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FINAL REPORT

BY

THE CITY COLLEGE RESEARCH FOUNDATION  
THE CITY COLLEGE

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Convent Avenue at 138th Street  
New York, N.Y. 10031

To: NATIONAL AERONAUTICS AND SPACE ADMINISTRATION  
Washington, D.C. 20546  
Grant No. NGR-33-013-009

On: "ATOMIZATION OF VISCOELASTIC FLUIDS:

For the Period: 1 January 1968 - 30 June 1969

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Date: May 1970

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The work under the grant covered a four year period dealing with the fundamental aspects of atomization of viscoelastic liquids. The work is at present being continued under NSF Grant No. GK-11374.

The results of the research have been published in three papers, copies of which are attached to this report (ref. 1-5). A short summary of these results and their application to problems of space propulsion is given below.

A linearized stability analysis (1, 2, 4) based on the assumptions that the fluid is completely relaxed predicts that viscoelastic fluids are more unstable than Newtonian fluids with the same zero viscosity. Fluids possessing a yield stress, however, should be more stable. Experiments with highly elastic fluids show (1,5) that their breakup is governed by nonlinear phenomena and that wave formation is suppressed. Even mildly concentrated solutions of highly elastic solutions could not be atomized in a jet.

On the other hand, completely gellified solutions of non-elastic thickeners (ref. 3,5) could be atomized very early. What is important is that the relaxation time of the structural recovery of the gel be longer than the breakup time of the jet. It is possible to obtain thickeners, which on the one hand will allow the complete gellification of the fuel, but will also be easily extended through a nozzle and atomized.

Such gellified fuels might be important to prevent sloshing and to allow the incorporation of solid particulate additives to liquid fuels.

The results of the research indicate that a correct choice of the thickening agent is of extreme importance since otherwise the atomization of the fuel is going to be difficult or impossible. Some simple tests and theoretical guidelines for the correct thickening agent are provided as a result of this research program.

In ref. 2 the results of the theoretical work are applied to some more general problems of constitutive equations for viscoelastic liquids.

#### References

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2. J. Yerushalmi, S. Katz, R. Shinnar. "The Response of Viscoelastic Materials to Small Deformations." *Chem. Eng. Science*, 24, 1371-1383 (1969).
3. M. Goldin, R. Pfeffer and R. Shinnar. "Breakup of Capillary Jets of non-Newtonian Fluids Having a Yield Stress." Paper presented at A.I.Ch.E. Meeting, Washington, D.C., November 1969.
4. J. Yerushalmi. "Stability of a Filament of a Viscoelastic Fluid." Ph.D. Thesis, Dept. of Chem. Eng., City College, May 1969.
5. M. Goldin. "Atomization of Viscoelastic Fluids." Ph.D. Thesis, Dept. of Chem. Eng., City College, May 1970.