the case, when reversed bending tests are carried out. It is sufficient that a certain stress inversion take place as a stress decrease succeeding a stress increase. Thus the maximum shear stress in an elastic cylinder simply comes back round zero, when the internal pressure is released. The fractures caused by the metal fatigue suddenly occur without being announced by a suspicious deformation of the material. By their appearance by which specialists are not taken in, one recognizes a destruction caused by a crystalline decohesion. One would not easily understand, why a metal perfectly sound and elastically acted upon, breaks, because it is "tired", if it could not be reasonably assumed, that it is the seat of a microplasticity phenomenon, which is hardly perceptible for it is probably in these tiny regions, that the destruction occurs, such destruction being accounted for by crystalline lamellae moving in opposite directions and rubbing one against the other.

The parts of a compressor, submitted to numerous and rapid pulsations of the pressure are necessarily to be counted among those of which the fatigue has to be taken into account, when their dimensions are to be calculated. But the apparatuses, which slowly but continuously work such as the mercury pumps are also themselves threatened by the fatigue. Such fractures have already been reported. Reversed tensile and bending fatigue tests are abundantly dealt with in the technical literature. It seems however, that the solution of our problem can hardly be based on their results. Torsional tests and tests carried out on hollow cylinders submitted to alternating pressures were found more suitable to the purpose by MORRISON, CROSSLAND and PARRY who carried out such tests [1956, 1957, 1959, 1960a and 1960b]. It was also found that for each steel there is an upper limit of the shear stress τ below which the test piece is not yet broken after 10 millions of cycles, whereas above this limit of τ, the test piece breaks the quicker as the value of τ is higher. It is obvious that a design is to be based on this limit. A lot of experiments have been carried out but their number appears to be not yet high enough for determining with great precision the fatigue limit and expressing it by a percentage of the tensile ultimate stress. As far as a ferritic or martensitic steel is concerned, it seems not unreasonable to say that such a percentage may amount to 30%.

Different methods have been tried with a view to increasing the fatigue endurance. The bore of the cylinder has been nitrided. As the nitride layer's volume slightly increases in the course of this treatment, this layer is compressed by the remainder of the wall and that is a favourable circumstance because the small defects occuring in the immediate vicinity of the bore less increase the value of the stresses when the cylinder is submitted to a pressure. An other method which seems to be an adequate one, consists in reinforcing the cylinder by "autofrettage" with a view to putting it under the same favourable circumstances. As the self-reinforced cylinder is obviously the seat of a phenomenon called "hysteresis" and wastes energy, one could believe that the fatigue endurance is diminished. In fact it is the contrary which occurs. A last method, which is the simpliest one consists in choosing a material as homogenous as possible, such as a steel obtained by consumable electrode remelting.

The ageing is also a phenomenon which is connected to the structure of the material as the fatigue is. We will not dwell upon this phenomenon, which is too well known but one will remember that a steel runs the risk of becoming brittle by ageing.

Corrosion by chemical agents is a term which covers numerous specific cases. For instance, it is obvious that a steel decarburized by hydrogen under pressure is entirely different from a steel attacked by an acid and showing corrosion pits. As a rule one recommends to choose the metal which best resists the chemical agent considered and to carefully polish the interior of the vessel. If the mechanical properties of the metal are too weak, the cylinder can be reinforced or self-reinforced or any method of the same kind can be applied to the same purpose.

7. The Effects of the Temperature

The unpleasant effects of the temperature upon the steels and alloys are mainly the following ones :

a) appearance of temperature stresses,

b) creep at high temperatures, impairing the strength of the material,

c) possible embrittlement of the material at low temperatures. Let us now briefly discuss these three items.

a) Stresses resulting from an unequal expansion of the material appear in a cylindrical wall as soon a temperature gradient appears. These stresses are the temperature ones, which may become dangerous, when they are superimposed upon the pressure ones. When one assumes — and that is a very restrictive assumption indeed — that the distribution of the temperatures obeys the law of the cylindrical symmetry and varies neither in the axial direction nor throughout the time, that the axial strain is constant and that the Young modulus as well as Poisson's ratio and other characteristics of the material are constant within the interval of temperature considered