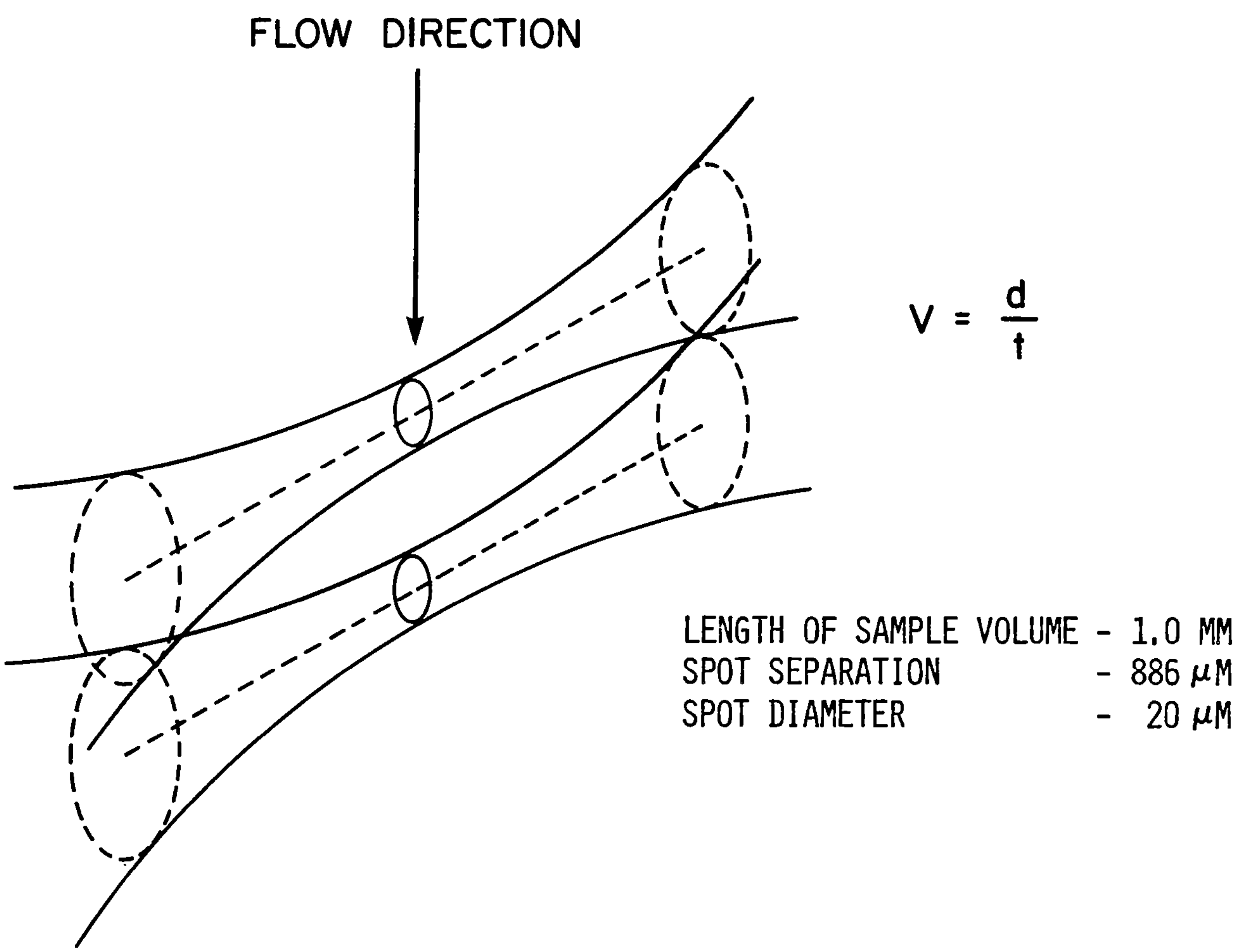
VELOCITY AND FLOW ANGLE MEASUREMENTS IN THE LANGLEY 0.3-METER TRANSONIC CRYOGENIC TUNNEL USING A LASER TRANSIT ANEMOMETER

W. C. Honaker
NASA Langley Research Center
Hampton, Virginia

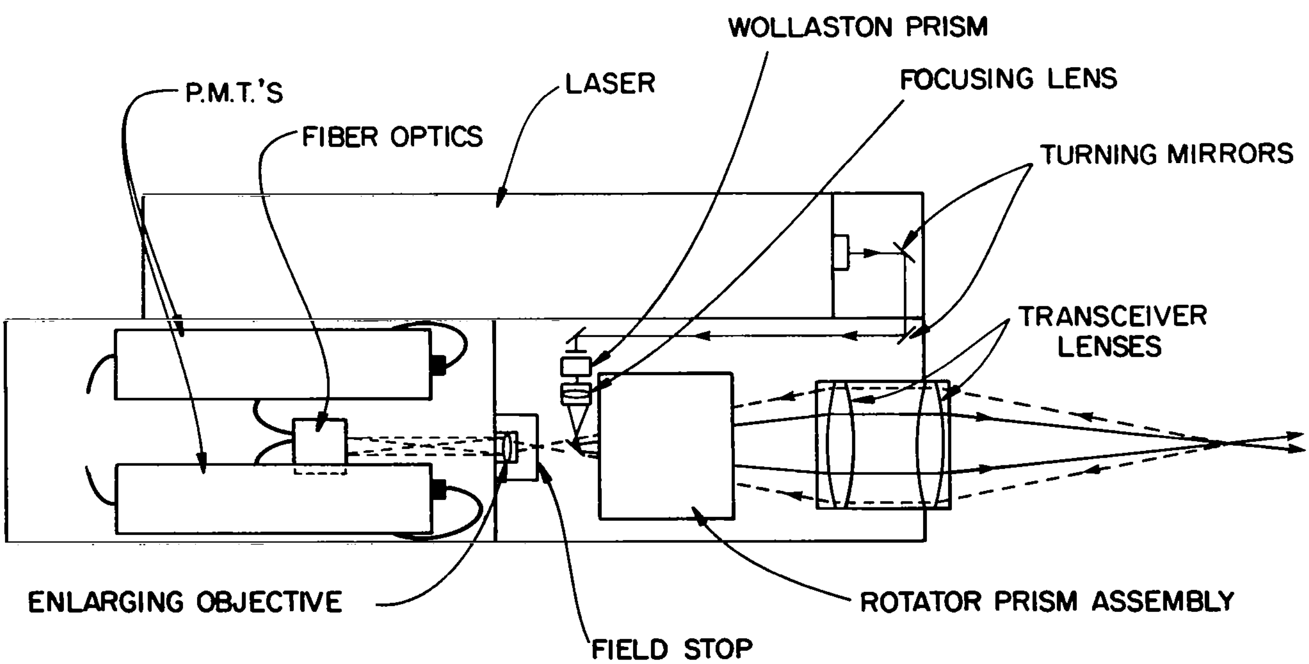
LASER TRANSIT ANEMOMETER

The Laser Transit Anemometer (LTA), or "2-spot" system, is an outgrowth of difficulties encountered by using the more familiar fringe system (e.g., measurements inside turbomachinery). In the LTA system two parallel laser beams of known separation and cross sectional area are focussed at the same location or plane. When a particle in a flow field passes through both beams and the time is recorded for its transit (time of flight), its velocity can be calculated knowing the distance between the beams. By rotating the two beams (spots) around a common center and recording the number of valid events (a particle which passes through both spots in the proper sequence) at each angle the flow angle can be determined by curve fitting a predetermined number of angles or points and calculating the peak of what should be a gaussian curve. The best angle or flow angle is defined as the angle at which the maximum number of valid events occurs.



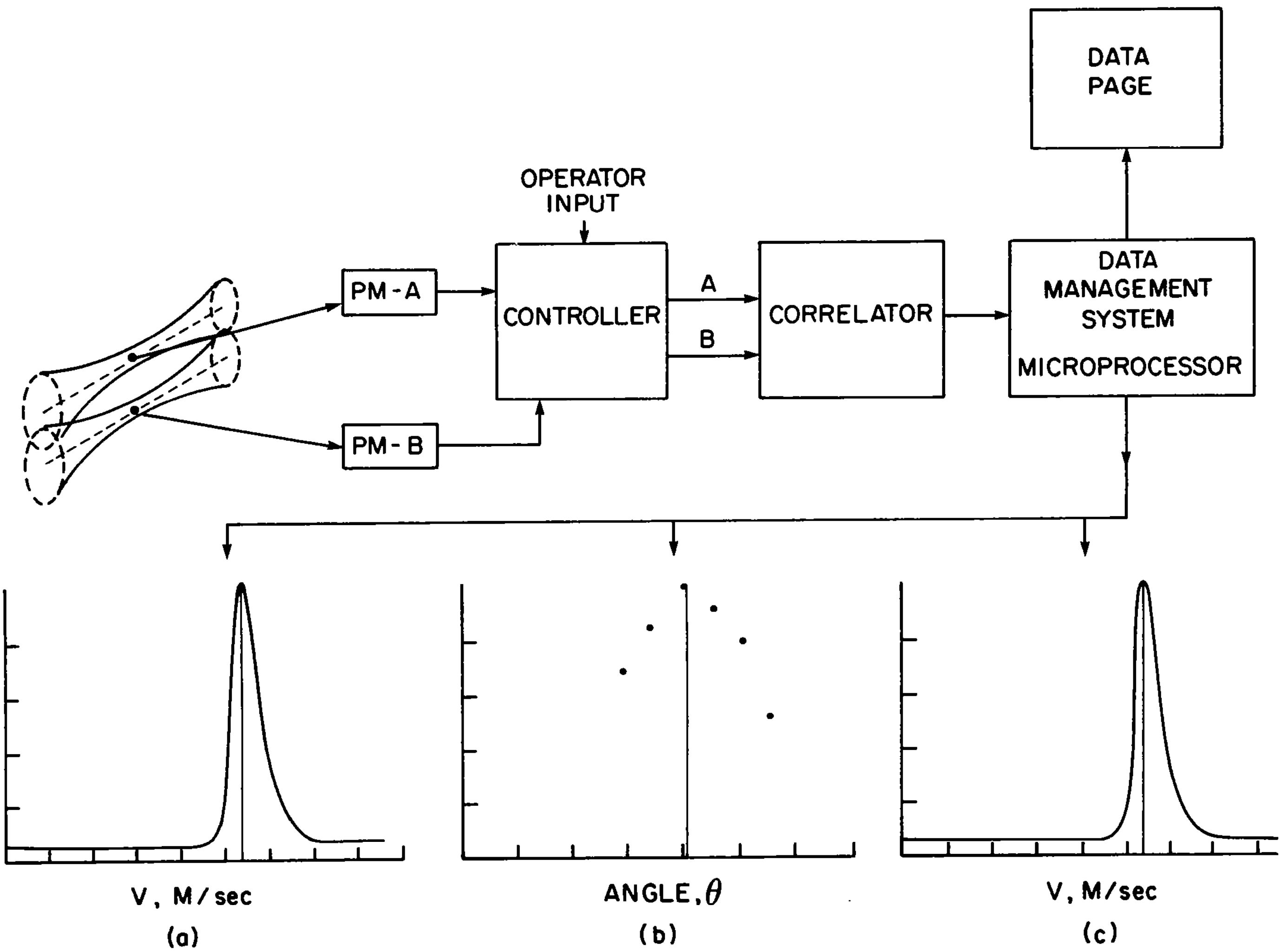
LTA OPTICAL HEAD

The LTA optical head consists of a one watt laser, two channels of electronics for the photomultiplier, beam splitting optics and transceiver optics, and spot rotation system and control circuits. Laser power is provided by a one watt Lexel laser. Four turning mirrors are used to transport the laser beam to the lower half of the optics head. The beam is split by a Wollastan prism inclined to the polarization axis to give equal intensity beams (polarized at right angles to each other). The image is relayed by the central part of the output system, the transceiver mirror, the rotator prism and inner and outer transceiver lenses to produce the illuminated region in front of the system. The sample volume is reimaged by the outer annulus of the transceiver lenses and rotator prism and the small transceiver mirror now behaves as a stop. The field stop contains two holes conjugate with the spots to reject flare. These stops are magnified on to the ends of optical fibers which act as secondary stops and further reduce flare and channel cross talk before transmitting the light to two photomultiplier tubes. The rotator prism allows the plane containing the two spots and the optical axis to be rotated such that the spots orbit a common center.



LTA ELECTRONIC SYSTEM FUNCTIONAL BLOCK DIAGRAM

The major components of the LTA are: Optics head, controller, correlator and data management system. To make velocity and flow angle measurements with the system one must be familiar with the equipment and the flow field of interest. An initial correlogram is taken to assure that all instrument settings are correct to give a reasonable peak at approximately 60 percent of full scale on plot (a) ((a) is a plot of data rate vs velocity). After a successful first correlogram has been taken a best angle search is made in (b) ((b) is a plot of data rate vs angle). From this best angle search the data system will choose a best angle if a valid peak is found. The system will then orientate the spots at that angle and take a best angle correlogram (c) ((c) is a plot of data rate vs velocity). From this correlogram velocity, flow angle and turbulence intensity are calculated and displayed on a data page. All of the plots and data page can then be printed or stored on diskette at the option of the operator.



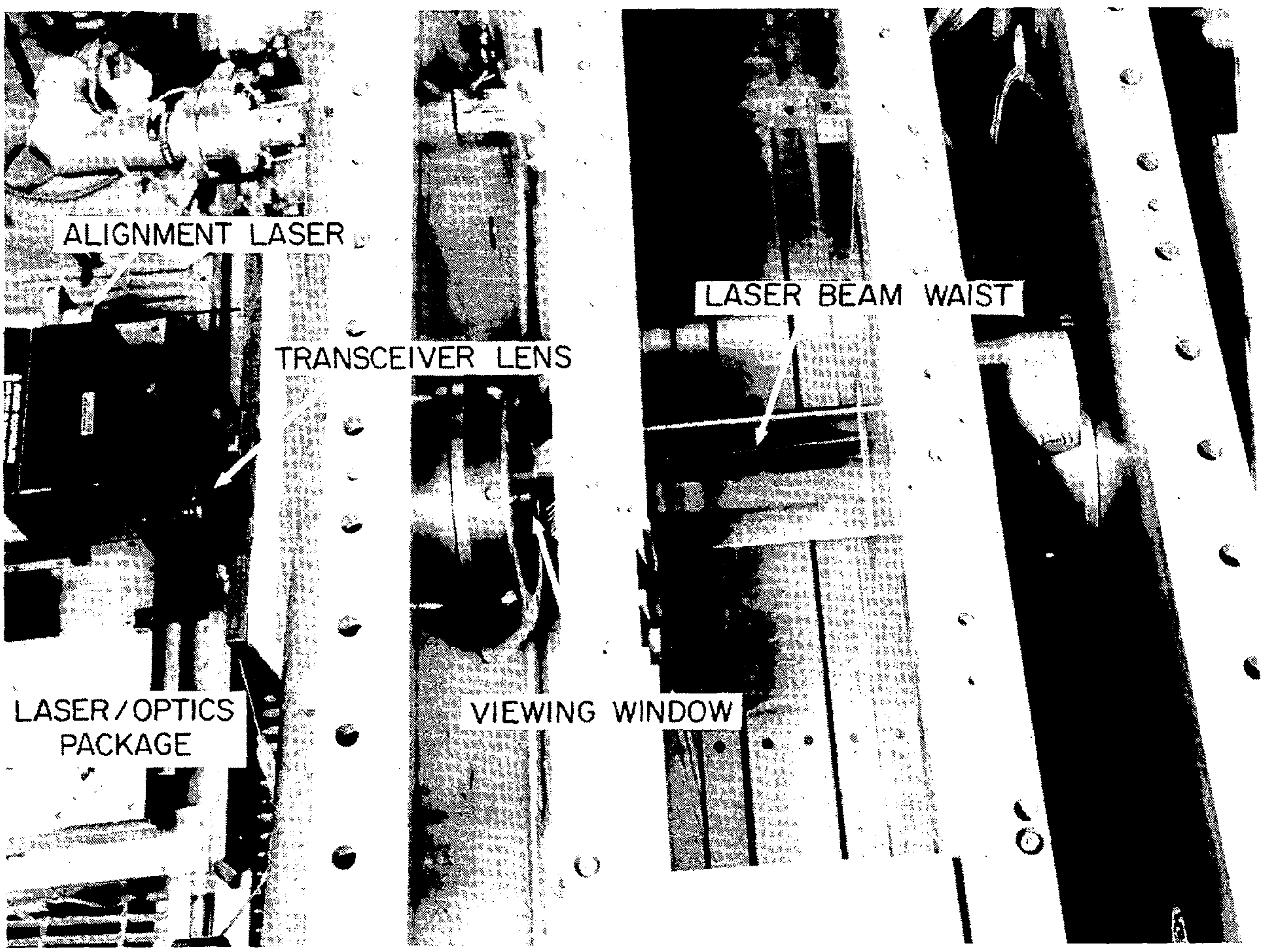
LTA - DATA PAGE

Information required to run the system and the program is entered into the data management system by a data page. To run the complete program, items 1-13 must be entered by the keyboard input. Items 1-13 can then be recorded on diskette and changes made as the operator desires. After a data point is completed the results are recorded in items 14-22 and can be printed or stored on diskette for future and further analyses by a large computer.

1NO OF STORES	***	14VEL(M/S)	****.**
2SPOT SEP(MM)	****	15TURB(%)	**.**
3DURATION	*	16DATA RATE	******
4DT(NS)	****	17BACK RATE	******
5PTS ABT PEAK	**	18D/B RATIO	****.**
6DISC RANGE	*	19ANGLE	***.**
7NO ANGLES	*	20RATE A/S	*******
8THETA(NOW)	***.*	21RATE B/S	*******
9THETA(ASK)	***.*	22DTHETA	**.**
10THETA(GET)	***.*		
11EXPT NO	****		
12RUN NO	****		
13DTHETA	**.**		

0.3 METER TRANSONIC CRYOGENIC TUNNEL (TCT) SETUP

This is a top view of the TCT experimental arrangement showing the inside of the test section and the position of the LTA system. The laser beam waist was located 3.5 centimeters above the surface of a NACA-0012 airfoil for the majority of the experimental data points. The LTA system was mounted on a scan rig in order to make measurements over the entire surface of the model. An alignment laser and photodiode system was used to track the relative position of the test section as the tunnel was cooled and moved with respect to the LTA. As the tunnel cooled the viewing window frosted. This problem was solved by purging the outside surface with dry nitrogen and keeping a positive pressure between that surface and a window of plate glass located about 15 centimeters to the left of the viewing window. In turn the plate glass window was kept free of condensation by a low velocity hair dryer (no heat).



RANGE OF PARAMETERS USED DURING TCT EXPERIMENT

The reason for this entry into the TCT was to further evaluate the LTA system and to determine if there was enough natural particulates in the flow to make velocity and flow angle measurements. Listed below is the range of temperatures, pressures, Mach numbers, velocities, data rate and flow angles used and measured during this experiment. Also shown is the velocity change measured during a scan across the shock for one of the conditions.

T_t - 95 TO 285K

P_t - 17 TO 60 PSIA

M_∞ - 0.11 TO 0.85

VELOCITY - 42 TO 320 M/SEC

DATA RATE - 2-898 CTS/SEC

ANGLE - 91 - 94°

VELOCITY CHANGE ACROSS SHOCK - 318 TO 232 M/SEC

COMPARISON OF LTA MEASURED VELOCITY WITH FLOW FIELD CALCULATIONS

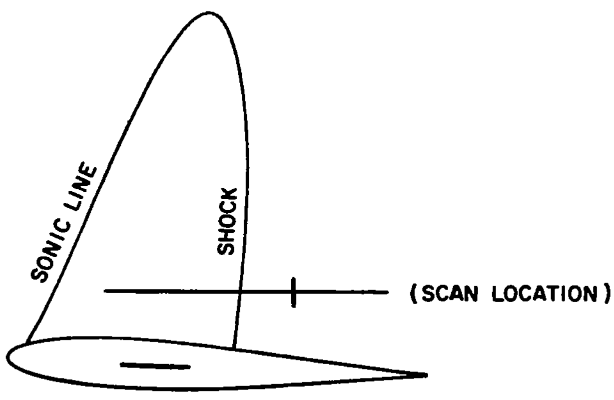
This sketch shows the airfoil used (NACA-0012) with the location of the sonic line and shock position when the tunnel parameters are those listed to the left of the sketch. A horizontal scan was made at the position of the horizontal line on the sketch and at zero angle of attack. A calculation was made of Mach Number around the airfoil using a 2-dimensional transonic code developed by Korn and Garabedian. Shown in the table are values obtained from the calculation as well as values measured with the LTA system. The calculations assume free air and no real gas effects were considered. Further calculations are being made which, including these factors, should bring the two values into closer agreement.

CONCLUSIONS

- The LTA system functioned properly although conditions were less than desirable. (Transceiver through 3 windows and the laser head was at a 6^0 angle to eliminate flare)
- Particle concentration remained at levels high enough to make velocity and flow angle measurements at all tunnel conditions used in this experiment.

	AHEAD SHOCK		DOWNSTREAM SHOCK		RATIO
	M	VEL M/SEC	M	VEL M/SEC	V_2/V_1
2D TRANSONIC AIRFOIL CODE	1.25	306	0.813	214	.700
MEASURED VELOCITY-LTA		317		232	.732
% DIFF		4		8	5

$M = 0.85$
$T_t = 192K$
$P_t = 30$ PSIA
$R = 8 \times 10^6$



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