) .GE. PLOTI4E*MULTIME) CALL PLOTVEL
   IF (IDATAPT .LE. LENARR) GO TO 105
   IF (WRITAP .EQ. 3HYES) GO TO 135
   GO TO 103
134 WRITE (6,2) (TIME(I),VELOC(I,J),I=1,6,J=1,LENARR)
   WRITE (6,2) (TIME(I),VELOC(I,J),I=1,6,J=1,LENARR)
   FORMATT(1) = (100,4X,F10.3,28A6,F6.3,6X/)
   GO TO 103
135 CONTINUE
140 CONTINUE
END
SUBROUTINE CALIBRA

COMMON TIME(I1), VELOC(I + 100), NCHANNC, LENARR, NFILE, NREC, ICAL
COMMON /BCAIHR/, NCALVAL, ACTVOLT(S), SLOPE(S), ZERO(TAP(I)),
STANDEV(I), VARI
DIMENSION SUNCAL(I), SUMTAP(I), SQVALUE(I), SUMACT(I), ACT X TAP(I),
SUMSQ(I), TOTMEAN(I), RECMEAN(I), TEPMEAN(I), SUNEAN(I)

ICHECK = 0
NSAMPLE = 0
LASTCAL = 0
ICALVAL = 1
DO 100 I = 1, NCHANNC
SUMEAN(I) = 0.0
TEMPSUM(I) = 0.0
SUNCAL(I) = 0.0
SUMACT(I) = 0.0
SUMTAP(I) = 0.0
ACT X TAP(I) = 0.0
TEMPSUM(I) = 0.0
RECMEAN(I) = 0.0
DO 100 J = 1, NCALVAL
TOTMEAN(I, J) = 0.0
DO 110 I = 1, NCHANNC
SUMSOII, J) = 0.0
100 SUMSOII, J) = 0.0

CALL RUFANE
GOTO BUF = 3H NO
IF (ICALVAL .EQ. NCALVAL) LASTCAL = LASTCAL + 1
DO 110 K = 1, LENARR
DO 110 I = 1, NCHANNC
SUMCAL(I, K) = SUMCAL(I) * VELOC(I, K)
IF (ICHECK .GT. 0) GO TO 131
NSAMPLE = NSAMPLE + 1
DO 125 I = 1, NCHANNC
RECMEAN(I) = SUMCAL(I) / LENARR
IF (NREC .EQ. 0) GO TO 120
IF (RECMEAN(I) .LT. TOTMEAN(I, ICALVAL) .OR. RECMEAN(I) .GT. TOTMEAN(I, ICALVAL) .AND. ICALVAL .GT. NCALVAL .AND. LASTCAL .GT. 3) GO TO 160
ICHECK = ICHECK * 1
WRITE(6, 3) NRECOR(I, ICALVAL) ACTVOLT(I, ICALVAL)
3 FORMAT(1HO.5A, TEMPORARY MEANS*bx*, RECORD NUMBER*14.9X, CALIBRATION*
1 FORMAT(HS, S(5)*CHANNEL*10X, MEAN*13X, CUMULATIVE MEAN*8X, NUM
2 RECORDS FOR CUMULATIVE MEAN)
DO 123 K = 1, LENARR
123 SUMSOII, ICALVAL) = SUMSOII, ICALVAL) * VELOC(I, K)**2
SUMEAN(I) = SUMEAN(I) + RECMEAN(I)
SUMCAL(I) = 0.0
TOTMEAN(I, ICALVAL) = SUMEAN(I) / NSAMPLE
WRITE(IK, 1) RECMEAN(I) + TOTMEAN(I, ICALVAL), NSAMPLE
1 FORMAT(HS, 13X, 1D12.5, 1D12.5, 1D12.5, 1D12.5, 1D12.5, 1D12.5, 1D12.5)
GO TO 105
130 NSAMPLE = NSAMPLE - 1
ICALVAL = ICALVAL + 1
131 IF (ICALVAL .GT. NCALVAL .AND. LASTCAL .GT. 3) GO TO 160
ICHECK = ICHECK + 1
WRITE(6, 5) NRECOR(I, ICALVAL) ACTVOLT(I, ICALVAL)
5 FORMAT(HS, 5*X, TEMPORARY MEANS*8X, RECORD NUMBER*14.18X, CALIBRATION*
Do 100 I=1, NCHANNC
RECMEAN(I) = SUMCAL(I)/LENARR
WRITE(6.4) I, RECMEAN(I)
100 SUMCAL(I) = 0.0
IF (ICHECK .EQ. 0) GO TO 135
D00 137 K=1, LENARR
'SUMSQUARECALVAL(I) = SUMCAL(I)*VELOC(I)*K*2
TEMPSUM(I) = TEMPSUM(I)*RECMEAN(I)
135 IF (RECMEAN(I) .GT. TOTMEAN(I*ICALVAL(I) - VARI) .OR. RECMEAN(I) .LT. TOTMEAN(I*ICALVAL(I) - VARI) GOTOBUF=3
CONTINUE
IF (ICHECK .GT. 3) GO TO 160
IF (GOTOBUF .EQ. 3) GOTO 105
DO 150 I=1, NCHANNC
TEMPSUM(I) = 0.0
150 SUMSQ(I*ICALVAL(I)) = SUMSQ(I*ICALVAL(I) - VARI) GOTOBUF=3
CONTINUE
IF (ICHECK .GT. 3) GO TO 160
IF (GOTOBUF .EQ. 3) GOTO 105
DO 150 I=1, NCHANNC
SUMSQUARECALVAL(I) = SUMSQ(I*ICALVAL(I)) - TOTMEAN(I*ICALVAL(I))*SUMSQUARECALVAL(I)*NSAMPLE(LENARR) - TOTMEAN(I*ICALVAL(I))*NSAMPLE(LENARR)
D00 170 I=1, NCHANNC
SUMEAN(I) = TEMPSUM(I)/NSAMPLE
TEMPSUM(I) = 0.0
ICHECK = 0
IF (ICALVAL .LE. NCALVAL) GO TO 10!
180 WRITE(6.7) NRECORDS
7 FORMATT(1H0.5X,*ACTUAL VS TAPE VOLTAGE*10X*LEAST SQUARE METHOD*5X*NU
*NUMBER RECORDS USED FOR CALCULATIONS*13)
DO 200 I=1, NCHANNC
DO 190 J=1, NCALVAL
SUMTAP(I) = SUMTAP(I) + TOTMEAN(I)*J
SVALUE(I) = SVALUE(I) + TOTMEAN(I)*J**2
ACT = TAP(I) = ACT X TAP(I) + TOTMEAN(I)*ACTVOLT(I)
190 SUMACT(I) = SUMACT(I) + ACTVOLT(I)
SVALUE(I) = SVALUE(I) + TOTMEAN(I)*SVALUE(I)
ACT = TAP(I) + TOTMEAN(I)*ACTVOLT(I)
SVALUE(I) = SVALUE(I) + TOTMEAN(I)*SVALUE(I)
SVALUE(I) = SVALUE(I)
WRITE(6.8) I, TAP(I) + TOTMEAN(I)*ACTVOLT(I)
8 FORMATT(1H0.1X, *VALUES USED FOR LEAST SQUARE CALCULATIONS*13)
WRITE(6.9) I, TAP(I) + TOTMEAN(I)*NCALVAL
9 FORMATT(1H0.1X,*VALUES OBTAINED FROM LEAST SQUARE CALCULATIONS*7X*S
SURROUTINE CALIBRA TRACE

RETURN
END
SUBROUTINE BUFANE
COMMON TIME(IO1),VELOC(15,100),NCHANNC,LENARR,NFILE,NRECOR,IEXIT
COMMON/BUFANE/IDENT,IPARITY,LPADAT,EOFMUL,NOTIF,PLT
COMMON/UNPK/IW1ME,ICOMWRD(200),IDATWRD(1000)
100 DO 105 I=1,LPADAT
105 ICWNRD(I) = 0
LUNPDAT = LPADAT * 5
DO 110 I = 1,LUNPDAT
110 IDATWRD(I) = 0
115 NRECOR = NRECOR + 1
120 NUFFER IN (1,1)(ITIME,ICOMWRD(LPADAT))
125 IF (UNIT(1)) EQ.0,130,135
130 NRECOR = NRECOR - 1
WRITE (6,1) NRECOR, NFILE
NRECOR = 0
NFILE = NFILE + 1
IF (NFILE .GT. NTOTFIL) GO TO 136
IF (IDENT .EQ. 3HYES) CALL HEADER
GO TO 100
135 IPARITY = IPARITY + 1
WRITE (6,2) NRECOR, NFILE
NRECOR = NRECOR - 1
WRITE (6,3) IPARITY
GO TO 115
136 IF (PLOT .EQ. 3HYES) IEXIT = 3HYES
IF (PLOT .EQ. 3HYES) GO TO 150
CALL EXIT
140 CALL UNPAK
CALL SORTANE
1 FORMAT (1HO*, THERE ARE *14* RECORDS ON FILE NUMBER*13)
2 FORMAT (1HO*, PARITY ERROR OCCURRED ON RECORD NUMBER*16* FILE Numb
   *13)
3 FORMAT (1HO*, THERE HAVE BEEN*13* PARITY ERRORS*)
150 RETURN
END .
SUBROUTINE HEADER
COMMON TIME(10), VELOC(15,100), NCHANN, NLENARR, NFILE, NREC, NEXIT
COMMON/HEADER/ID(2)
BUFFER IN(1,0), ID(1), ID(2)

IF (UNIT (1)) 100, 110, 110
110 WRITE (6, 2) NFILE
   2 FORMAT (100, * PARITY ERROR OR EOF OCCURRED IN HEADER OF FILE NO*
   13)
100 WRITE (6, 1) ID, NFILE
   1 FORMAT (10H1, * HEADER IN BINARY *2A10* ON FILE NUMBER *12*
120 RETURN
END
SUBROUTINE SORTANE
COMMON TIME(10),VELOC(6,100),MCHANNC,LENARR,NFILE,NREC,IREXIT
COMMON/PSORT/IBEGSKP,WRTDAT,ISKIP,FACTOR
COMMON/UNPK/ITIME,ICOMWRD(200),IDATWRD(1000)
   5 M = IBEGSKP
   100 1 = 1 + LENARR
        VELOC(1,1) = IDATWRD(M) * FACTOR
        VELOC(2,1) = IDATWRD(M+1) * FACTOR
        VELOC(3,1) = IDATWRD(M+2) * FACTOR
        VELOC(4,1) = IDATWRD(M+3) * FACTOR
        VELOC(5,1) = IDATWRD(M+4) * FACTOR
        VELOC(6,1) = IDATWRD(M+5) * FACTOR
   19  M = M + ISKIP
   15  IF ( WRTDAT .EQ. 3 ) CALL DATA#1
   10  RETURN
   END
SUBROUTINE DATAWR
COMMON TIME(IO1),VELOC(6,100),NCHANNC,LENARR,NFILE,NRECOR,IER
COMMON/UNPK/I TIME,ICOMWRD(I200),IDATWRD(I200)
DO 10 I=1,NCHANNC
10 WRITE (6,1) I,(VELOC(I,J),J=1,LENARR)
FORMAT (15X,ANEMOMETER VELOCITY DATA,LEVEL NUMBER*12/101
+ (10F11.5/))
PRINT 2,TIME
2 FORMAT (1MG*10X,TIME AT BEGINNING OF RECORD*110)
RETURN
END
SUBROUTINE SKIPEOF TRACE

COMMON TIME(101), VELOC(100), NCHANNC, LENARR, NFILE, NRECOR, IEXIT
COMMON/BUFSIZE/IDENT, IDATE, IDAT, IDATWD(1000)
COMMON/UNPK/ITIME, ICOMWRD(200), IDATWD(1000)
COMMON/BSKIPEOF/NFILSKP, NRECSKP
NREC = 0
IF (INFILNE.GT. NFILSKP) GO TO 125
100 BUFFER IN(1,1) ITIME, ICOMWRD(LPCDAT))
IF (UNIT(1)) 115 120 110
10 NREC = NREC + 1
LEN = LENGTH(1)
NRECOR = NREC + 1
PRINT 2*NFILE, NRECOR, NREC, LEN
2 FORMAT(1H5, S*PARITY ERROR OCCURRED WHILE SKIPPING FILE*12* RECORD
*14/13* RECORDS HAVE BEEN SKIPPED. LENGTH WAS*14/)
GO TO 110
115 LEN = LENGTH(1)
NREC = NREC + 1
NRECOR = NREC + 1
IF (LEN.NE. LPCDAT * 1) WRITE(6*3) LEN, NRECOR, NREC, LEN
3 FORMAT(1H5, S*RECORD SKIPPED OF IMPROPER LENGTH. LENGTH WAS*14/)
*RECORD*14* FILES*12* REC*12* RECORDS SKIPPED*)
GO TO 100
120 WRITE(6,4) NREC, NFILE, NRECOR
4 FORMAT(1H5, S*RECORDS ON FILE*12* THERE WERE*14* RECORD
*RECORDS ON THIS FILE*)
NFILE = NFILE + 1
IF (IDENT.NE. 'YES') CALL HEADER
NREC = 0
NRECOR = 0
IF (INFILNE.LE. NFILSKP) GO TO 100
125 IF (NRECSKP.EQ. 0) RETURN
DO 160 IF,NRECSKP
BUFFER IN(1,1) ITIME, ICOMWRD(LPCDAT))
IF (UNIT(1)) 130 150 140
130 NREC = NREC + 1
NRECOR = NREC + 1
LEN = LENGTH(1)
IF (LEN.NE. LPCDAT * 1) WRITE(6*3) LEN, NRECOR, NREC, LEN
GO TO 140
140 NREC = NREC + 1
NRECOR = NREC + 1
LEN = LENGTH(1)
WRITE(6,5) NRECSKP, NFILE, NRECOR, LEN, NREC
5 FORMAT(1H5, S*PARITY ERROR OCCURRED WHILE SKIPPING*12* RECORDS ON
*FILE*12* RECOR*14* LENGTH*14* RECORDS SKIPPED*13)
GO TO 160
150 WRITE(6,6) NFILE, NRECOR, NREC
6 FORMAT(1H5, S*EOF OCCURRED WHILE SKIPPING RECORDS ON FILE*12* THEN
ST RECORD*14* RECORDS HAVE BEEN SKIPPED*)
CONTINUE
WRITE(6,7) NREC, NFILE
7 FORMAT(1H5, S*KXI3 RECORDS HAVE BEEN SKIPPED ON FILE*12)
RETURN
END
SUBROUTINE VOLTADJ TRACE
COMMON TIME(101),VELOC(6+100),NCHANNEL,LENARR,NFILE,NRECOR,EXIT
COMMON/VOLTAD/ICHANGE,SCALE(6),ZEROACT(6),VOLTCMG,TIMECHG
   ISCALE(6)
   IF (ICHANGE .GT. 0) READ (51)(ISCALE(I)=1,6) VOLTCHG,TIMECHG
   DO 90 I = 1,6
   10 SCALE(I) = 40.166
   ZEROACT(I) = 2.799
   GO TO 90
   20 SCALE(I) = 743.867
   ZEROACT(I) = 2.413
   GO TO 90
   30 SCALE(I) = 0.0
   ZEROACT(I) = 2.103
   GO TO 90
   40 SCALE(I) = 81.437
   ZEROACT(I) = 2.281
   GO TO 90
   50 SCALE(I) = 0.0
   ZEROACT(I) = 2.083
   GO TO 90
   60 SCALE(I) = 42.161
   ZEROACT(I) = 3.674
   GO TO 90
   70 SCALE(I) = 83.606
   ZEROACT(I) = 3.065
   GO TO 90
   80 SCALE(I) = 0.0
   ZEROACT(I) = 0.0
   GO TO 90
   90 CONTINUE
SUBROUTINE VOLTADJ

ZEROACT(I) = 0.0
GO TO 90
80 GO TO (81, 82, 83) * ISCALE(I)
81 SCALE(I) = 40.217
ZEROACT(I) = 3.764
GO TO 90
82 SCALE(I) = 77.313
ZEROACT(I) = 3.639
GO TO 90
83 SCALE(I) = 0.0
ZEROACT(I) = 0.0
90 CONTINUE
ICHANGE = ICHANGE + 1
1 FORMAT (16(12) * A3, F5.3)
2 WRITE (n+2)
3 FORMAT (1H0, 5X * ACTUAL VOLTAGE VS VELOCITY * SCALE(I) * ZEROACT(I))
100 WRITE (5+31) * SCALE(I) * ZEROACT(I)
75 RETURN
END
SUBROUTINE PLOTVEL

COMMON TIME(10), VELOC6), NCHANNC, LENARR, FILE, NRECORT, EXIT
COMMON/BPLOTVE/ELEV(6), SUMAVE(16), ISAMPLE, LABELX(4), LABELY(4)

LTITLE(4), MULTIME, DATAPT

DIMENSION AVEVEL(6)
MULTIME = MULTIME + 1
WHITE(I+1), TIME(I+DATAPT-1), NRECORT

FORMAT(1M0, SX*VELOCITY PROFILE PLOITED AT TIME*F9.3, SX*RECORD NUMB
ER*14, I5X*VALUES USED FOR PLOT*5X*LEVEL*5X*ELEVATION* M.*5X*VELOCI
TY* M/SEC*)

DO 100 I = 1, NCHANNC
100 AVEVEL(I) = 0.0
DO 110 I = 1, NCHANNC

AVEVEL(I) = SUMAVE(I)/ISAMPLE
WRITE(6+2), I, ELEV(I), AVEVEL(I)
110 FORMAT(1H +3H[1, IDX6, +3H[4, +3])

SUMAVE(I) = 0.0

CALL I0101 {AVEVEL, ELEV, 6 + 2, UHM, LABELA, LABELY, LTITLE} + 1
ISAMPLE = 0

IF (EXIT .EQ. YES) CALL EXIT
RETURN
END
IDENT UNPAK

INSERT LENGTHS OF PACKED AND UNPACKED ARRAYS

311 LENGTHA SET 201
1750 LENGTHB SET 1000

USE /UNPK/

0 NE BSS LENGTHA
311 B BSS LENGTHB

USE ENTRY UNPAK

0 UNPAK BSS 1
1 7170000001 7100000000
2 43214 5110000000 C
3 6100000000 6170000000 C
4 6150000000 6150000000 6150000000
5 5011000001 5011000001 GET A(I)
6 6165000000 6165000000 GET A(I)
7 22556 67515
8 11621
9 11760
10 0307000001 0307000001 CBX A(I)
11 21A01 56650
12 0467000000 0467000000
13 43214 0400000000 0400000000
14 20260 615577777773 INMID
15 0400000006 0400000006
16 0 DONE UNPAK

END
APPENDIX A-3

Computer Program for Determination of Temperature and Humidity Profiles
PROGRAM TEMPNUM (INPUT, OUTPUT, TAPE5 = INPUT, TAPE6 = OUTPUT, TAPE1 = OUTPUT, TAPE2 = OUTPUT, TAPE3 = OUTPUT, TAPE4 = OUTPUT)

COMMON NFIL, NREC, LENARR, NCHECK, TEMP(10), 100; WRITE
COMMON/FSORT/FEOBAK, FACTOR, ISKIP
COMMON/BINSCTA/NINSCL, VARIN, EXCITO = RESIS(10, 2) + CALRES(10, 2)

COMMON/NCALRES/SLOPE(10), ZEROTAP(10)
COMMON/UNPK/IDENT, MULEOF, EXIT=NTOTFIL, PLOT=IPARITY, ZEROTIM

COMMON/BCALRES/SLOPE(10), ZEROTAP(10)
COMMON/8HUMI/184, SARPRES, PCPV, HUMIDI(10)
COMMON/BPLOTEN/AVETEMP(10), TITL1, TITL2, TITLE

DIMENSION RESIS(10), SUMTEMP(10)
DATA LABLEX/40H, YFMPERATURE/C, LABELY/40H, FLEVATIDN0M

READ(15) CALTAPE, CALINST, IDENT, MULEOF, PLOT, NCHECK, LENARR

FORMAT(HEATLAT, CPV, VARITP, ACTVOL(11) = 15, RESIS(11) = 110)

5 COMMON/FORMAT/A40, TITL1, TITL2, TITLE

READ(15) CALTAPE, CALINST, IDENT, MULEOF, PLOT, NCHECK, LENARR

FORMAT(HEATLAT, CPV, VARITP, ACTVOL(11) = 15, RESIS(11) = 110)

READ(15) CALTAPE, CALINST, IDENT, MULEOF, PLOT, NCHECK, LENARR

FORMAT(HEATLAT, CPV, VARITP, ACTVOL(11) = 15, RESIS(11) = 110)

READ(15) CALTAPE, CALINST, IDENT, MULEOF, PLOT, NCHECK, LENARR

FORMAT(HEATLAT, CPV, VARITP, ACTVOL(11) = 15, RESIS(11) = 110)

READ(15) CALTAPE, CALINST, IDENT, MULEOF, PLOT, NCHECK, LENARR

FORMAT(HEATLAT, CPV, VARITP, ACTVOL(11) = 15, RESIS(11) = 110)

READ(15) CALTAPE, CALINST, IDENT, MULEOF, PLOT, NCHECK, LENARR

FORMAT(HEATLAT, CPV, VARITP, ACTVOL(11) = 15, RESIS(11) = 110)
PROGRAM TEMPUM  TRACE

FACTOR = SORT(2.01/(2.0**9-1.0))
NFILE = 1
NRECOR = 0
ZEROTIM = 0.0
IPARITY = 0
MULREC = 1
DO 100 I=1,NCHAN

100 SUMTEMP(I) = 0.0
   IF (CALTAP.EQ.3HYES) CALL TAPECAL
   IF (CALINST.EQ.3HYES) CALL INSTCAL
   NFILESKP = 1
   NRECFSKP = 0
   IF (NFILE.LE.1) CALL SKIPEOF
   JCLOCK = 0
   ZEROTIM = 0.0
   NRECOR = 0
   READS(5) FSTREC
   FIN = .TRUE.
   NFILE = 0
   NREC = 0
   CALL SKIPEOF
   CALL BUFTEMP
   DO 300 I=1,NCHAN
   300 SUMTEMP(I) = SUMTEMP(J) + TEMP(I)**K
   IF (NREC .LE. NAYEREC*MULREC) GO TO 200
   GO TO 500
   400 NAVEREC = NREC-(INAVEC(MULREC-1))
   DO 500 I=1,NCHAN
   500 SUMTEMP(I) = SUMTEMP(I)/INAVEC(NLARR)
   AVETEMP(I) = SUMTEMP(I)/INAVEC(NLARR)
   AVETEMP(I) = (SLOPE(I)*AVETEMP(I) + ZEROTAP(I))/GAIN(I)
   FACTOR = AVETEMP(I)/EXECUTO
   FACTOR = RESIS(I)/(RESIS(I) + RESIS(I))
   AVETEMP(I) = RESIS(I,2)/(FACTOR2-FACTORI- RESIS(I,2))
   IF (I .LT. 1) GO TO 700
   DO 600 J=2*NC-ANN
   600 RESISR(J) = AVETEMP(I)
   700 AVETEMP(I) = A(1)*AVETEMP(I) + C*AVETEMP(I)**2 + D*AVETEMP(I)**3 + E*AVETEMP(I)**4
   TIME = TIME+TIME-ZEROTIM)/10000.
   WRITE(6,2)TIME,NRECOR,(AVETEMP(I))=1=1,NCHAN
   2 FORMAT(9X,2TIME,NRECOR,(AVETEMP(I))=1=1,NCHAN
   
   100 DO (631,LEVEL=0.0,10.0)
   105 DO (10.0,LEVEL=0.0,50.0)
   100 DO (50.0,LEVEL=0.0,100.0)
   400 DO (100.0,LEVEL=0.0,500.0)
   CALL HUMID
   IF (PLOT.EQ.3HYES) CALL PLOTEMP
   MULREC = MULREC + 1

   PAGE 2
MULREC = MULREC + 1

IF (IEXIT .NE. 3) YES) GO TO 200
END
SUBROUTINE TAPECAL

COMMON/BTAPECA/NCALVAL*VARITP,ACTVOLT(5)
COMMON/BCALIBR/SLOPE(10),ZEROTAP(10)
COMMON NFILE, NREC0+LENARR, NCHAN+TEMP(10*100), WRITEDAT
DIMENSION SUMCAL(10), SUMTAP(10), SQVALUE(10), SUMACT(10), ACTX TAP(10), TOTMEAN(10), TOTMEAN(10), SUMSQ(10), RECMAN(10)

ICHECK = 0
NSAMPLE = 0
LASTCAL = 0
ICALVAL = 1
DO 100 I=1,NCHAN
SUMCAL(I) = 0.0
TEMPSUM(I) = 0.0
SUMTAP(I) = 0.0
SUMCAL(I) = 0.0
SUMACT(I) = 0.0
SQAVALUE(I) = 0.0
ACTX TAP(I) = 0.0
RECMAN(I) = 0.0
DO 100 J=1,ICALVAL
STANDEV(I,J) = 0.0
TOTMEAN(I,J) = 0.0
100 SUMSO(I,J) = 0.0
CALL BUFTEMP
GO TO BUF

30 FORMAT(IH00S,RECORD MEANS*4X*RECORD NUMBER*14E7Z*CALIBRATION*12,4X*INPUT VALUE*FI/I1X*CHANNFL*OIX*NMEAN*13X*CUMULATIVE MEAN*)
DO 600 I=1,NCHAN
RECMEAN(I) = SUMCAL(I)/LENARR
IF (ICHECK .GT. 0) GO TO 800
NSAMPLE = NSAMPLE + 1
WRITE(6,1) NSAMPLE + 1
WRITE(6,2) NRECOR, ICALVAL, ACTVOLT(ICALVAL)
600 IF (NRECOR .GT. 1) GO TO 400
IF (RECMEAN(I) .GT. TOTMEAN(I,ICALVAL) + VARITP *0. RECMEAN(I))
   LT. TOTMEAN(I,ICALVAL) - VARIITP GO TO 700
700 NSAMPLE = NSAMPLE - 1
ICALVAL = ICALVAL *A. LASTCAL *A. 3) GO TO 1300
800 IF (ICALVAL .GT. NCALVAL *A. LASTCAL .GT. 3) GO TO 1300
SUBROUTINE TAPECAL TRACE

ICHECK = ICHECK + 1
WRITE(6,5) NRECOR, ICALVAL, ACTVOLT(ICALVAL)
5 FORMAT(1H0.5X*TEMPORARY MEANS*R*RECORD NUMBER*I4.10X*CALIBRATION
   *12.4X*INPUT VALUE *F5.1/11X*CHANNEL*I8X*MEAN*)
DO 1100 I=1,NCHAN
   RECMEA(I) = SUMCAL(I)/LENARR
   WRITE(6,6) ICHECK
6 FORMAT('I4.6*I12X*CALIBRATION*I4.6*I12X*MEAN*I12.4*
   IN$3(ICALVAL),I4.6)' SUMCAL(I) = 0.0
   IF (ICHECK .EQ. 1) GO TO 1000
   DO 900 K=1,LENARR
   SUMSO(I,ICALVAL) = SUMSO(I,ICALVAL) + TEMP(I,K)*2
   TEMPSUM(I) = TEMPSUM(I) + RECMEA(I)
900 CONTINUE
   1000 IF (RECMEA(I) .GT. TOHMEAN(I,ICALVAL-1) + VARI**2 .AND. RECMEA(I)
   .LT. TOHMEAN(I,ICALVAL-1) - VARI**2) GOTO BUF
1100 CONTINUE
   IF (ICHECK .EQ. 3) GO TO 1300
   IF (GOTOBUF .EQ. 3) GO TO 200
   DO 3200 I=NCHAN,1,-1
   TEMPSUM(I) = 0.0
3200 ICHECK = 0
ICALVAL = ICALVAL - 1
GO TO 200
1300 IEND = ICALVAL - 1
WRITE(6,9) ICHEL
9 FORMAT(12X*I12.XF9.3)
NSAMPLE = ICHECK = 1
DO 1500 I=1,NCHAN
   SUMMEAN(I) = TEMPSUM(I)
   STANDEV(I,ICALVAL) = TEMPSUM(I)/NSAMPLE
1500 TEMPSUM(I) = 0.0
ICHECK = 0
IF (ICALVAL .LE. NCALVAL) GO TO 200
1550 WRITE(6,10) NRECOR
10 FORMAT(1H0.5X*ACTUAL VS TAPE VOLTAGE*I8X*LEAST SQUARE METHOD*I5X*NU
   MBER RECORDS USED FOR CALCULATIONS*I3)
DO 1700 J=1,NCHAN
   DO 1600 I=1,NCALVAL
      SUMTAP(I) = SUMTAP(I) + TMEAN(I,J)
      SVALUE(I) = SVALUE(I) + TMEAN(I,J)**2
      ACT X TAP(I) = ACT X TAP(I) + TMEAN(I,J) * ACTVOLT(J)
1600 SUMACT(I) = SUMACT(I) + ACTVOLT(J)
      SLOPE(I) = (SUMACT(I)*SUMTAP(I) - NCALVAL*ACT X TAP(I))/
         (+ (SUMTAP(I)**2-NCALVAL*SVALUE(I))
         - ZEROTAP(I) = (SUMTAP(I)*ACT X TAP(I) - SUMACT(I)*SVALUE(I))/
          (+ (SUMTAP(I)**2-NCALVAL*SVALUE(I))
         ) WRITE(6,11) I,ACTVOLT(J),TMEAN(I,J),J=1,NCALVAL
11 FORMAT(1H0.5X*CALIBRATION*l13.15X*VALUES USED FOR LEAST SQUARE C
SUBROUTINE TAPECAL TRACE

CALCULATIONS=10X*INPUT VALUE=5X*TAPE VALUE=169X=11X=3)

1700 WRITE(6,12) SLOPE(I),ZERO,TAPE(I)
12 FORMAT(1H0,15X*VALUES OBTAINED FROM LEAST SQUARE CALCULATIONS* 7X*,
SLOPE=8X*INTERCEPT=6X=3*3)

RETURN
END
SUBROUTINE INSTCAL

COMMON/BINSTCA/NINSCAL,VARIIN,EXCITO,RESIST(10,2),CALRES(10,2)
GAIN(10)
COMMON/BCALIBR/SLOPE(10),ZERO(10)
COMMON/NFILE,NRECOR,LENARR,CHANNN,TEMP(10,100),WRITEDAT
COMMON/BKPCOF,BDATA,LPCDAT,NRECSP,NFILSP

DIMENSION SUMAVE(10),TSUMAVE(10),SUPVALUES(2),STANDEV(10),TSUMSO(10)

TOTA((10),SUMTEMP(10),TSUMSO(10),STANDEV(10))

COMMON/BNFILE/NRECOR,LENARR,CHANNN,TEMP(10,100),WRITEDAT
COMMON/BNFILE/NRECOR,LENARR,CHANNN,TEMP(10,100),WRITEDAT

COMMON/BCALIBR/SLOPE(10),ZERO(10)

COMMON/BNFILE/NRECOR,LENARR,CHANNN,TEMP(10,100),WRITEDAT
COMMON/BNFILE/NRECOR,LENARR,CHANNN,TEMP(10,100),WRITEDAT

COMMON/BKPCOF,BDATA,LPCDAT,NRECSP,NFILSP

DIMENSION SUMAVE(10),TSUMAVE(10),SUPVALUES(2),STANDEV(10),TSUMSO(10)

TOTA((10),SUMTEMP(10),TSUMSO(10),STANDEV(10))

COMMON/BNFILE/NRECOR,LENARR,CHANNN,TEMP(10,100),WRITEDAT
COMMON/BNFILE/NRECOR,LENARR,CHANNN,TEMP(10,100),WRITEDAT

COMMON/BNFILE/NRECOR,LENARR,CHANNN,TEMP(10,100),WRITEDAT
COMMON/BNFILE/NRECOR,LENARR,CHANNN,TEMP(10,100),WRITEDAT

COMMON/BNFILE/NRECOR,LENARR,CHANNN,TEMP(10,100),WRITEDAT
COMMON/BNFILE/NRECOR,LENARR,CHANNN,TEMP(10,100),WRITEDAT

COMMON/BNFILE/NRECOR,LENARR,CHANNN,TEMP(10,100),WRITEDAT
COMMON/BNFILE/NRECOR,LENARR,CHANNN,TEMP(10,100),WRITEDAT

COMMON/BNFILE/NRECOR,LENARR,CHANNN,TEMP(10,100),WRITEDAT
COMMON/BNFILE/NRECOR,LENARR,CHANNN,TEMP(10,100),WRITEDAT

COMMON/BNFILE/NRECOR,LENARR,CHANNN,TEMP(10,100),WRITEDAT
COMMON/BNFILE/NRECOR,LENARR,CHANNN,TEMP(10,100),WRITEDAT

COMMON/BNFILE/NRECOR,LENARR,CHANNN,TEMP(10,100),WRITEDAT
COMMON/BNFILE/NRECOR,LENARR,CHANNN,TEMP(10,100),WRITEDAT

COMMON/BNFILE/NRECOR,LENARR,CHANNN,TEMP(10,100),WRITEDAT
COMMON/BNFILE/NRECOR,LENARR,CHANNN,TEMP(10,100),WRITEDAT

COMMON/BNFILE/NRECOR,LENARR,CHANNN,TEMP(10,100),WRITEDAT
COMMON/BNFILE/NRECOR,LENARR,CHANNN,TEMP(10,100),WRITEDAT

COMMON/BNFILE/NRECOR,LENARR,CHANNN,TEMP(10,100),WRITEDAT
COMMON/BNFILE/NRECOR,LENARR,CHANNN,TEMP(10,100),WRITEDAT

COMMON/BNFILE/NRECOR,LENARR,CHANNN,TEMP(10,100),WRITEDAT
COMMON/BNFILE/NRECOR,LENARR,CHANNN,TEMP(10,100),WRITEDAT

COMMON/BNFILE/NRECOR,LENARR,CHANNN,TEMP(10,100),WRITEDAT
COMMON/BNFILE/NRECOR,LENARR,CHANNN,TEMP(10,100),WRITEDAT

COMMON/BNFILE/NRECOR,LENARR,CHANNN,TEMP(10,100),WRITEDAT
COMMON/BNFILE/NRECOR,LENARR,CHANNN,TEMP(10,100),WRITEDAT

COMMON/BNFILE/NRECOR,LENARR,CHANNN,TEMP(10,100),WRITEDAT
COMMON/BNFILE/NRECOR,LENARR,CHANNN,TEMP(10,100),WRITEDAT

COMMON/BNFILE/NRECOR,LENARR,CHANNN,TEMP(10,100),WRITEDAT
COMMON/BNFILE/NRECOR,LENARR,CHANNN,TEMP(10,100),WRITEDAT

COMMON/BNFILE/NRECOR,LENARR,CHANNN,TEMP(10,100),WRITEDAT
COMMON/BNFILE/NRECOR,LENARR,CHANNN,TEMP(10,100),WRITEDAT

COMMON/BNFILE/NRECOR,LENARR,CHANNN,TEMP(10,100),WRITEDAT
COMMON/BNFILE/NRECOR,LENARR,CHANNN,TEMP(10,100),WRITEDAT
SUBROUTINE INSTCAL

COC 6400 FTN V3.0-P261 OPT=O 02/10/72 08:46.42. PAGE 2

.ATON*I2X*INPUT*AI10*11X*CHANNEL=10X*SUM OF MEANS*13X*NUMBER OF
RECORDS IN SUM*)
DO 900 IN1=NCHANN
TSUMAVE(I) = TSMAVE(I) + AVEPEC(I)
WRITE(6,51)TSUMAVE(I),END
5 FORMAT(1H13X12X16*F6.3,12X)
DO 900 K=1,LENARR
900 TSMAVE() = TSMAVE(I) + TEMP(I+K)**2
IF (ABS(AVEPEC(I)) .GT. ABS(TOTAVE(I,NSCAL-1)) .AND. DIFF(I)) GO TO 1100
IF (GOTONUF .EQ. YES) GO TO 200
DO 1000 I1=NCHANN
TSUMAVE(I) = 0.0

1000 TSMAVE(I) = 0.0
LEVEL = 10H.ZERO INPUT
ICHECK = 0
INSCAL = INSCAL - 1
GO TO 200

1050 INSCAL = INSCAL + 1
NSAMPLE = NSAMPLE - 1
1100 IEND = INSCAL - 1
LEVEL = 10H.ZERO INPUT
IF (ICHECK .EQ. FULL) LEVEL = 10H.FULL SCALE
WRITE(6,61) IEND,LEVEL

6 FORMAT(1H10X5X*STANDARD DEVIATIONS*10X*CALIBRATION*12X*INPUT =AI10
/1X*CHANNEL=10X*RSN=)
DO 1200 I=1,NCHANN
STANDEV(I,INSCAL-1) = SORT(SOVALUE(I))NSAMPLE*LENARR-10AVE(I,NSCAL-1)**2)
1200 WRITE(6,71)STANDEV(I),END
7 FORMAT(1H14X12X7F6.3)
NSAMPLE = ICHECK
DO 1300 I1=NCHANN
1300 TSMAVE() = TSMAVE(I)
TOTAVE(I,INSCAL) = TSMAVE(I)/NSAMPLE
SOVALUE(I) = TSMAVE(I)
TSUMSO(I) = 0.0

1300 TSMAVE(I) = 0.0
ICHECK = 0
NSAMPLE = NSAMPLE + 1
LEVEL = 10H.FULL SCALE
IF (INSCAL .GT. NSCAL) GO TO 200

1400 DO 1500 I1=NCHANN
1500 TOTAVE(I,NSCAL) = SLOPE(I) * TOTAVE(I,NSCAL-1) + ZEROTAP(I)
ACTUAL(I) = EXCITVOL*RESIS(I,1)/RESIS(I,2) + CALRES(I,1)) - (RESI
* (1I1)I1RESIS(I,1) + CALRES(I,2))
GAIN(I) = (TOTAVE(I,2) - TOTAVE(I,1))/ACTUAL(I)

1600 WRITE(6,69)I,1.TOTAVE(I,1),TOTAVE(I,2)ACTUAL(I),GAIN(I)
8 FORMAT(1H14X10H,M A N E L E M A N S VALUES FOR GAIN COMPUTATION)
ONSAI10X*INPUT*5*TAPE VALUE*5*ACTUAL VALUE*/5X*ZERO*7F6.3,12X0
,9*56X*FULL SCALE=6XF6.3,11XF6.3,15X*GAIN COMPUTED*F10.3)
RETURN
END
SUBROUTINE BUFTEMP

COMMON/BBUFTEM/IDENT, MULEOF, IEXIT, NTOTFILE, NFILE, IPARITY, ZEROTIM

J CLOCK

COMMON/BKPEOF/BADATA, LPADAT, NRECSK, I NLFILE, I NLRECS, I NLFILE

COMMON/UNPK/ITIME, IDATAWRD, (200), IDATWRD, (1000)

IF (IDENT .EQ. '3H NO', A. BADATA .EQ. '3H NO', A. NRECORD .EQ. 0)

CALL HEADER

CORTIME = '3H NO'

if (MULEOF .NE. '3H YES')

GO TO 300

NFILE = NFILE + 1

IF (NFILE .GT. NTOTFILE)

GO TO 300

GO TO 100

300 IF (PLOT .EQ. '3H YES') EXIT = '3H YES'

IF (PLOT .EQ. '3H YES') RETURN

CALL EXIT

400 WRITE(6,2) NRECORD, NFILE

2 FORMAT(1R0, 'Parity Error in Data: Records on File: ')

IPARITY = IPARITY + 1

WRITE(6,3) IPARITY

3 FORMAT(1R0, 'There have been ')

CALL UNPAK

CALL SORT

IF (WRITDATA .EQ. '3H NO') CALL DATWRIT

GO TO 600

500 CALL UNPAK

CALL SORT

600 IF (NRECORD .EQ. 1 .A. ITIME .NE. 0) ZEROTIM = ITIME

IF (ITIME = 999999 .GT. -120001) CORTIME = '3H YES'

ITIME = ITIME + JCLOCK = JCLOCK + 1

RETURN

END
SUBROUTINE HEADER
COMMON NFILE,NRECOR,LREARR,NCHANN,TEMP(100),WRITDAT
DIMENSION ID(2)
BUFFER IN(1,0),(ID1),ID(2)
IF (UNIT(1),200) 200,100,100
100 WRITE(6) NFILE
1 FORMAT(I9,1X,PARITY ERROR OR FOF IN HEADER OF FILE NUMBER*13)
200 WRITE(6) NFILE,(ID(1)*1=2)
2 FORMAT(I9,1X,HEADER ON FILE*13 IS *210)
RETURN
END
SUBROUTINE SORT

COMMON NFILE,NRECOR,LENARR,NCHAN,TEMP(10+100)*WRITDAT
COMMON/BSORT/IBEGSKP,FACTOR,ISKIP
COMMON/UNPK/ITIME,ICOMWRD(200),IDATWRD(1000)
M = IBEGSKP
L = 0
DO 200 I = 1,LENARR
DO 100 K = 1, NCHAN
TEMP(K,1) = IDATWRD(M*L) * FACTOR
100 L = L + 1
L = 0
200 M=M#ISKIP
IF (WRITDAT .EQ. 'YES') CALL DATWRIT
RETURN
END
SUBROUTINE DATWRIT
COMMON/UNPH/ITIME!COMMONR{100}.DATEWRD(1000)
COMMON NFILE,NRECOR,LENARR,NCMANN,TEMP(10,100).WRITDAT
WRITE(6,1) NRECOR. ITIME
1 FORMAT(I0,* RECORD NUMBER*15* ITIME IS*110)
DO 100 I=1.NCMANN
100 WRITE(6,2) I*(TEMP{1.k}K=1.LFNARR)
2 FORMAT(1HO,* TAPE CHANNEL NUMBER*13*c(I68,3))
RETURN
END
SUBROUTINE SKIPEOF
COMMON/BSKPEOF/BADAT+LPACDAT+NRRECSKP+NFILSKP
COMMON/BUFTEM/IDENT+MULEOF+EXIT+NOTFIL+PLOT+IPARITY+ZEROTIN
JCLK
COMMON/UNPK/I TIME+ICOMWRD(200)+IDATWRD(100)
COMMON/NFILE+NRECOR+LENARR+NHANN+LENPI+100+WRITEAT
NREC=0
IF(NFILE.GT.NFILSKP)GO TO 500
100 BUFFER IN(I+1)(ITIME+ICOMWRD(LPACDAT))
10 IF (UNIT(1)).EQ.99*200
200 LEN = LENGTH(I)
NREC = NREC +1
WRITE(I+1)NFILE,NRECOR,NREC,LEN
1 IF(I+1).EQ.3HYES)CALL HEADER
IF(NFILE.LE.NFILSKP)GO TO 100
500 IF(NRECSKP.EQ.0)RETURN
DO 900 I=1,NRECSKP
IF(I+1).EQ.99*200 RETURN
DO 900 I+1,NRECSKP
BUFFER IN(I+1)(ITIME+ICOMWRD(LPACDAT))
IF(UNIT(1)).EQ.99*200 RETURN
600 NREC = NREC +1
NRECOR = NRECOR +1
LEN = LENGTH(I)
WRITE(I+4)NRECOR,NRECOR,LEN
4 IF(I+1).EQ.3HYES)CALL HEADER
IF(NFILE.LE.NFILSKP)GO TO 500
700 IF(I+1).EQ.99*200 RETURN
IF(I+1).EQ.99*200 RETURN
6 WRITE(I+1)NRECOR,NRECOR,LEN
5 IF(I+1).EQ.3HYES)CALL HEADER
IF(NFILE.LE.NFILSKP)GO TO 500
800 NRECOR = NRECOR +1
NRECOR = NRECOR +1
LEN = LENGTH(I)
WRITE(I+4)NRECOR,NRECOR,LEN
900 CONTINUE
SUBROUTINE SKIPEOF TRACE
RETURN
END