ELECTRORHEOLOGICAL FLUID-DAMPERS: TESTING MODELING AND APPLICATIONS IN VIBRATION AND SEISMIC PROTECTION OF STRUCTURES

by

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The objective of this project is to combine the advantages of passive energy dissipation for seismic protection of structures with the benefit of actively controlling structural response. This is possible by using electrorheological fluid dampers, where the damping force that develops is controlled by modifying the viscosity, dynamic shear modulus or even the 'yield' stress of the fluid within the damper. In this way, semi active dampers produce control forces which are induced by the motion of the structure and do not require external power.

An electrorheological fluid damper with applications to vibration and seismic protection of structures is under development. The damper consist of a cylinder and a piston rod that pushes the ER-fluid through a stationary annular duct. A reservoir is present to accommodate the fluid volume displaced by the piston rod and by thermal expansion. The electric field is created perpendicular to the fluid flow. In this way the ER-fluid is subjected to a "nonlinear" Poiseille flow, and the damper force is proportional to the developed pressure drop. A preliminary design of the damper is shown in Figure 1. With this design, relative small dampers can deliver the high forces needed in civil engineering applications, by simply selecting the appropriate duct-gap.

Two types of ER-fluids have been prepared and tested. The carrier of the first fluid is a mineral oil; whereas, the carrier of the second fluid is a nematic liquid crystal. The suspended solid in both fluids is zeolite. Dynamic properties of the fluids have been measured under various electric fields, and a realistic viscoelastoplastic model has been proposed to approximate the response. The predictions of the model are in good agreement with experimental data. Comprehensive testing of the ER-damper is scheduled to start in Fall 1994.

At high electric fields the behavior of the damper is expected to be highly nonlinear. While, constitutive modeling of the ER-damper using a continuum mechanics approach is one of the concentrations of our project, neural network algorithms are also under investigation in order to develop efficient control strategies. Neural network algorithms have been proposed in the past to control ER-dampers that find applications in protection warfare systems developed by the US. Navy.

The long-term goals of the project are: (a) Develop and construct an electrorheological fluid damper with applications to seismic protection of structures; (b) Validate realistic constitutive models and other modeling strategies; (c) Develop control algorithms to achieve optimal response of structures with added ER-dampers.
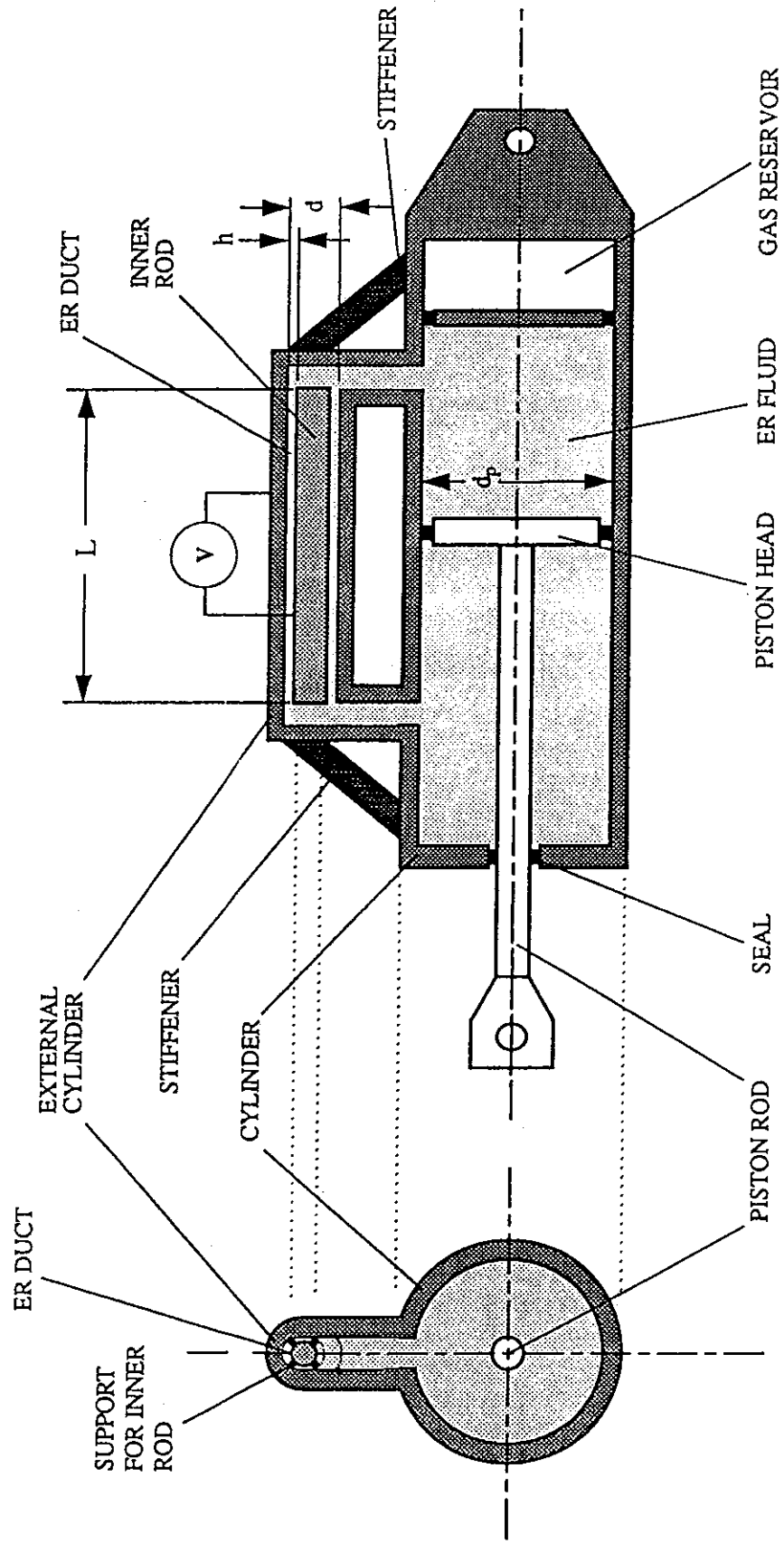
Fig. 1

STIFFENER

ER DUCT

INNER ROD

d

h

GAS RESERVOIR

ER FLUID

d_p

PISTON HEAD

L

V

ER DUCT

SUPPORT FOR INNER ROD

EXTERNAL CYLINDER

STIFFENER

CYLINDER

SEAL

PISTON ROD