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SKYLAB FLUID MECHANICS DEMONSTRATIONS

by

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The substance of this presentation is a motion picture film which illustrates some of the fluid mechanics demonstrations accomplished on the Skylab missions. It is representative of the many hours of data taken in flight, most of which is from the third and last manned mission. These demonstrations were conducted on an unscheduled basis whenever a member of the crew, usually the science pilot, could make some time available. Because these demonstrations were not proposed and approved for flight until very late relative to the other Skylab experiments, the amount of crew familiarization and training, additional hardware and inflight time which could be made available were minimal.

The improvement in the techniques of handling fluids in zero gravity during the course of the three missions is first shown. A very light thread was sometimes used to stabilize fluid drops. Syringes with large openings were found to be useful for dispensing the fluids. Ink or small amounts of drink juices were often added to water to provide better visualization. Most of the data was taken with the onboard television system. On the last flight the use of a close-up lens provided excellent viewing of the investigations. The list of phenomena to be explored also increased significantly with each mission.

The modes of oscillation of a fluid droplet on a flat plate were then presented. The drop was perturbed by either oscillation of the plate or by impingement of a jet of air from above the drop and directed perpendicular to the plate. The motions of the drop were followed through many cycles to permit study of the damping and development of modes of oscillation different than the one excited.

A large portion of the film illustrates the characteristics of fluid spheres in zero gravity. Sphere sizes approximately 5 to 20 cc were used. Each sphere was perturbed symmetrically about a plane through the center of the sphere and the modes of oscillation and damping were followed. Spheres of a water-soap mixture or of a low density soap froth were observed to demonstrate the effects of changes in density, viscosity and surface tension on the modes of oscillation and damping. Water spheres were rotated and fission of the sphere was observed. With rotation of a sphere, a "dog bone" geometry developed before fission. A toroidial form was never observed. Collisions between water drops were also studied. Different relative drop sizes, velocities and impact parameters were used. Lastly, air was injected into water spheres so that a "sphere within a sphere" was observed. Bubble collapse and the very pronounced increase in damping of sphere oscillations was observed.

The largest fraction of effort was directed at the study of liquid floating zones, a demonstration suggested and developed by Dr. J. R. Carruthers of Bell Laboratories. Cylinders of 6, 14, and 20 cc of fluid were stabilized between two circular plates of 7/8 inch diameter. The fluid was allowed to wet the flat surface of each plate but was prevented from wetting the edges by use of Krytox lubricant. The plates were then rotated at various speeds in either the same direction or opposite directions and the resultant fluid motions observed. The most commonly observed instability was a bowing of the cylinder or "C shaped" instability. Mixtures of soap and water and a soap froth were again used in addition to colored water. Bubbles were also injected into the cylindrical water column. The coalescence of the bubbles, their movement to the center of the axis of rotation and their effect of increasing the damping of the column were observed. Longitudinal vibration, that is, vibration of the end plates along the axis of the column, was studied with each column before rotation. When the vibration was of the correct frequency, standing waves were observed. An increase in the frequency produced an increase in the number of modes observed. In order to aid in flow visualization, soap fragments were added to clear water columns in several runs. Lastly, the maximum theoretical stable column length of π times the diameter (2.75 inches) was observed to be slightly exceeded (2.90 inches) but the shape was that of an unduloid which slightly increased the stability and made it possible.

The fluid mechanics demonstrations conducted on Skylab only scratched the surface of the useful fluid mechanics experiments that can and should be done on future shuttle missions in the 1980's.