An $n$-dimensional knot is a pair $(S^{n+2}, k^n)$, where $k^n \subset S^{n+2}$ is a smooth oriented submanifold homeomorphic to the $n$-sphere. A knot is called stable if its complement has the homotopy $[(n+3)/3]$-type of $S^1$ and $n \geq 5$. Two knots are isotopic if there exists an isotopy of the ambient sphere sending one knot onto another with preserved orientations.

The first section of this paper provides a classification of stable knots in terms of the stable homotopy theory. Our main invariant is a homotopy generalization of isometry structure introduced by Kervaire [10]. Detailed analysis of all possible modifications of Seifert manifold enables us to formulate an equivalence relation on the set of stable isometry structures, factor set being exactly the set of all stable knot types. This found equivalence relation is new for the algebraic situation of [10] as well; it gives there an effective algebraic description of isotopy types (instead of cobordism classes as in [10]) of simple odd-dimensional knots.

As it was shown in [7], the classical homology invariants fail to form a complete system even for simple even-dimensional knots. The results of §1 allow us, however, to expect that more or less extensive algebraic classification of stable knots might have been constructed by applying generalized homology theories. §2, where we study extraordinary Alexander modules expressing them through modules of Seifert manifolds, gives a few steps in this direction.

Our technique of covering functors makes it possible to manage difficulties caused by non-compactness of the infinite cyclic covering and by lack of suitable duality theorems for generalized homology. This technique suggests a general construction of various forms on extraordinary Alexander modules among which there are, on the one hand, all known forms and, on the other hand, a number of new.

### 1. A STABLE-HOMOTOPY CLASSIFICATION OF KNOTS

1.1. THE CARVING MAP. Let $V^n \subset S^{n+2}$ be a smooth compact connected oriented submanifold with boundary being a homology sphere.
Let \( i_+, i_- : V \to S^{n+2}_V \) be small translations along positive and negative normal fields, respectively. It is easy to show that for \( k > 0 \) the homomorphism \( H_k \to H_k(S^{n+2}_V) \), sending \( \alpha \in H_k \) to \( i_+(\alpha) - i_-(\alpha) \), is an isomorphism. In fact, if \( \alpha = \{ \alpha_t \} \) is in its kernel, then there is a chain \( \beta \) in \( S^{n+2}_V \) with \( \partial \beta = i_+\alpha - i_-\alpha \); if we add to \( \beta \) the cylinder over \( \alpha \) we obtain a cycle \( \gamma \) which intersects \( V \) along \( \alpha \). This implies \( \alpha = 0 \), because \( \gamma \) is the boundary of some chain \( \delta \) lying in \( S^{n+2}_V \) (since \( H_{k+1}(S^{n+2}_V - \partial V) = 0 \) for \( k > 0 \)) and so \( \alpha \) is the boundary of the intersection of \( \delta \) with \( V \). The fact that \( i_+ - i_- \) is onto may be proved similarly.

Consider the map \( h : S V \to S(S^{n+2}_V) \), where

\[
h_t = \begin{cases} 
[i_+(v), 2t] & \text{for } 0 \leq t \leq \frac{1}{2}, \\
[i_-(v), 2-2t] & \text{for } \frac{1}{2} \leq t \leq 1,
\end{cases}
\]

\( S \) denoting non-reduced suspension. By the statement in the previous paragraph \( h \) induces isomorphism in integer homology. Besides, both spaces in question are simply connected and so \( h \) is a homotopy equivalence. Therefore there exists map \( \pi : S V \to S V \) with \( h \circ \pi \) homotopic to \( S_t \) and \( \pi \) is unique up to homotopy. This map \( \pi \) will be called carving map.

The map \( \pi \) acts on homology of \( V \) and this action is easy to describe: if \( \alpha = \{ \alpha_t \} \in H_k \) and \( \beta \) is a \((k+1)\)-chain in \( S^{n+2}_V - \partial V \) with boundary \( i_+\alpha \) then \( \pi \alpha \in H_k \) is the homology class of \( \beta \cap \text{int } \alpha \). For classical knots the matrix representing the action of \( \pi \) on the one-dimensional homology appeared in [17] and was denoted by \( \gamma \).

1.2. THE INTERSECTION FORM. Let \( Y \) be the complement of an open tubular neighbourhood of \( V \) in \( S^{n+2}_V \). Fix base-points in \( V \) and in \( Y \) and consider the canonical Spanier-Whitehead duality \( V : V \wedge Y \to S^{n+1}_V \). Regarding \( i_+, i_- : V \to Y \) as \( S \)-maps we may form the \( S \)-map \( \iota : V \wedge V \to S^{n+1}_V \) by \( \iota = \psi(1 \wedge (i_+ - i_-)) \). This map \( \iota \) will be called intersection form of \( V \). It may be shown that \( \iota \) does not depend on the imbedding \( V \subset S^{n+2}_V \), and is determined by the topology type of \( V \). But we shall not use this fact and so omit its proof.

To formulate properties of the \( S \)-maps \( \iota \) and \( \pi \) we shall use the following notion. A stable isometry structure of dimension \( n \) is a triplet \( (X, \iota, \pi) \), where \( X \) is a finite pointed CW-complex and \( \iota : X \wedge X \to S^{n+1}_V \), \( \pi : X \to X \) are two \( S \)-maps satisfying: (a) \( \iota \) is a duality; (b) \( \iota = (-1)^{n+1} \iota \);