Developing methods by which the strength of glass-plastic cylindrical shells can be diagnosed is one of the urgent problems which relate to the assurance of high reliability with the minimum mass [1-5]. Methods of determining the ultimate internal pressure in thin-walled shells with strain gauges [4] and through ultrasonic tests [5] have already been proposed. The use of these methods requires that a reliable relation exist between the deformation characteristics and the strength properties of the glass-plastic material in the test specimen and (especially in ultrasonic testing [5] based on the strength criteria for a given material [6] and data from tensile tests by extrusion) that the properties of the material be uniform over the entire volume of the specimen and of the margin. Various studies [1, 7, 8] have revealed that these conditions do not always prevail.

In cylindrical shells wound parallel with two layers of impregnated glass-cloth, a 50% displacement of each texture layer produces annular zones which differ from the main wall and the margin [7] in that here the laps of glass-cloth tape have a variable glass and binder content with a higher concentration of microdiscontinuities. Considering the strong effect which microdiscontinuities (e.g., pores) have on the strength and the stiffness of glass-plastics in interlaminar shear [9], one may expect the strength of such shells and their mode of fracture to depend on the strength of the weakest zones with cloth laps, on their distribution over the shell, and on the degree of nonuniformity which characterizes the distribution of the mechanical properties of the material and the distribution of the structural properties over these zones throughout the volume. All this points to the
necessity of using nondestructive methods for local testing of glass-plastics contained in a product. In order to justify a particular choice of nondestructive methods from among available ones (as, for instance [1, 8, 10-13], by establishing the need for an additional test or for solving a few other problems associated with developing a method of diagnosis on the basis of such an approach), it is necessary to first find out what the main factors responsible for the strength of a product are, then to account for the selectivity (selective sensitivity) of the physical characteristics used in nondestructive testing, and, finally, to determine how the strength of a product is related to these measured characteristics. These problems, related to the practical aspects of diagnosis, are most expediently solved by the experimental—theoretical method that has been used in the theory of testing complex systems [14] for revealing the relevant (governing) factors and constructing a mathematical model to describe the relation between these factors and the efficacy of a given complex system. The relevant factors are selected on the basis of a qualitative analysis of the system, with the use of simplified models, while their relation to the efficacy is obtained statistically in the form of an approximating expression from results of tests in which the values of those relevant factors have been varied over a given range. It is assumed here, furthermore, that the sought relation can be put in the form of a polynomial [14].

A shell may be treated as a complex system whose efficacy parameter, say its strength $q$, is generally a function of several groups of parameters:

$$q = \varphi \{ (M_i); (G_i); (T_i); (D_i); (S_i) \},$$

where $(M_i)$ characterizes the mechanical properties of the material and their distribution over the specimen volume; $(G_i)$ characterizes the geometry and the structural features of the specimen; $(T_i)$ characterizes the technology of the given product; $(D_i)$ characterizes the defects revealed by defectoscopy and their distribution over the specimen volume; and $(S_i)$ characterizes the service conditions and, especially, the mode of loading.

In comparative testing of one-item batches produced by some conventional technology and not defective beyond permissible limits, the problem can be reduced to a determination of the comparative strength, i.e., of the change in the strength of a test specimen relative to a standard or a "sacrificial" specimen. It then becomes unnecessary to account for many factors whose constancy can be ensured by the appropriate production technology and process control. With the problem formulated in this way, in many practically important cases expression (1) simplifies to $q = \varphi \{ (M_i) \}$. One assumes here that changes in the mechanical properties of the glass-plastic in a product may be caused, essentially, by random deviations in the technological process which cannot be measured and controlled during production.

Considering the feasibility of measuring the changes in various mechanical properties of glass-plastics by diagnostic methods [1, 8, 10-13], and for the purpose of verifying the validity of the proposed approach, the development of a method for diagnosing the strength of shells has been delineated in terms of the following tasks it must perform:

1) reveal the indicators of mechanical properties and their nonuniformity within a specimen (relevant factors) which could be responsible for fracture in the weakest zone of glass-Textolite laps and also of the thin-walled parallel-wound glass-cloth cylindrical shell as an entity under a momentary internal hydrostatic pressure load;

2) be applicable to shells of specific nominal dimensions so that the appropriate test procedure can be selected for measuring those characteristics which represent the relevant factors and to make it feasible to obtain, for practical use in diagnosis, an approximating expression which describes the relation between the comparative strength of a product and those measured characteristics.

§1. For determining the relevant factors we will use simplified models and consider three extreme states of a lap zone located within the center portion of a shell, namely: fracture by unwinding caused by tangential forces only, fracture by parting of laps caused by axial forces only, and fracture due to combined action of forces in both directions.