HOLOGRAPHIC INTERFEROMETRY AND TOMOGRAPHY AT AMES RESEARCH CENTER

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ABSTRACT

The Aerodynamic Research Branch of NASA, Ames Research Center has been pursuing a program in laser holographic interferometry and tomography for the past three years. A new YAG laser holographic interferometer system and reconstruction laboratory for the Ames 2- by 2-Foot Transonic Wind Tunnel was put into operation last year. This system provides dual plate and double pulse holography for quantitative and qualitative measurements, respectively. The program to date consists of making interferometric measurements of two-dimensional airfoils and three-dimensional bodies of revolution for the tomography feasibility study. The two-dimensional work included supercritical airfoils, an oscillating airfoil undergoing dynamic stall, and a circulation control airfoil. The tomography experiments centered around hemispherical nose and tangent ogive models. In addition, the tomography work covered the development of a Fourier transform code for the retrieval of the three-dimensional density distributions from the interferograms.

The new interferometer gives excellent infinite fringe interferograms in both dual plate and double pulse modes. Quantitative data for surface pressures on a wing were within 1% of those from pressure orifices, see Figure 1. Excellent definitions of shock waves, boundary layers, and wakes can be seen in the interferograms, see Figure 2. The location of flow separation regions can also be readily detected. Figure 3 shows the separated flow line along with oil flow confirmation. Interferograms give density data over the large inviscid regions and the data can be used to verify theoretical calculations, see Figure 4. This technique can be adapted for unsteady flows. Excellent interferograms of an airfoil undergoing dynamic stall are shown in Figure 5. Note the wake flows and the typical hysteresis effects of flow separation and reattachment as the airfoil oscillates. Double pulse interferograms were used to freeze the flow and the vortex shedding process can be seen in Figure 6. Figures 7 and 8 are typical interferograms of hemispherical and tangent ogives used for tomography. These data will be compared with theoretical density contours to evaluate the feasibility of tomography for aerodynamics. Figures 9(a) and 9(b) are computer simulations to check out the accuracy of the Fourier code. Input density contours from a Navier-Stokes code for flow over the tangent ogive are compared with those from the Fourier code. Good results were obtained. Finally, Figure 10 shows a sketch of the interferometer including transmitting and receiving optics.

In summary, a new type of laser holographic interferometer was built and excellent interferograms were obtained. Two-dimensional data can be obtained routinely. A Fourier code for tomography was developed and experiments are under way. This area looks promising.

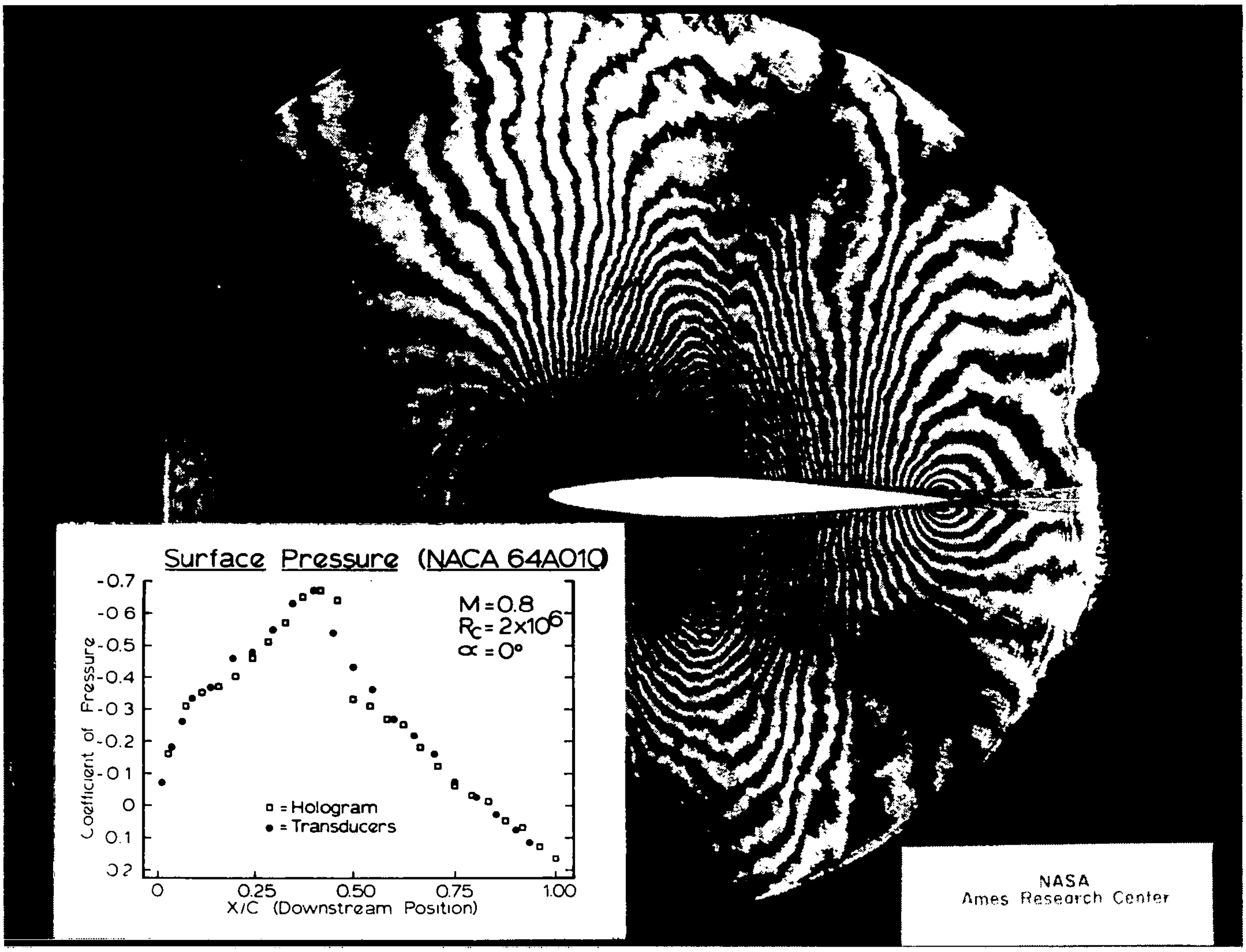


Figure 1.- Comparison of surface pressures on an NACA 64A010 airfoil from interferograms and transducers.

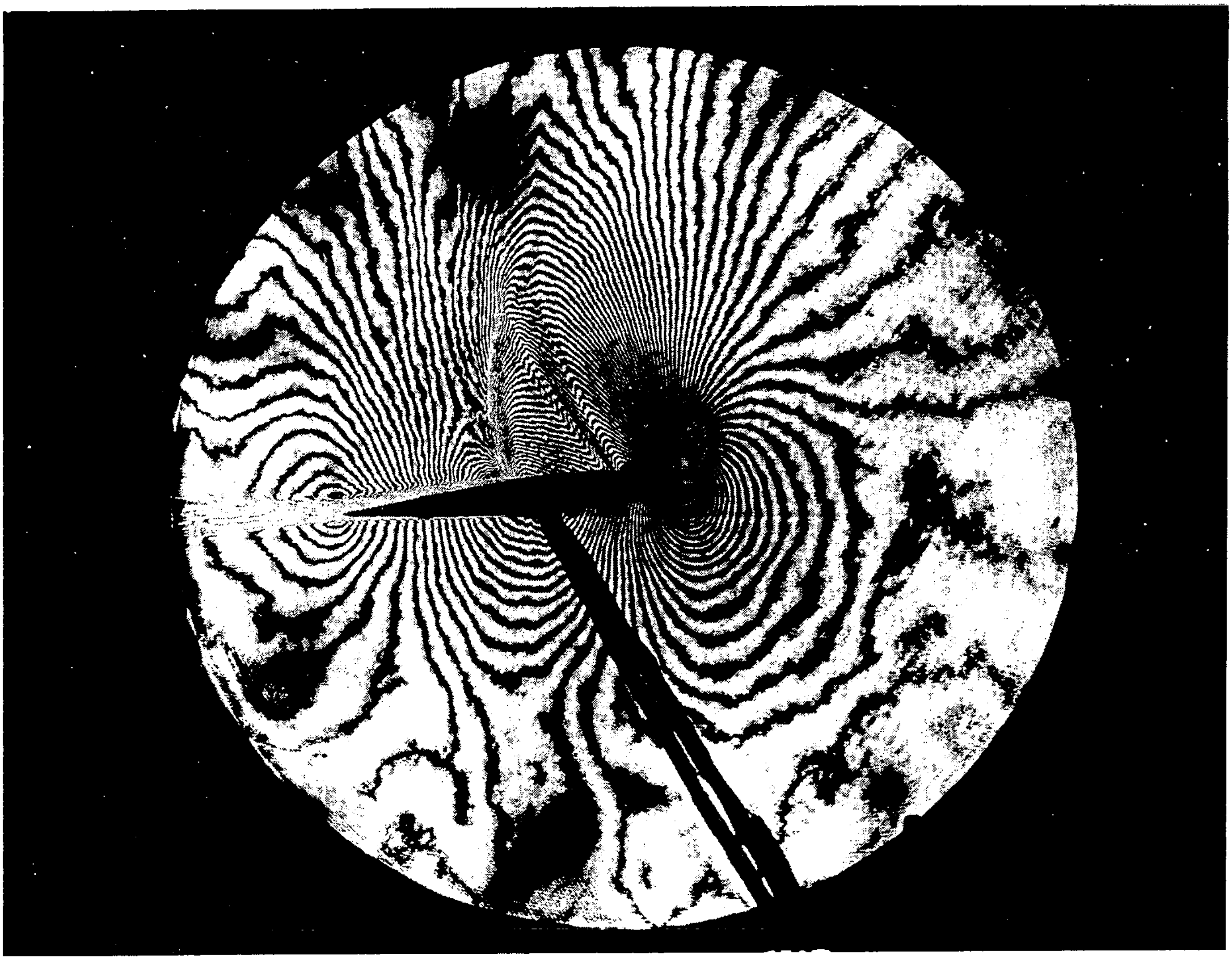


Figure 2.- Interferogram of NACA 64A010 at $M_\infty = 0.8$.

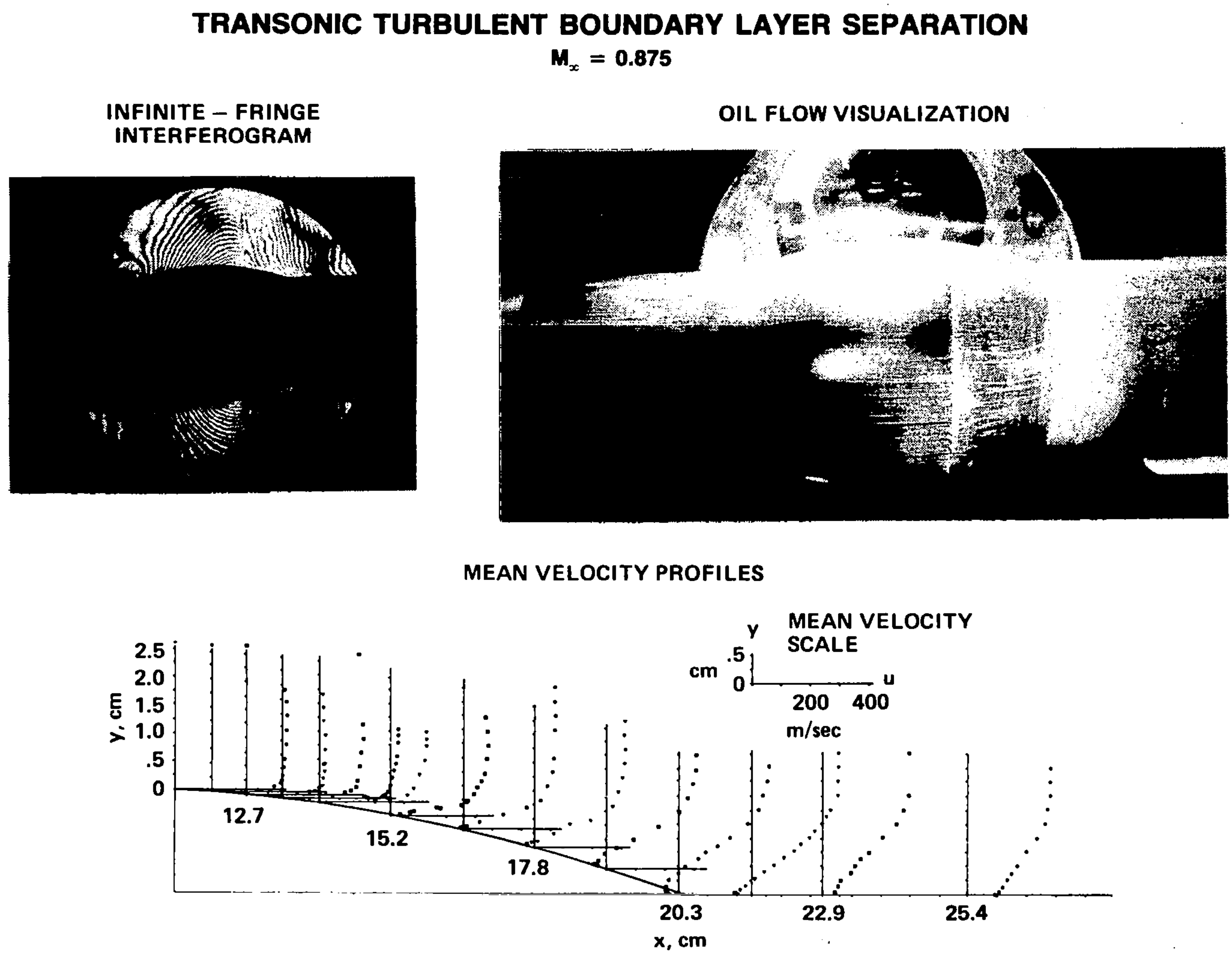
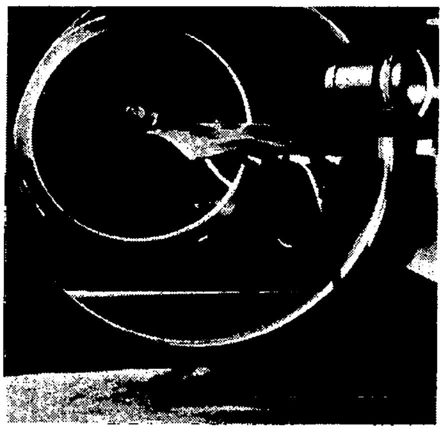
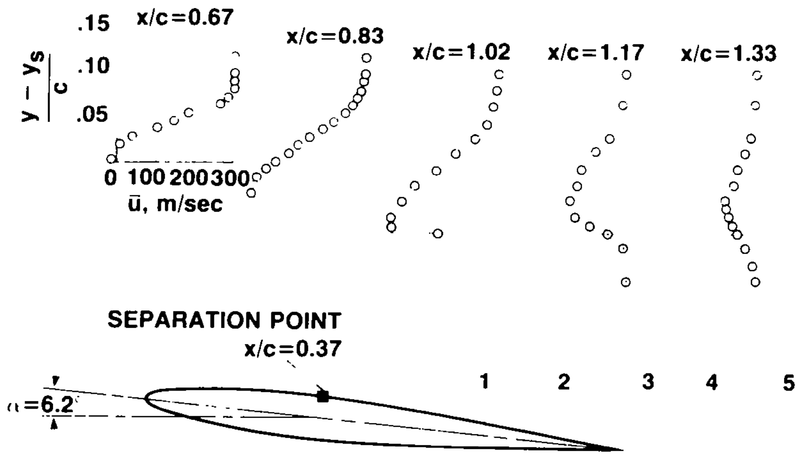


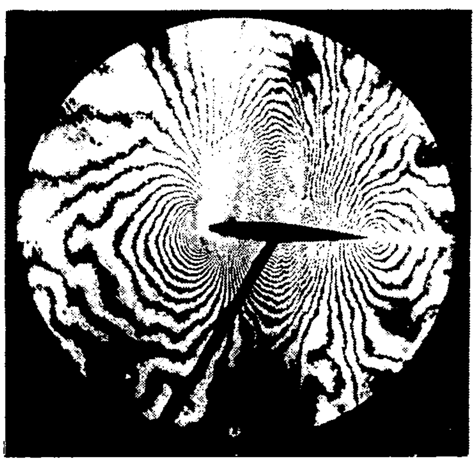
Figure 3.- Comparison of separation region.

UNIQUE DATA FOR AIRCRAFT DESIGN





VERIFICATION OF THEORIES FOR AIRCRAFT DESIGN



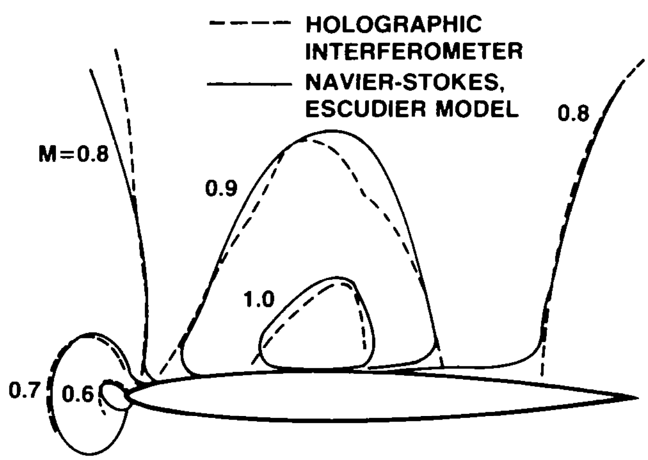


Figure 4.- Comparison of Mach number contours.

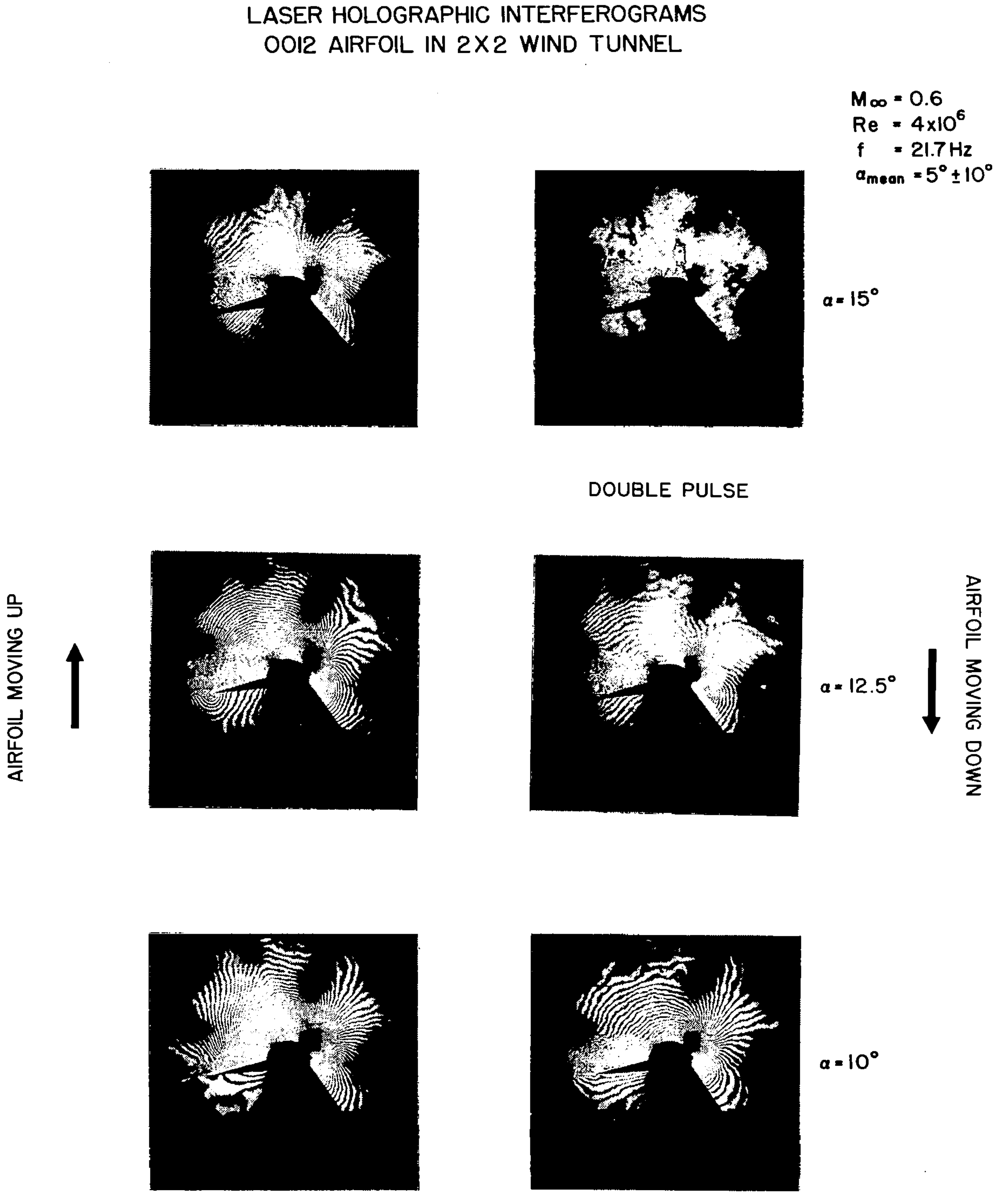


Figure 5.- Interferograms of 0012 airfoil undergoing dynamic stall.

Figure 6.- Double pulse interferogram of 0012 airfoil.

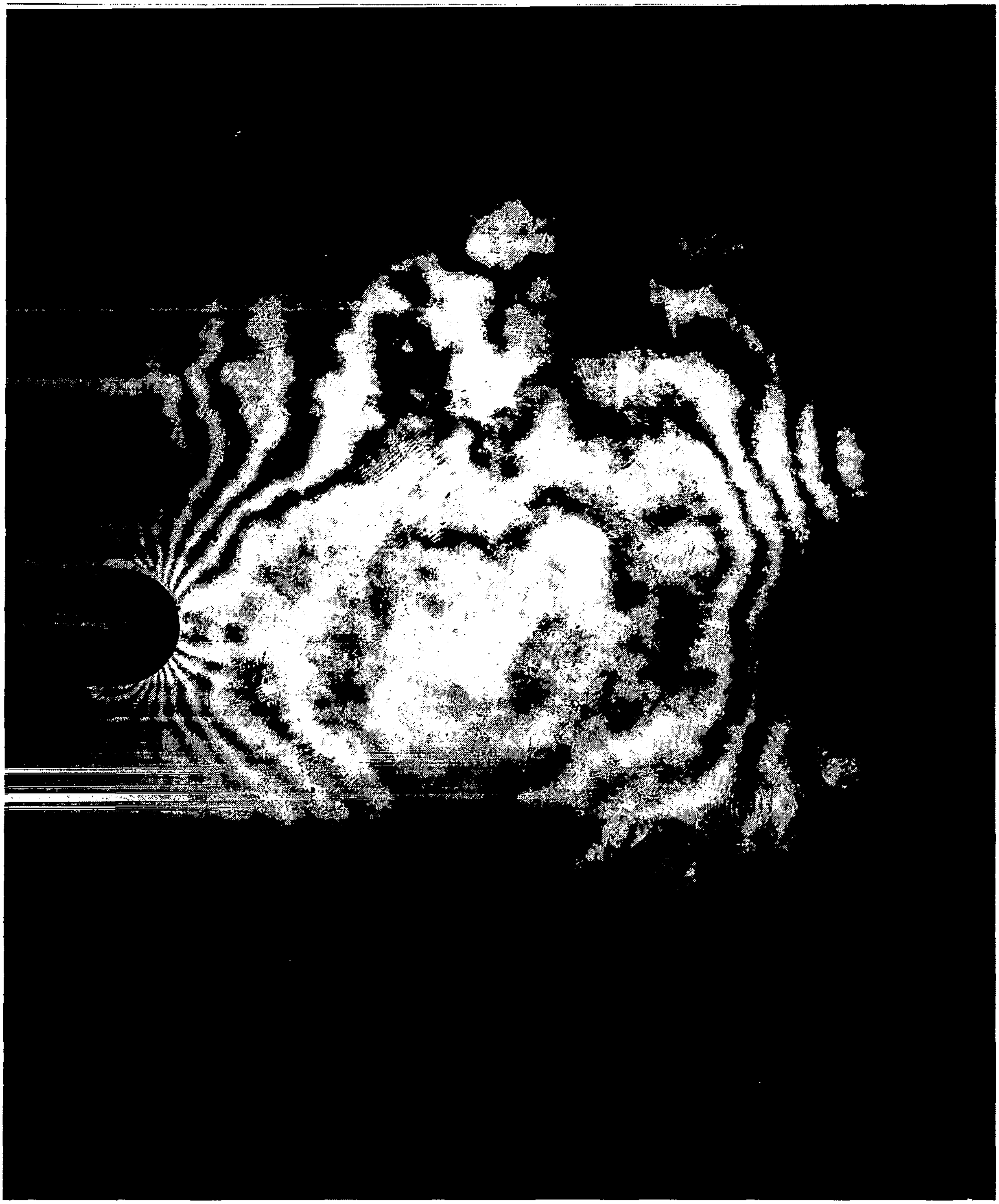


Figure 7.- Hemispherical cylinder at $M_\infty = 0.6$.

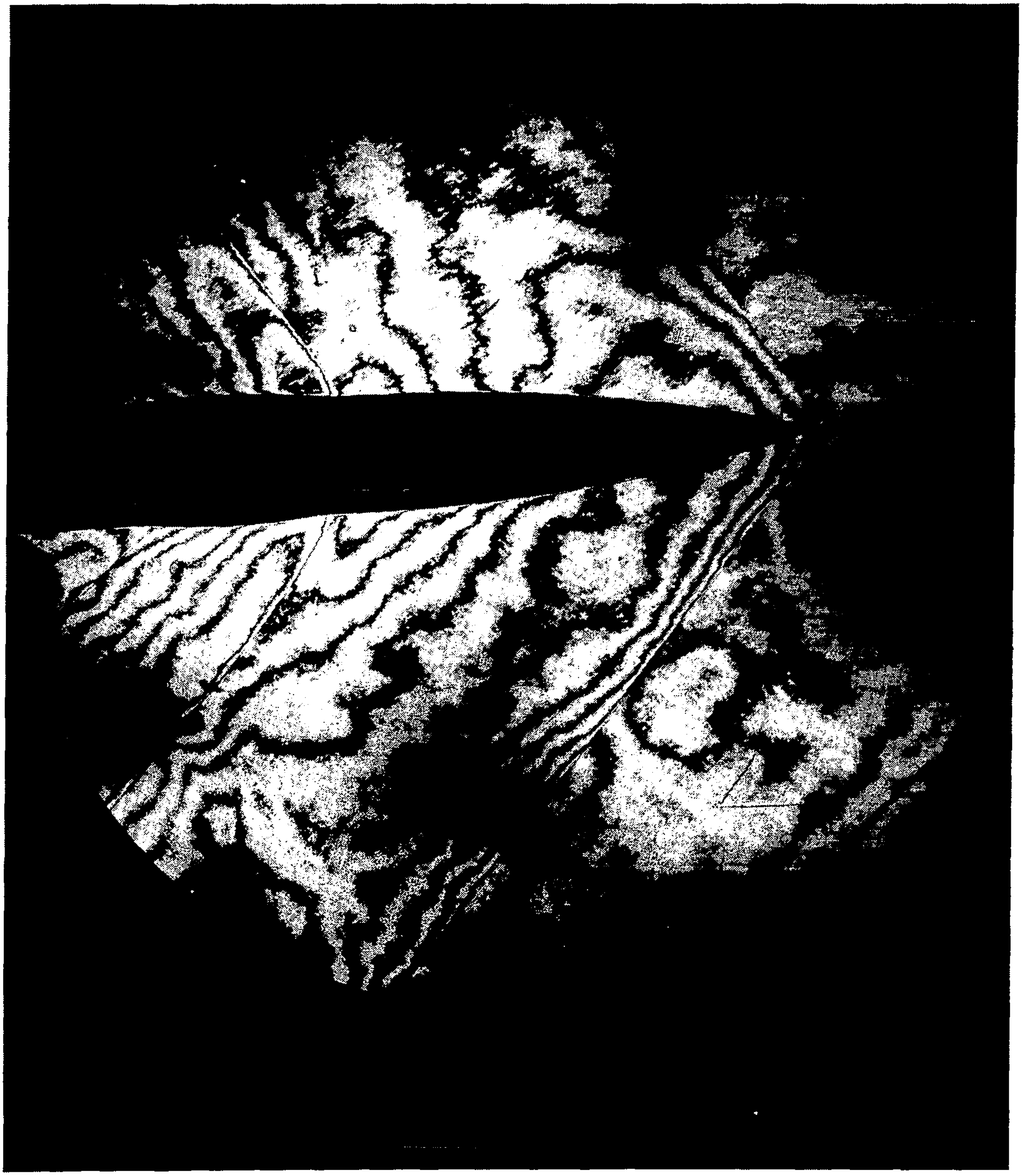


Figure 8.- Tangent ogive at M_∞ = 1.25.

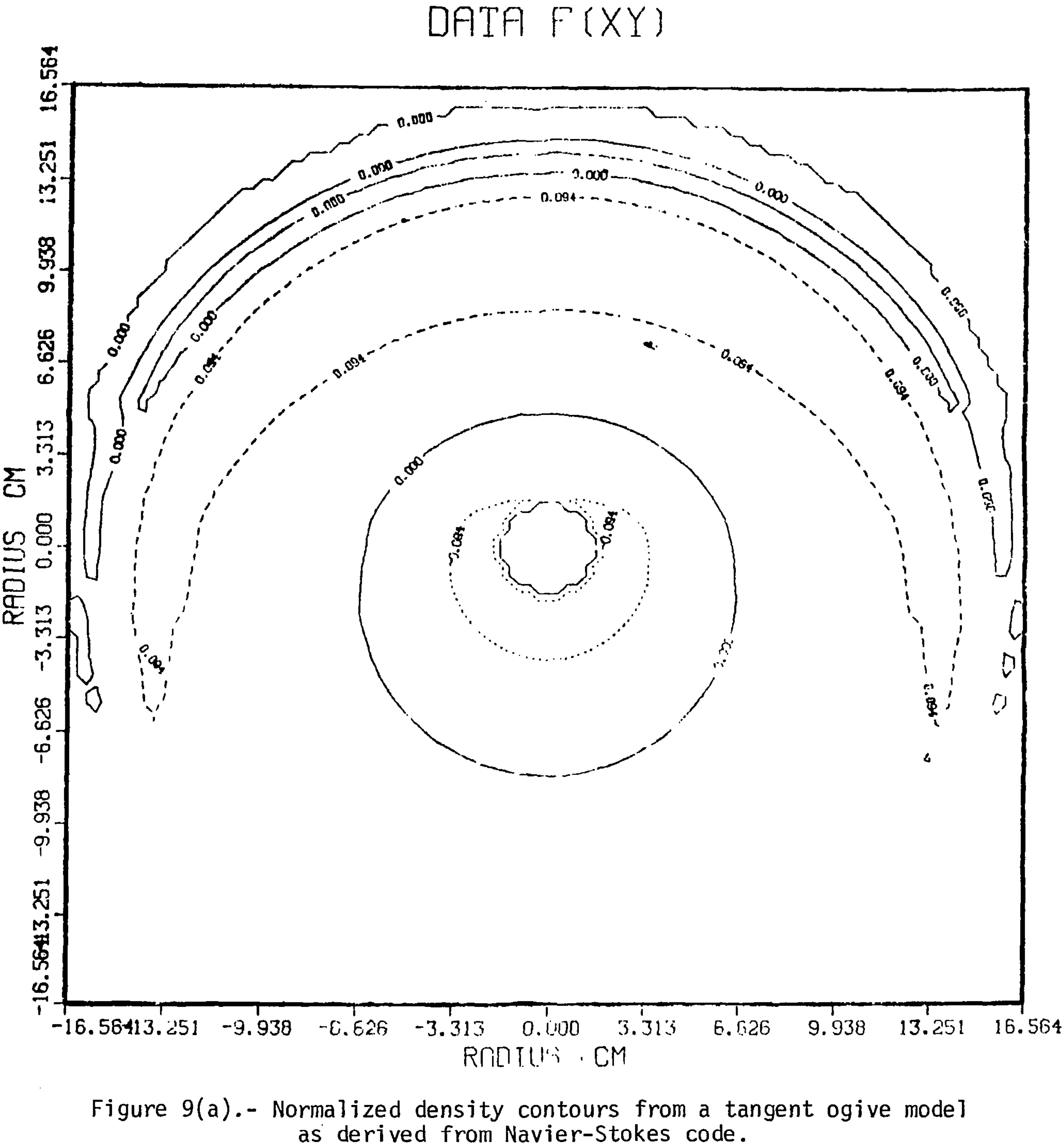


Figure 9(a).- Normalized density contours from a tangent ogive model as derived from Navier-Stokes code.

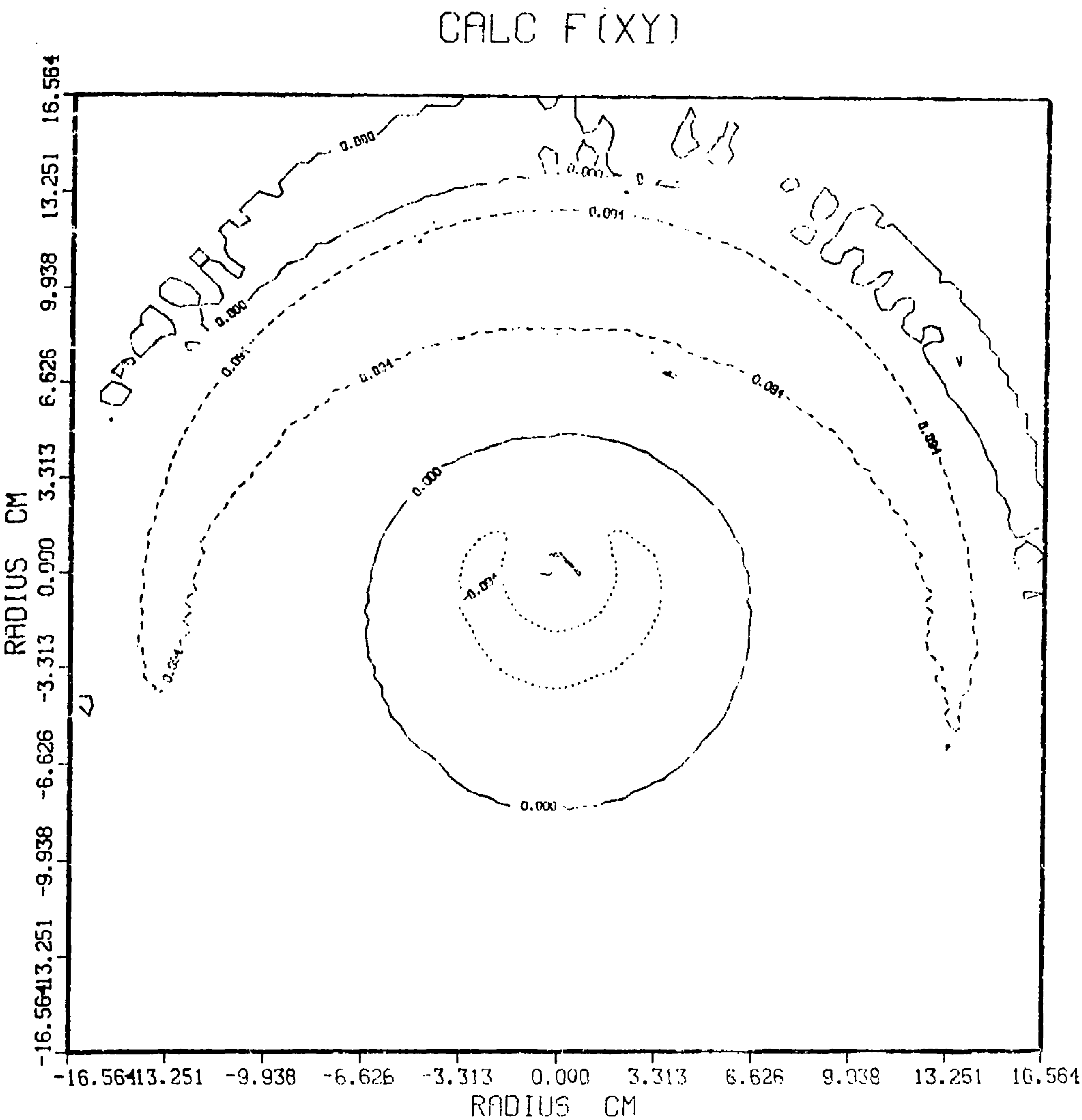
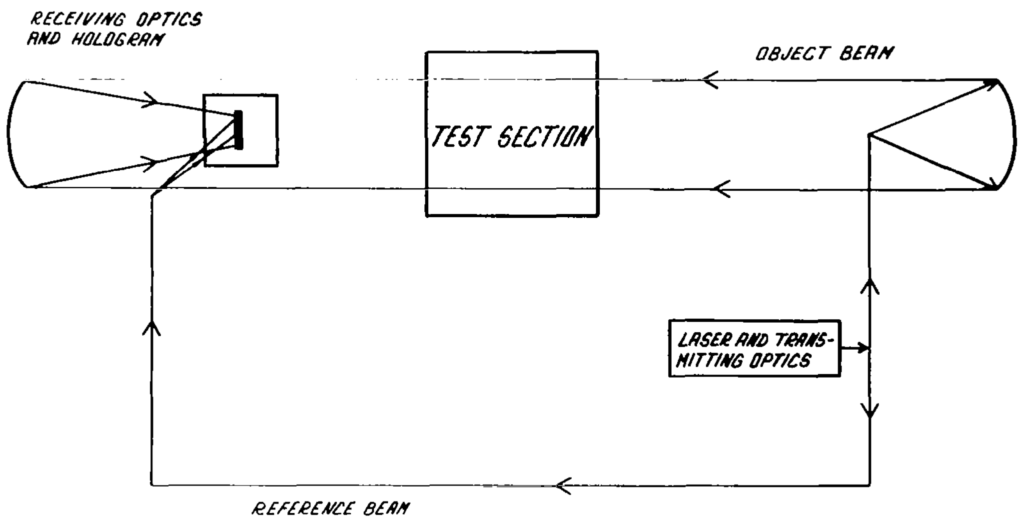
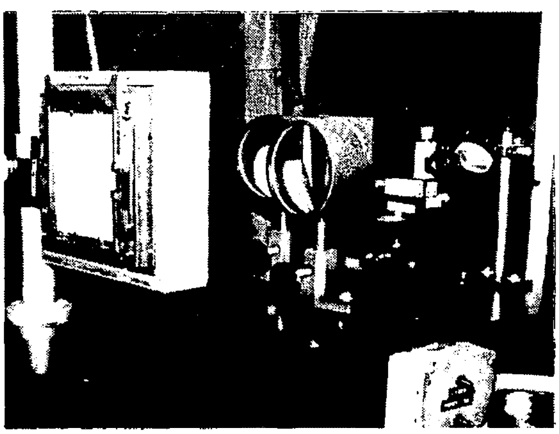


Figure 9(b).- Normalized density contours from the Fourier reconstruction code using data from Navier-Stokes code.





RECEIVING OPTICS
AND HOLOGRAM

LASER AND TRANSMITTING
OPTICS

Figure 10.- 2 × 2 laser holographic interferometer.