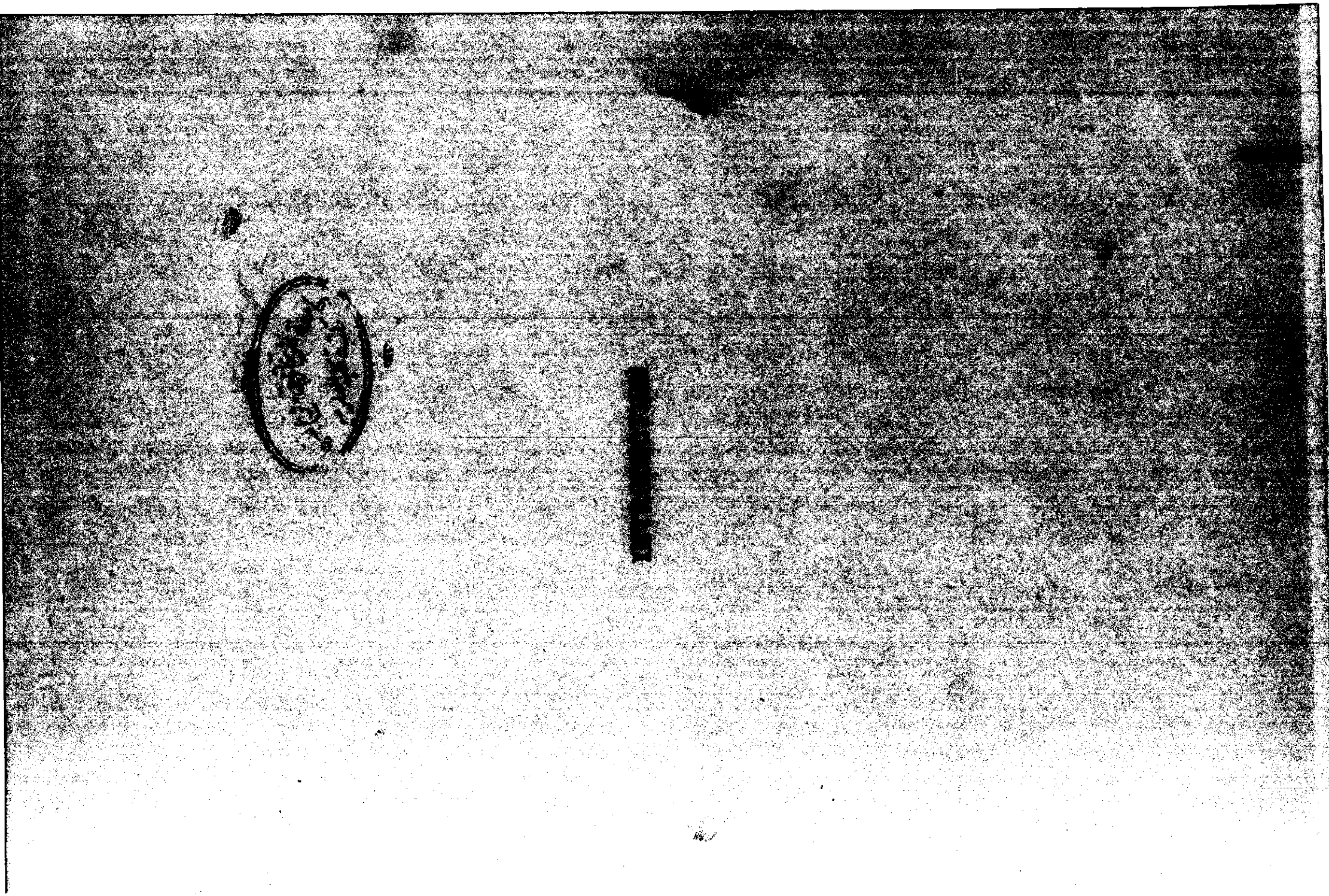

## INTRODUCTION

The conventional rheometers based on the realization of either steady or periodic viscometric flow are not capable to determine the non-Newtonian properties of fluids. For this reason, one of the major purposes of rheology is to investigate further types of flow other than viscometric flow, which allows the determination of some of the non-Newtonian properties of fluids. The flow of a fluid of grade two in the annullar region between two eccentric cylinders was the subject for a series of publications where axial motion [3,4 ], and rotational motion [5,6,7 ] were discussed separately. For any of the two types of flow the velocity field was found to coinside with that of the Newtonian fluid. The combined axial and rotational flow [1,2] showed that the velocity field for a fluid of grade two differs from that of a Newtonian fluid by a correction term added to the axial component of velocity. This term exists only in presence of the combined flow and vanishes if either the rotational or axial flow does not exist. In this work the authors suggested the application of this boundary value problem for the construction of a rheometer which allows the determination of some of the elastic constants besides the Newtonian

viscosity.

It is worthy to mention that about 25 years ago [8 ] the force and torque acting on a sphere which undergoes simultaneous rotational and translational creeping motion in a fluid delivers nearly complete characterization of an incommpressible fluid at least up to third order. However, the practical realization of a corresponding device has never been realized .

About 20 years ago Walters et al [5 ] designed special case of both cylinders rotating with the same angular velocity. With this device it was possible to determine in the first approximation both components of the complex viscosity.

The rheometer based on the two eccentric cylinders which is realized partially in the present thesis allows the determination of material constants up to the second order. Due to the difficulties in the construction, the apparatus is designed to perform the rotational motion only. It is worthy that further trials are made to construct a more developed type which performs translational motion besides the

rotational one. However, the present rheometer showed to be reliable in measuring the Newtonian viscosity $\mu$ and the elastic constant $\alpha_1$ of the second order in a conenvient way and with only one and the same set up.

The eccentric cylinder geometry proved to be suitable for practical construction of a rheometer which gives trustworthy results compared with the existing rheometers. Indeed, it realizes Zidan's concept [1,2] only incompletely, insofar, relative rotation of the inner-cylinder is allowed for but no supplementary translational motion or application of an axial pressure gradient, in short, it realizes the well-known journal-bearing flow.

This device was projected as an auxillary set-up to a rheometrics mechanical spectrometer of a type suitable for measurements with the eccentric disc technique. Of course, with such an apparatus only incomplete information can be realized on second and third order behaviours. It is, however, possible to control the results in the range of slow rotational speeds completely by comparison with results from a conventional cone-and-plate rheometer. Moreover, an additional control is given for the zero-shear viscosity

insofar its magnitude results both from the measurements of the torque and of one of the force components in the plane of rotational motion.

This work is based on the work of Zidan and Abu-Elhassan [1,2] after making a major modification of the stream function. This modification was in the first order stream function because their function was not enough to characterize the fluid contained in annulus region between two eccentric cylinders, and consequently the forces, the torque and the pressure distribution function.

This thesis consists of 5 chapters. The first one deals with the kinematics and dynamics of the flow, and presents the theory of the constitutive equation of a simple fluid, specially, the retarded motion approximation leading to fluids of grade n.

The definition of the present boundary value problem as well as the formulation of the equations of motion which emerges from the method of successive approximation are included in the second chapter.

Chapter three is devoted to the calculation of the resultant forces and torque on the boundaries from the solutions given in chapter two. Some useful parameters are defined which are of practical importance.

The construction of the apparatus is discussed in details in the fourth chapter. The present apparatus is evaluated critically in comparison with the cone-and-plate rheometer.

The last chapter includes the experimental results obtained with the present device. These results are discussed and compared with similar measurements obtained by the cone-and-plate rheometer.