SYNOPSIS

The present thesis deals with problems of unsteady boundary layers in viscous incompressible fluids. The thesis is divided into six chapters.

In chapter I, a brief review of the previous results directly related to the present work is given.

Chapter II is devoted to the study of the effects of plate oscillations superimposed on the two dimensional stagnation point flow of an incompressible viscous and electrically conducting fluid under a transverse magnetic field. An approximate integral method has been used to solve the boundary layer equations. Separate solutions for low and high frequency ranges are obtained. For very high frequencies, the flow pattern is a superposition of the steady flow and the oscillatory 'shear wave' unaffected by the magnetic field. For low frequencies the oscillatory flow always lags behind the plate oscillations. However, as the strength of the magnetic field increases, thus tendency to phase lag is more than compensated near the free stream. The transient case when the plate moves impulsively from rest is also discussed.

In chapter III is studied the forced convection laminar boundary layer flow of a viscous incompressible and electrically conducting fluid from a semi-infinite flat plate, when the plate temperature oscillates in time about a constant non-zero mean while the free stream is isothermal. The fluid flow and the applied magnetic field at a great distance from the plate are both assumed to be constant and parallel to the plate. By introducing the concept of similarity the Navier-Stokes equations and the energy equation are reduced to a set of ordinary non-linear differential equations and are then integrated using an approximate integral method. Separate solutions for low and high frequency ranges are obtained. It is found that in the low frequency range the oscillating component of the temperature in the boundary layer always lags behind the plate temperature oscillations while the rate of heat transfer has a phase lead. In the high frequency range the temperature in the boundary layer is of the 'shear wave' type.

Chapter IV is devoted to the study of free convection flow and heat transfer from a semi-infinite horizontal flat plate whose temperature oscillates harmonically with time. The solution is obtained by a process of successive approximations, the first approximation satisfying the linear equations in which the inertia terms are neglected. It is found that a steady temperature is induced at large distances from the plate which is positive or negative according as Prandtl number is less than or greater than unity, that the rate of heat transfer consists of three parts, a steady component, a component oscillating with the frequency of the plate temperature and the third oscillating with double the frequency. It is also found that the skin friction oscillates with the frequency of the plate temperature but lags behind by $\frac{\pi}{2}$.

In chapter V we consider the transient free convection flow between two horizontal plates. Initially the plates and the fluid are at the same temperature and there is no flow. At time $t=0$, the plates are suddenly heated which causes flow. Two cases are considered (i) when the temperature of one of the plates is given a step rise (ii) when one of the plates is given a periodically varying temperature. Exact solutions of the Navier-Stokes and energy equations have been obtained with the help of Laplace Transforms. It is found that the velocity is proportional to Rayleigh number and is positive or negative according as the axial temperature gradient is negative or positive. The velocity profiles tend to become parabolic with the lapse of time and ultimately die out. For the transient case the temperature increases even beyond the steady value for some value of time before finally coming to the steady value. The temperature gradient at one of the plates decreases very rapidly even becomes zero for some value of Rayleigh number and finally tends to a steady state, while at the other plate it increases even beyond its steady state value before attaining it. In the second case for very small frequencies, the system behaves almost similar to the transient case. For higher frequencies, initially the temperature profiles are more or less similar to that of the transient case but with lapse of tiem, when the transients die out, they are similar to a forced oscillatory system.

Chapter VI is devoted to the study of the oscillatory free convection flow in ducts of arbitrary cross-section when the temperature of the duct wall oscillates in time. The general problem is formulated in terms of variational principles and is completely solved in two particular cases of flow between two plates and in circular pipe. It is found that the velocity profiles are quasi-steady for small frequencies but become increasingly distorted for high frequencies. The skin-friction fluctuations lag behind the temperature fluctuations. The phase lag increases as frequency increases but decreases with Rayleigh number. The oscillatory component of the rate of heat transfer at the wall has a phase lead over the wall temperature fluctuations which decreases as Rayleigh number increases. This phase difference becomes even negative for large values of Rayleigh number.