DEPARTMENT OF THE ARMY

TRANSLATION NO.	ID NO.
J-3495	2 2040478 67

REQUESTER	CONTROL NO.	TRANSLATOR'S INITIALS	DATE COMPLETED
	612-67		24 MAY 1968

LANGUAGE	GEOGRAPHIC AREA (If different from place of publication)
Russian	USSR

ENGLISH TITLE OF TRANSLATION

Shipboard Soft Containers

PAGE NUMBERS TRANSLATED FROM ORIGINAL DOCUMENT

FOREIGN TITLE OF TRANSLATION

Sudovyye Myagkiye Yemkosti

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FOREIGN TITLE OF DOCUMENT (Complete only if different from title of translation)

PUBLISHER	DATE AND PLACE OF PUBLICATION
"Sudostroyeniye" Publishing House	1966. Leningrad, Russia

COMMENTS

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TRANSLATION

Extensive information about a new type of transport equipment - elastic storage containers - is set forth in this book. The method of design, construction and peculiarities of exploiting the basic types of shipboard soft containers are examined.

The book is intended for engineer-technical and scientific workers of the shipbuilding industry, and also for workers of the merchant, river and trading fleet.

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FOREWORD

The successes of the chemical industry have created the premises for development of a new kind of transport equipment -- soft containers. Along with towed floating containers for the transport and trading fleet, other varieties of soft containers, located directly aboard ship, in many cases can also prove to be highly useful.

Soft containers, especially shipboard, began to appear relatively recently, and are still not sufficiently examined in literature. Interest in the new designs of containers is very high meanwhile. Taking this into account, the authors have included in this book, not only data concerning already completed and tested types of soft containers, but the projected and patent materials available to them as well. The book is based, to a considerable degree, on the results of theoretical, project design, and testing work by the collective of the Theory and Construction of Ships Faculty of the Vladivootok Higher Maritime Engineering School. The work was conducted, beginning in 1959, both independently and in accordance with tasks set by various organizations. We must especially note the fruitful cooperation with Glavdal'vostokrybprom and its Vostokrybkholodflot Trust, without whose participation, the practical testing of the authors' ideas would have been delayed for many years. I. I. Korobkin and A. S. Babayev most actively facilitated the conduct of joint work.

Described in the book are the basic types, classes and kinds of soft containers which are found and might come into use on ships in the forthcoming years. Brief information on the methods of calculating and designing each kind of container is given. Because the mechanics of construction of soft containers are only now being worked out, the recommendations set forth are not in all cases comprehensive. Where possible, conclusions are carried up to the calculating formulas and graphs which are usable by a wide circle of engineer-technical workers.

Sections 1, 2 chapter II, Sections 12, 13, 18, 19, 22 to 24 and the Appendix were written by V. E. Magula; Sections 3, 4, 20 by B. I. Druz', Sections 14 to 16, 25 by V. D. Kulagin; Sections 26, 28 to 30 by Ye. P. Miloslavskaya and M. V. Novoselov; Section 17 by V. D. Kulagin and M. V. Novoselov; Section 21 by B. I. Druz' and M. V. Novoselov.

The text and tables in Section 4, regarding rubberized materials, were written by Yu. F. Andrianov, the data on the strength characteristics of soft container casings were set forth by S. D. Knoring, and all information concerning the project of an all purpose ship in Sections 14, 17, 25 and 27 is by A. R. Lekhtsiyer, for which the authors express their sincere gratitude. The sketches of soft containers were made by artist Ye. P. Pokrovkin.

The authors thank A. I. Azovtsev, G. S. Zubkov, V. V. Moroz, L. M. Mal'tsev, F. R. Nitochkin, and P. V. Marchenko for their great help in carrying out experimental and theoretical research, and also for calculating and constructing computation graphics.

CHAPTER I

GENERAL INFORMATION ON SHIPBOARD SOFT CONTAINERS

Section 1. Purpose and Fields of Application of Soft Containers.

The distinctive feature of hard materials, especially metals, consists of the combination of high strength with great rigidity. This quality, necessary for the normal operation of the majority of mechanisms and structures, plays a negative role in a number of cases by not permitting design of structures of minimal weight. Moreover, rigid structures usually have an identical volume in their operating and non-operating modes, and therefore, transporting them is often made more difficult.

Other pliable materials -- such as fabrics and films, have been known for a long time and are widely used in everyday life and in transportation. A considerable quantity of dry cargoes, for example, have been and are being transported in soft packings. But, the wide technical use of soft materials has been accompanied by the lack, in the majority of them, of the most important quality -- impermeability. The current growth of soft designs became possible only in recent years as a result of important successes in contemporary chemistry, which has created synthetic films, new strong fabrics, etc.

Within the general family of soft structures, the so-called soft containers are more and more frequently attracting the attention of shipbuilders, workers of maritime and river transport, and of the fishing industry. Under soft container, we mean either a closed or open reservoir, formed out of soft casing and intended for storing or transporting liquid, paste like or free flowing cargoes.

The term "soft casing" is comparatively new, and therefore in order to understand what follows, it must be precisely defined (1). Let us agree to take under soft, a thin casing having the following properties: the capability to take chained (membrane) stresses, having a definite rigidity when extended, the capability to undergo only very slight compression, bending, and torsion which, after exceeding certain critical values cause the casing to lose stability and form creases when the material is working at its limits of elasticity; the casing material in most cases is anistotropic, and possesses mass (weight).

In possessing these properties, a soft casing in and of itself may not have a firm surface shape, but acquires it only under the action of an external load. Thus, the surface of the casing can most frequently adapt its shape to each combination of external loads.

From the definition, it is clear that an understanding of "soft casing" is also required in terms of quantitative criteria. The ratio of the limit of bending strength σ_{bi} to the modulus of normal elasticity E of the casing material (if it is homogeneous) or its elastic warp (if it is reinforced) can be recommended as a criterion in our initial approach. Let us call a casing soft if

$$\frac{\sigma_{bi}}{E} \geqslant S.$$

The criterion denotes the casing's capability to form creases when the material is working within the limits of elasticity. Among materials used in making soft containers, S = 0.05 to 20, which corresponds to the minimal radius for bending the material into a crease of about ten of its thicknesses.

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(1) The terms "elastic tankage," "flexible tankage" and "elastic containers," are widespread in Soviet and foreign literature. The authors consider the term "soft container" more apt, because structural mechanics puts a somewhat different sense on its understanding of a "flexible, elastic casing" (See [20]).

In practical calculations, a soft casing can, for the most part, be considered as absolutely flexible, i.e., assume that it completely does not possess rigidity when bent or twisted, and is not susceptible to cutting, bending or twisting, or to compression.

The lively interest in soft shipboard containers is explained by its numerous merits in comparison to analogous rigid structures. Among these can be noted the following:

a) the small weight of the soft container itself in relation to the cargo carried within it: for various containers it fluctuates from 1 to 5%. This explains the fact that soft containers operate in a most advantageous condition, without moments of stress, which for them, is natural and of which they are uniquely capable.

b) the small volume of a soft container and, consequently, the need for empty space for its stowage. Thus, a shipboard container of 20 m^3 usable volume has a volume of about 0.3 m^3 in a folded condition, and together with rigid reinforcing structures (for a single container) -- of about 1 m^3. The combination of small weight and volume with great pliability also adds to soft containers such merits as good transportability when empty. This will permit transportation expenditures to be reduced by a great deal, since empty containers can be delivered to a base folded up.

Soft containers also have definite shortcomings in comparison with metal structures. Basic among these are -- the ease of damage to casings by accidental blows or punctures; damage by abrasion; deterioration of the casing's quality over the course of time under the sun's rays and the elements. Because of this, soft containers have a relatively short service life. As for operational shortcomings of soft containers, there are certain difficulties in filling and emptying them, the need for careful control of the degree to which they are filled, and the difficulty of coping with the container's oscillations during the time the ship is rolling.

An objective analysis of soft containers' qualities enables us to note the following prospective fields for their use aboard ships, where their merits present themselves as advantageous, and their shortcomings as not so essential:

use of soft containers for transporting small portions of liquid and paste like cargoes aboard dry cargo ships;

use of soft containers for delivery of fresh water and other liquid cargoes by dry cargo and refrigerated ships during ballast runs;

use of soft containers for increasing the reserves of fresh water and fuel aboard independently cruising ships;

use of soft and semi-rigid packing instead of rigid packing for transporting liquid and free flowing dry cargoes;

use of soft linings in rigid containers, boxes, and cases for transporting liquid, paste like and free flowing dry cargoes in them;

use of combined purpose soft containers. Shipboard soft containers can be used successfully in through transport of mixed liquid and free flowing dry materials. In roadstead operations, if the specific weight of the filling permits, containers can be loaded directly on the water and be towed to shore by a cutter. In certain cases, the container can also be used after loading as storage for that same cargo;

use of soft containers for ship to ship transfer at sea, without contact, of fuel, water, products, and almost, even fish products.

The prospects for use of soft shipboard containers are analyzed in more detail in chapter VI, but it is clear even from the short list introduced here, that shipboard soft containers have many fields of application.

Section 2. Basic Design Types of Soft Containers.

Up to the present, the classification of soft containers has not been thought out to its conclusion. They have been divided spontaneously into these or the other groups, as various designs have been worked out and in accordance with various indices. For the time being, it is impossible to create a complete classification of soft containers because it is difficult to foresee the paths of their future development. The classification presented below must therefore, be examined only as an initial attempt, requiring additions and changes.

Let us classify soft containers according to three main indices: shape and design of casing, operating conditions, and function.

Classification of soft containers by shape and design of casing. A distinctive feature of a majority of soft containers -- is the dependence of their shape on the conditions of operation. One and the same container can, for example, represent a circular cylinder when used in a vertical condition, a cylinder with another shape when disposed horizontally, but lose any definite shape whatever after being emptied. It is therefore necessary to define what is meant by the shape of the container.

It would be most correct to describe the shape of a soft container casing with the aid of the characteristic of the so-called internal surface geometry. Internal geometry considers those properties of the surfaces which do not depend upon their bending, by which, whether the casing is filled or empty, it is expanded or twisted. In conformity with industrial terminology, such type of characteristic could be generally described by the term "shape of a cutout casing." However, the meaning of internal geometry has for the time being not come into wide usage. Therefore, let us define shape of soft container for the purpose of classification as characterized by the form most natural for practical purposes -- the shape of a casing filled with air which is under a certain surplus pressure.

From this kind of definition, the following types of soft containers can be distinguished.

Cylindrical containers (Figure 1a,g,zh, k, n, r). This type of container can be subdivided according to the shape of the endings: flat endings, spherical, conical, cushioned or tubular (when the flat panels of the casing are closed with a flexible or rigid part -- by a beam, or by a lock).

Containers symmetrical to an axis -- whose casings present a rotational surface, with the axis of rotation oriented vertically (Figure 1b, d, z, l, o, s). It is possible to imagine many varieties of shapes of containers symmetrical to an axis: teardrop shaped, spherical, conical, barrel shaped, tore shaped, lens shaped, and others. Cylindrical containers in their vertical orientation must also be included among these.

Cushion shaped containers -- a variety of cylindrical type containers, with cushion shaped edges, where the ratio of casing length to width is close to unity (Figure 1v, e, i, m, p, t).

Mattress shaped containers -- cylindrical or cushion shaped containers, whose casing is fastened internally by clasps, which give some small height to the container in its operating condition (Figure 1,m).

Box type containers -- having the shape of a right angled parallelopiped or prism and functioning only in conjunction with a rigid compartment or framework but not forming a structural whole with these.

Semi-rigid type containers, whose casings are structurally connected by rigid parts (bottoms, walls, etc.). In shape, these can belong to any of the types enumerated (Figure 1, r, s, t).

Classification of soft containers by operating conditions. By operating conditions, we will mean the manner of stowing or securing the container, and the environment in which it is employed. In accord with this definition, let us divide containers into the following types:

Free-lying containers -- soft containers, which, in the operating mode rest on a horizontal flat surface (or a surface similar to that, in location and shape) and are fastened to it, if necessary, by means of flexible ties (Figure 1, a, b, v).

Suspended containers -- soft containers which, in the operating mode, are suspended (Figure 1, g, d, e).

Enclosed containers -- stowed in a rigid compartment of any arbitrary shape (Figure 1, m, z, i).

Floating containers -- soft containers, having positive buoyancy, which in the operating mode are located on the surface of the water (Figure 1, k, l, m).

Submerged containers -- soft containers, used under a liquid surface (usually under water) and, if necessary, capable of having both positive and negative buoyancy (Figure 1, n, o, p, t).

Combined purpose containers, which may be used in a varying environment or in various conditions, for example, afloat or on dry land, free-lying as well as enclosed.

By function, soft containers are divided mainly into storage containers and transport containers. Each of these groups can be divided into a number of types. Only the shipboard type of containers are considered in this book.

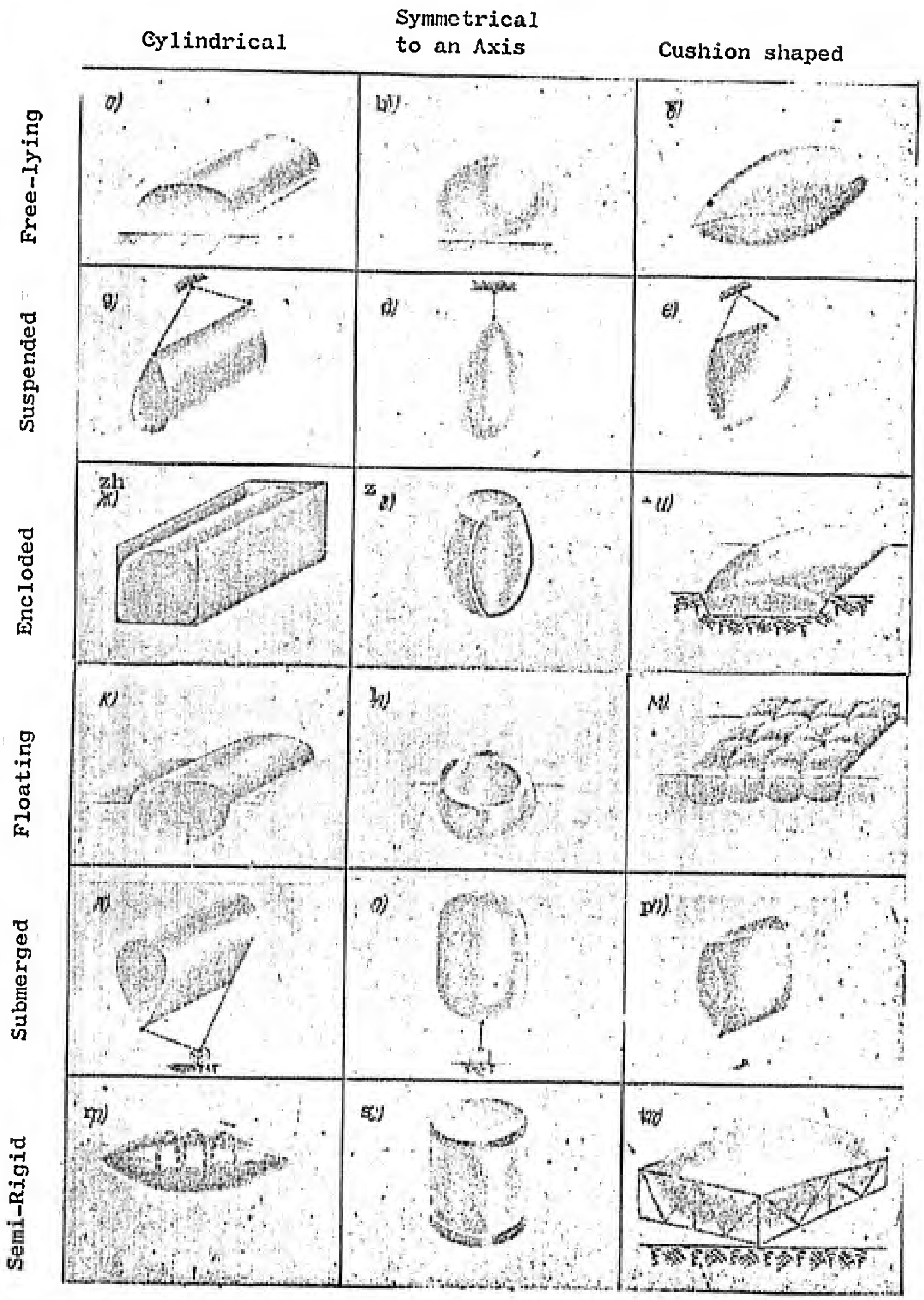

Figure 1. Basic Types of Soft Containers.

Section 3. Materials used in the manufacture of soft container casings.

The material of soft container casings must meet a number of rigid demands. The most important of these are: strength, low rigidity, impermeability, stability against interaction with the internal filler and with the external environment, protection of the cargo's condition, stability against abrasion, the capability of being handled technologically, sufficiently low in cost, and durability.

One material can seldom meet all of the requirements demanded of this or that type of soft container casing. It is especially difficult to reconcile the requirements of high strength and low rigidity. Homogeneous casings, made from a single material, are therefore found only in containers of small size and in close fitting containers which serve as linings in rigid containers or within stronger casings.

Non-homogeneous casings, made out of several materials, are used in soft containers most frequently of all. Plastics or rubber, which are reinforced with fabrics, meshes, or fibers, are used as the basic materials of casings. The reinforcement serves as a strong flexible frame for the casing while the basic material ensures its impermeability and protects the reinforcement from chemical and other types of interaction with the outside elements.

Component parts of soft container casings are now, as a rule, being made out of high molecular synthetic materials which are manufactured by synthesis of low molecular compounds in polymerization or polycondensation reactions. These materials, conditionally, divide into plastic materials (plastics with a sufficiently high coefficient of elasticity) and rubber (elastics, or elastomers) having the capability of returning to shape after undergoing large deformations.

In polymerization identical molecules are combined. Polymerization of two or several different materials is called copolymerization, and the materials derived -- copolymers. In polycondensation a large number of molecules of different materials is combined into one molecule, but, as distinct from copolymerization, by-products of the reaction are split off.

Products of polymerization and polycondensation most often do not have the necessary technical qualities, and these are called tars.

With respect to heating, tars and plastic materials are divided into thermoplastics, or thermoplasts, and thermosetting, or reactoplasts. Thermoplasts are capable of being softened repeatedly upon heating and then rehardening upon cooling. Thermosetting plastics become soft upon heating just once. Elements are then formed out of them.

In order to obtain plastics with the necessary properties, special ingredients are added to tars: fillers, plasticizers, lubricating materials, etc.

One of the most important properties which casings of many types of soft containers must have is stability against the action of petroleum products. Stability can be increased by selection of plasticizers by introduction of inorganic fillers, carbon black, vulcanizing agents, and by combining with many synthetic tars. The purity of the polymer materials also influences stability.

All synthetic materials possess such an important quality as biological stability, i.e., the capability to resist damage by plant (fungi, bacteria, etc.) and animal (insect, mollusk, etc.) organisms.

In manufacturing soft container casings, plastics are used for impregnation of fabrics, manufacturing synthetic films, fibers and glues. Rubber products are also used for impregnating fabrics and manufacturing rubber films and glues. Far from all varieties of these have come into use in the production of soft containers. Nevertheless, because experience in designing soft casings is still not extensive, it will be useful to present a short summary of the basic types of synthetic films, fibers and rubbers being produced.

Plastic films are produced in large quantities in the USSR and other countries. Basic data on the physico-mechanical properties of several types of films are shown below, and also in Tables 1 and [12].

Polyethylene is obtained in the polymerization of gaseous hydrocarbon of ethylene. Industry makes low, medium, and high pressure polyethylene. Films of high pressure polyethylene are produced without plasticizers by which their sanitary hygienic qualities are increased. They have no odor or taste, are non-toxic, and do not milden. They are very stable toward various aggressive elements under normal temperature, but become swollen under prolonged action of fats and oils. At low temperature the strength of polyethylene films does not become reduced. A shortcoming of polyethylene films is their aging under the interaction of solar radiation and the oxygen in the air. Aging reduces the mechanical qualities of the films, their resistance to cold, and forms hydroperoxides which upon decomposition give the products protected by the film an unpleasant taste and odor. The films have low heat resistance (up to 90° C).

TABLE 1

Physico-Mechanical Properties of Films

Film Materials		Density, g/cm^3	Strength Limits, kG/cm^2	Relative Elongation %	Resistance to Fracture (No. of double folds)	Heat Resistance, °C	Resistance to freezing - °C	Water Absorption, %
High pressure Polyethylene		0,91—0,92	120—200	320	50 000	90	60	0—0,8
Low pressure Polyethylene		0,94—0,96	400	200—700	a) Очень высокое	125	70	0
Polypropylene		0,90	1200—1800	250—700	a) Очень высокое	125—167	15—70	0,005
ПК-4	Polyamides	1,12	200—300	200	60 000			
Nylon 66 and 610	Polyamides	1,09—1,14	630		16 000		73	0,4—1,5
Rilsan	Polyamides	1,04	700—800	250—450		130—140		1,0
Lavsan	Polyesters	1,38—1,40	1200—1700	70—150		145—150	60—70	0,3—0,4
Thermo	Polyesters	1,00—1,03	470—550	200			57	
Non-plasticized	Polyvinylchloride	1,38	300—600	10—50	b) Незначит.	80	0—10	0,2
Plasticized	Polyvinylchloride	1,2—1,35	100—300	100—350	50 000	60—80	20—60	0,3
Polyvinylidenechloride		1,68	490—770	300		60—90	30—40	0,2
Polyvinyl alchol		1,21—1,31	700—1000	200—600	a) Очець высокое		40	c) Может растворяться
Teflon FER		2,14—2,17	180—220	250—330		250		0

Legion: a) Very high, b) Insignificant, c) can be dissolved.

Films of low pressure polyethylene possess higher heat resistance (up to 125°C) and impermeability to gasses, greater stability toward the action of fats and oils, and better mechanical qualities than films of high pressure polyethylene.

Better quality films are obtained with copolymerization of ethylene and propylene. To increase strength, heat resistance and impermeability, polyethylene films are mated with films made of polyethylene terephtalatum (mylar), acetyl cellulose, polyvinylidene chloride, and polyamides.

Polyethylene films are widely used as linings for flexible packings, containers, paper and jute bags, and also for internal coverings of soft container casings which are intended for food products and potable water.

Polypropylene -- is a high molecular regularly structured polymer. Films of polypropylene are thermo-plastic and are almost indistinguishable from those of polyethylene in chemical properties. Impermeability to moisture and gas, and the mechanical properties of polypropylene films is somewhat higher than those of polyethylene, and the specific weight is lower. Polypropylene's shortcomings include low resistance to cold of certain kinds and aging under the action of solar rays.

Polypropylene films are used in the manufacture of linings for flexible packing and as a packaging material. While they also have better qualities than polyethylene films, they cannot compete with them at present because of the considerable cost.

Polyamides are obtained by means of polycondensation of amino carbonic acid, diamines, and dicarbonic acid or the polymerization of lactams.

Polyamide films possess high strength, resistance to abrasion, low coefficient of friction, sufficiently high heat resistance, and good adhesion to metals. When set on fire, they spontaneously dampen after elimination of the flames. They are stable toward the majority of chemical reagents, aside from concentrated mineral acids, formic and acetic acid, and phenols. They possess good impermeability with respect to gasses.

Films with the brand PK-4, of polycaprolactam, (in the GDR - Perfol), are made in the USSR. In moist air, it becomes very swollen; has relatively high permeability to steam; is insufficiently stable toward solar light; and the film contains low molecular materials (caprolactam) which are toxic to the human organism.

Films of nylon 66 and 610 do not contain plasticizers, have no odor, and are non-toxic. However, they are considerably permeable to steam and water absorption. Rilsan type films have the lowest density and low water absorption, as a result of which they possess the greatest constancy of mechanical properties. They have especially high resistability to alkalis, saline solutions, sea water, oils and petroleum products. They are non-toxic.

Polyamide films are used as anti-diffusion padding in soft container casings, in the packing of various kinds of products and liquids.

Polyesters. Polyester tars are obtained by means of the polycondensation of organic acids with alcohols.

In the USSR, films under the name lavsan are produced from polyethylene terephtalatum. Lavsan type films yield poorly to welding by usual methods. Thermo-welded polyester films are produced in England. Their physico-mechanical properties are distinct from the properties of lavsan-type films (see Table 1). Polyester films have for the time being not received wide distribution because of the difficulty of welding and the comparatively high cost.

Polychlorvinyl (polyvinylchloride) is obtained by means of polymerization of a gas -- chloride of vinyl. Films are produced based on unplasticized and plasticized polyvinyl chloride.

Unplasticized polyvinylchloride -- a sufficiently rigid, but flexible material, has high strength and chemical stability. It has good stability toward the action of acids and alkalis, and the majority of solvents and fats. It is soluble in ethers and ketones, and becomes swollen in aromatic hydrocarbons. It has good technological qualities, glues and welds well, can be shaped when heated, and is difficult to set on fire. Unplasticized polyvinyl chloride has low permeability to steam, water and gas, has almost no odor, and is physiologically harmless. Among the shortcomings of polyvinyl chloride are poor adhesion with other materials, low resistance to heat, insufficient stability to light and cold, and brittleness of films at temperatures below 0°C.

By plasticizing polyvinyl chloride, films can be obtained which have elastic properties at normal and reduced temperatures. A large amount of plasticizers (up to 40%) can be contained in the film, and they worsen certain properties of the films, for example, they lower the strength of the film somewhat, and become harmful to the human organism.

Polyvinyl chloride films are the most widely distributed of all types in the various branches of industry. They are in especially wide use for packaging, manufacture of various types of bags, and linings of rigid and soft crates and containers. Small soft containers, linings for huge containers, and also brick linings for cement reservoirs are made from them.

Polyvinylidene chloride is a polymer of chloride of vinylidene. It is used in the form of a copolymer of chloride of vinylidene with a small amount of vinyl chloride and is called saran. Saran film has light chemical stability, exceptional elasticity, strength, and stability toward the action of solar rays.

Saran films are used in the form of linings for packings and containers, and also in the form of packets and bags.

Fluoroplasts are obtained in polymerization of processed ethylene and its homologues, in which the hydrogen atoms are mixed with fluorine. Fluoroplasts have high chemical stability, exceeding the stability not only of plastic, but also of such metals as platinum. The heat resistance of certain fluoroplasts approach 250°C, and their resistance to cold -- to 200°C. The basic shortcoming of fluoroplasts is their high cost.

The following fluoroplasts are used in industry: polytetrafluorethylene, polytrifluorochlorethylene, Teflon FER, polyvinylfluorine.

Polytetrafluorethylene (teflon) is stable toward all chemical reagents apart from alkaline metals and free fluorine, acting under pressure. In normal conditions, it does not have adhesive properties, and for sticking, therefore, its surface is processed with a solution of metallic sodium in liquid ammonia.

Several firms in the USA put out polytetrafluorethylene films reinforced with a glass lining. Such a film has an increased mechanical strength and rigidity, and decreased instability under the action of constant stress. In addition, a reinforced teflon is manufactured which is capable, after special processing of its surface layer, of being glued to other materials.

Polytrifluorochlorethylene is somewhat inferior to polytetrafluorsthylene with respect to chemical stability, but has better mechanical properties to make up for it. Thin films and coverings for other materials are made from polytrifluorochlorethylene, for operating in very aggressive environments.

Teflon FER (fluoridated ethylene propylene tar) has high chemical stability, and can be processed better than polytetrafluorethylene and polytrifluorochlorethylene. Various items and films, intended for operating in aggressive environments, are manufactured from teflon FER.

Polyvinylfluorine possesses good technological properties. The film called teslar is made from it. Teslar has high mechanical strength, high stability to influences in the atmosphere, and good chemical stability toward aggressive elements.

Yet another variety of film made of polyvinylfluorine is produced under the name tedlar. It also possesses high atmospheric stability and a good combination of physico-mechanical properties, and is therefore used successfully as an anticorrosion covering. Polyvinylfluorine films, despite the high cost, are mated with polyvinylchloride films.

SYNTHETIC FIBERS. There are natural fibers, from species of plants and animals, and chemical fibers, subdivided into artificial and synthetic types. Artificial fibers are obtained by chemical transformation of natural high molecular compounds celluloses and proteins. These include viscoses, acetates, cuprammonia and other fibers. Synthetic fibers are processed from high molecular compounds, which are obtained by synthesis of low molecular materials. Inorganic fibers, of glass, asbestos, etc., are also produced.

Chemical fibers are processed in three forms: filament fibers -- threads, composed of thin fibers of infinite length; staple fiber -- short-cut fibers similar to cotton and wool; and monofiber -- a thread of a single fiber.

Synthetic fibers are the ones mainly employed in the manufacture of soft containers. They are distinct from natural and artificial ones by their higher strength, resistance to abrasion, chemical stability, and low hydrophylic (capable of absorbing water) quality.

Let us examine the basic varieties of synthetic fibers, whose properties are described in Table 2.

Polyethylene fibers are manufactured from high, low, and medium pressure polyethylene. Polyethylene fibers are known abroad under the names: kurlen, marlex, polyten, etc. Fibers of low and medium pressure polyethylene have higher physico-mechanical properties. They all possess high stability toward the action of alkalis and acids, are not soluble in alcohols and ethers but become swollen in hydrocarbons, have low melting temperatures and low resistance to light. They are used in the manufacture of filtering fabrics in chemical and food industry, electrical insulating materials, ropes, nets, etc.

Polypropylene fibers have the least density compared with other fibers, high stability toward the majority of reagents, resistance to freezing, do not absorb moisture, but have low resistance to light. They are used for the same purposes.

Polyamide fibers. The most widespread of the polyamide fibers are the caprons (other names: in the USA -- nylon 6, in the GDR and FRG -- perlon, in Czechoslovakia -- silon, in Poland -- stilon, in Holland -- enkalon).

Capron nets are very strong and resilient. In a moist environment their strength diminishes by about 10% with simultaneous increase in elasticity. When heated above 120°C, their strength is considerably reduced. Capron is destroyed when illuminated by ultraviolet rays. Manganese salts are added to the nets to increase their resistance to light. Capron nets are stable toward many chemical materials.

Other polyamide fibers have about the same properties. All of them possess high resistance to abrasion. The following polyamide fibers are produced by industry: enant (nylon 7), rilsan (undekan, nylon 11), anide (nylon 66), and nylon 610. Polyamide fibers are used for the manufacture of tire cords, cables, fire hoses, and fishing nets. Capron fabrics now serve as the basic material for reinforcing soft container casings.

Polyester fibers are manufactured of polyethyleneterephtalatum. They are stable toward the majority of chemical reagents and have high resiliency. In heat resistance, they exceed all known natural and chemical fibers, their range of operating temperature is from 70 to 175°C, and they are resistant to the action of atmospheric influences and solar light. When they are wet, no loss of strength is observed. Polyester fibers have a lower resistance to abrasion than polyamides (by four to five times). Resistance to repeated bending is also lower. Among the shortcomings of polyester fibers are their strong electrical conductivity and low adhesion to natural and synthetic rubbers (in order to increase their adhesion, the fibers are processed with polyisocyanide salts.)

Physico-Mechanical Properties of Synthetic Fibers

a) Волокна	b) Плотность, г/см³	Предел прочности, кГ/см² c)	Относительное удлинение, % d)	e) Начальный модуль упругости (при удлинении на 1%), кГ/см²	Температура размягчения, °C f)	Температура плавления, °C g)	Морозостойкость, — °C h)	Водопоглощение, % i)
Of high density polyethylene	0,92	830—1240	45—50			105—110	45	
Of low density polyethylene	0,95	4700—6000	25—30			130—135	45	
Polypropylene	0,92	4500—5700	17—25	970—1160		165—170	20	
Capron: Filament normal	1,4	4500—4700	20—32	200—300	170	215	70	3,5—4,0
Capron: Filament reinforced	1,4	6900—8600	15—16	200—300	170	215	70	3,5—4,0
Capron: Staple	1,4	3600—5300	45—60	200—300	170	215	70	3,5—4,0
Polyesters: Filament normal	1,38	7500—8800	10—15	1080	230—240	255—260	70	0,4—0,5
Polyesters: Filament reinforced	1,38	5600—6300	20—25		230—240	255—260	70	0,4—0,5
Polyesters: Staple	1,38	4200—5600	25—40	250	230—240	255—260	70	0,4—0,5
Polyvinylchloride	1,39	3000—4200	25—180		80	180		0
Polyvinylidene chloride	1,68—1,75	6000	15—25		115	150—160	10	0
Of polyvinyl alcohol	1,26—1,27	3400—8000	15—30		220	232—237		4,5—5,0
Fluoride-containing: Teflon	2,1—2,3	3500	13	320	327		150	0
Fluoride-containing: Polyphene	2,2—2,3	1150—1610	15—40	102	320—326		150	0
Fluoride-containing: Ftorlon	1,96	9000—10800	6—9	1500	132—136		80	0,04
Polycaprilonitrile	1,16—1,17	5200—6200	14—17	800—830	235—250		30—40	0,8—1,2
Polycaprilonitrile modified	1,14—1,37	2250—4030	20—42	350—493				0,4—4,0
Polyurethane	1,21	5000	12—14		165—175	183	25—30	1,0—1,5

Legion: a) Fiber, b) Density, g/cm^3, c) Strength Limits, kG/cm^2, d) Relative Elongation, %, e) Initial Coefficient of Elasticity (at 1% elongation), kG/cm^2 f) Softening Temperature, °C, g) Melting Temperature, °C, h) Resistance to Freezing - °C, i) Water Absorption, %.

Polyester fibers are known under the following names: in the USSR -- lavsan, in the USA -- dacron, in England -- terilen, in the GDR -- lanon, in the FRG -- trevira, diolen, in Japan -- tetoron, in France -- tergal, in Czechoslovakia -- svitlen, in Holland -- terlenka, in Italy -- terital, in Poland -- elana, etc.

Manufactured out of polyester, fibers are cords for technical parts made of rubber, transmission belts, high-pressure fire hoses, gass, and oil resistant hoses, cables, fishing nets, filter fabrics, sails, tarpaulins, etc.

Polyvinylchloride fibers are manufactured in the form of silk and staple fibers. They possess high chemical stability, resistance to light, incombustibility, do not absorb moisture, but have low resistance to heat and are easily electrified. They are manufactured under the following names: in France -- rovil, fibrovil, thermovil, isovil; in Italy -- movil, in Japan -- teviron, etc. They are used for manufacturing filtering fabrics, special clothing, etc.

Polyvinylidene chloride fibers do not absorb moisture, have high resistance to light, are difficult to set on fire and spontaneously extinguish fire. They are chemically stable toward many reagents. They are produced under the following names: in the USSR -- soviden, in the USA -- permalon and venon, in England -- tigan, in Japan -- krekhalon, in France -- khloren. They are used for the manufacture of filtering fabrics, fishing nets, etc.

Fibers of polyvinyl alcohol are manufactured water soluble polyvinyl alcohol. They are resistant to atmospheric interaction and toward many chemical materials, but are dissolved in saline, sulphurous, phosphorous and formic acids. When wet, they lose 10 to 15% of their strength. They are resistant to abrasion. They are produced under the following names: vinilon, kuralon, kremon, sovilon, vinyl, vinol FO, monrio, myulon, kanebian, vinilan, etc. Fishing nets, cables, upholstery fabrics, etc., are manufactured of polyvinyl alcohol fibers.

Fluoride containing fibers have very high chemical stability toward various reagents, high resistance to light, heat resistance, strength, incombustibility, are non-flaming, and do not absorb moisture. However, they have great density and are long-lived. They are known under the following names: in the USSR -- polifen, ftorlon; in the USA -- teflon and teflon - 100X. They are used in the chemical industry for the manufacture of stuffing lining, padding, filters, other parts operating in strongly aggressive environments, and for manufacture of protective clothing, etc.

Polycaprilonitrile fibers are made of a linear polymer of nitrile acrylic acid. They have high strength, light and heat resistance, stability toward oxidizers, oils, organic solvents and various acids, and absorb tars well. However, they have little resistance to abrasion, heat, are insufficiently stable toward concentrated alkalis and certain acids. They are produced under the names: in the USSR -- nitron, in the USA -- orlon, acrilan, dynel M, verel, krilan; in the FRG -- dolan, dralen, pan, redon; in the GDR -- volkrilon, in France -- krilon, in Holland -- nimkrilon, in Italy -- orlon. They are used for the manufacture of filtering fabrics, protective coverings, fishing nets, tarpaulins, sails, tents, etc.

Polyacrylonitrile Modified fibers are inferior to unmodified polyacrylonitrile fibers in strength, light and heat resistance, in chemical stability, but have higher resistance to abrasion, and are less combustible. They are produced basically in the form of staple fibers with a content of up to 15% of modifier under the following names: in the USSR -- saniv, in the USA -- orlon-42, orlon-31, acrilan, kreslan, zefran, dynel, verel; in the FRG -- darvan, in Sweden -- takril, in England -- kurtel, in Japan -- kanekalon. They are used for manufacturing special clothing, filtering fabrics, etc.

Polyurethane fibers are manufactured of hexamethylenediisocyanide and tetramethyleneglycol. In its properties it lies in a position intermediate to the polyamide and polyester fibers. Their shortcomings are the difficulties in their processing. They are most frequently used in the form of monofibers. They are produced under the names -- perlon V, dorlon in the GDR and FRG, and others. Filtering materials, coverings, fishing rigs, and other things are manufactured of polyurethane fibers.

RUBBER MATERIALS. A group of elastomer materials -- rubbers, natural and synthetic -- are finding wide use in the manufacture of soft container casings.

Natural rubber materials are made from the milky sap, called latex, of rubber bearing trees. They are soluble in gasoline, benzol, chloraform, bisulphide of carbon, etc. Viscous solutions such as these are used as glue.

Vulcanization of natural rubber is carried out by means of interaction with sulphur, chloride of sulphur, organic peroxides, and other materials. The products of vulcanization, rubbers, have high elasticity within a wide range of temperatures, are impermeable to water and gas, have high electrical insulating properties, and are resistant to many aggressive environments. At a temperature of -70°C they lose elasticity and become brittle, but from 80 to 100°C they have plasticity. The soft kinds can return to shape after being stretched out more than 1000%. Their strength limit under tension approaches 350 kG/cm^2 (with respect to the original profile).

Synthetic rubbers are rubber like materials from which rubber is manufactured. Rubbers are obtained from polymerization, copolymerization or polycondensation of butadyene, styrol, isoprene, chloroprene, isobutylene, nitrile acrylic acid, a-methylstyryl, and other monomers.

Synthetic rubbers often exceed natural rubbers in their resistance to the action of aggressive environments and solvents, in heat resistance, resistance to abrasion, impermeability to gasses, resistance to light and ozone, and other properties. Rubbers have recently been synthesized which are close to natural rubber even in elasticity. The mechanical properties of rubber are being improved by vulcanization and the addition of accelerators which activate the vulcanization, of plasticizers, fillers, anti-aging and other materials.

Let us examine the basic properties of the most widely used synthetic rubbers. Their physico-mechanical properties are shown in Table 3.

Isoprene synthetic rubbers are the product of the polymerization of isoprene in the presence of catalysts. They are known by the following names: in the USSR -- SKI, and SKI-3, in the USA -- corall, ameripoll SN, and natsin. Isoprene synthetic rubbers have high mechanical qualities and have properties close to natural rubbers.

Ethylenepropylene rubbers are obtained by means of copolymerization of ethylene with propylene. Rubbers of ethyleneprophylene possess high mechanical and elastic properties, good resistance to aging at heightened temperatures, and toward the action of acids and alkalis, good impermeability to gasses, and are equal in cost to natural rubbers with respect to resistance to wear and therefore find wide use in industry.

Chloroprene rubbers are a product of polymerization of chloroprene or the copolymerization of chloroprene with a small amount of styrol, isoprene, or nitrile acrylic acid. They are manufactured in the USSR under the name nyrite, in the USA -- neoprene, and the FRG -- perbunen S.

Chloroprene rubbers and mixtures based upon them are close to natural rubbers in strength and elastic properties. They have good resistance to tearing, repeated deformations, and satisfactory resistance to abrasion. They have low permeability to gasses, are stable toward the action of petroleum products, acids, alkalis, and salts, extinguish themselves upon catching fire, and are resistant to light. Chloroprene rubbers possess good adhesiveness, and this facilitates the manufacture of multi-layered parts.

Drive belts, conveyor belts, pressure and suction hoses for the petroleum industry, protective coverings for cables, coatings for chemical apparatuses, and other things are manufactured of chloroprene rubbers. Chloroprenes are the most often used of all rubbers for soft container casings as external and internal coatings.

Divinylnitrile rubbers are obtained in copolymerization of divinyl (butadyene) and nitrile acrylic acid. They are produced in the USSR under the brands SKN-18, SKN-26, SKN-40 unregulated and regulated, in the USA -- chaykar, chemigum, butaprene, and parakryl, in Canada -- polysar and kraynak, in England -- chaykar and butacone, in the FRG -- perbunan, and in the GDR -- buna-N.

Divinylnitrile rubbers are well resistant to the action of mineral, plant and animal oils, fats and aliphatic hydrocarbons, and are stable toward the products of processed petroleum. They easily dissolve in acetones, methylethylketones, etc. They become strongly swollen and dissolve in aromatic hydrocarbons and chloride containing organic compounds. They are more stable than natural rubbers toward the action of oxygen, heat and light.

Regulated divinylnitrile rubbers have better technological properties than the unregulated, but to make up for it the rubbers manufactured from the

Physico-Mechanical Properties of Rubbers

Каучуки a)	Плотность, г/см³ b)	Предел прочности на разрыв, кГ/см² c)	Сопротивление раздиру, кГ/см d)	Модуль упругости, кГ/см² (при 300%-ном удлинении) e)	Относительное удлинение, % f)	Остаточное удлинение, % g)	Теплостойкость, °C h)	Морозостойкость, —°C i)
Natural	0,91—0,92	350			1000			
Isoprene		250—350			850—1200			70
Ethylenepropylene	0,80—0,86	280—500			540			
Chloroprene	1,21—1,25	300—330	37—45	19—23	960—1000	15—20	100—150	34—36
Divinylnitrile SKN-18	0,94	250—270	45—50	90—100	450—550	15—20		55
Divinylnitrile SKN-26	0,94	280—300	55—70	100—120	550—650	20—30		42
Divinylnitrile SKN-40	0,99	300—330	74—78	120—130	600—700	20—30		32
Polysulfide	1,3—1,4	105						
Siloxane		45			200—300		200—300	60
Fluoride Rubbers	1,85	130—260	26—70	85—155	330—350		204—315	20—40
Butyl Rubbers	0,91	180—220	10—15	12—15	850—950	6—9		45—60
Polyisobutylene	1,68				200			30
Sulfurchlorided Polyethylenes	1,1	250			200—600		150	
Polyurethane	1,26	300—420	50—175	50—250	400—650	5—35	130—140	30—40

Legend: a) Rubbers, b) Density, g/cm^3, c) Strength limit under tension, kG/cm^2, d) Resistance to Tearing, kG/cm, e) Coefficient of Elasticity, kG/cm^2 (at 300% Elongation), f) Relative Elongation, %, g) Residual Elongation, %, h) Heat Resistance, °C, i) Resistance to Freezing, -°C.

former have somewhat reduced strength limits. Rubbers made without fillers have lower mechanical properties. Carbon black rubbers possess high mechanical properties and good resistance to abrasion, exceeding the abrasion resistance of natural rubbers. Divinylnitrile rubbers have heightened gas-impermeability.

Divinylnitrile rubbers are used for parts with high oil and gasoline resistance. In the manufacture of soft container casings, they are mainly employed for internal coatings.

Sulfide rubbers (thiokols) are used basically as additives to other synthetic rubbers for preventing the formation of cracks due to ageing under light.

Siloxane rubbers are the products of polycondensation of alkyldichlorsilanes. They possess high thermal properties, being able to operate in temperatures of from - 60° up to 200 to 300°C. Their stability toward the action of oxygen, ozone, sunlight and aggressive environments are also high.

Fluoride containing rubbers (fluoride rubbers) are obtained as a result of copolymerization of unsaturated fluoridated hydrocarbons. They are produced in the USSR under the brand SKF, in the USA -- Kel-F and vyton. They have very high resistance to ageing, atmospheric interactions, to strong oxidizers, oils, solvents, fuels, to high temperatures, are not combustible, and can be used at 300°C. Among the shortcomings of fluoride containing rubbers is their low resistance to freezing. Manufactured from fluoride rubbers are containers for fuel storage, hoses for transfer of volatile fuel, parts operating in atmospheric conditions, etc.

Butylrubbers -- are a product of copolymerization of isobutylene and isoprene. They are known by the names: in the USA - NJ - butyl, in Canada -- polysarbutyl, and in France -- sokabutyl.

Butyl based rubbers have low gas permeability but instead have high stability toward the action of oxygen, ozone, and atmospheric interactions. Their strength under tension, resistance to tearing and to ageing from heat and repeated bending are also high. They have high stability toward acids, alkalis, salt solutions, acetone, alcohols, esters, animal and plant oils, and increased resistance to water. At the same time, they have poor resistance to petroleum oils and fuels, low light resistance and low elasticity.

Butyl rubber is widely used for the manufacture of materials operating in water, acids, and alkalis. Paddings and waddings for equipment operating at heightened temperatures are being manufactured from it. In soft container casings, butyl rubbers are used as internal coatings.

Polyisobutylene is obtained by polymerization of saturated hydrocarbon isobutylene in a medium of liquid ethylene in the presence of catalysts. This is a rubber like material, stable toward the action of mineral acids and aggressive environments. It is easily dissolved in aromatic and chlorinated hydrocarbons, but at the same time is not soluble in alcohols, ketones, complex esters and other polarized solvents, and is stable toward concentrated caustic alkalis.

Polyisobutylene is used basically for the manufacture of films and sheets. The filmy material withstands aggressive environments well. Roofing materials based on polyisobutylene are produced in England and France.

Sulfochlorinated polyethylene (hypalon) is obtained by means of the interaction of polyethylene with sulphuric gas and chlorine. It belongs to the elastomers, according to its elasticity, and is processed into equipment used in the rubber industry. With vulcanization, it forms a material having high mechanical strength and chemical stability toward the action of strong oxidizers and alkalis.

Sulfochlorinated polyethylene dissolves well in aromatic and chlorinated hydrocarbons. In the manufacture of films and container casings, sulfochlorinated polyethylene is used in a mixture with nitrile and other rubbers. The films have good resistance to oils, elasticity at low temperatures, resistance toward interaction of light, increased resistance to destruction by ozone, and heat resistance (it withstands heat of up to 150°C for 300 hours). In soft container casings, it is used basically for an internal coating.

Urethane (polyester) rubber is obtained in the interaction of polyester with diisocyanide. They are known under the following names: in the USSR -- SKU, in the USA -- chemigam, adiprene and gentan, in England -- vulcaprene, and in the FRG -- vulcollan.

Urethane rubbers have high physico-mechanical qualities. In resistance to abrasion, they considerably exceed all known industrial types of rubbers. They possess good strength under stress, elasticity, resistance to repeated deformation and tear, high stability toward the action of oils, gasoline, kerosene, benzol and other aliphatic and aromatic hydrocarbons, and good impermeability to gasses.

Section 4. Design and Manufacturing Technology of Soft Container Casings.

From the design point of view, the materials used for the manufacture of soft container casings can be sorted into two basic groups: unreinforced and reinforced.

Unreinforced materials ordinarily are films of one or another composition. They may be single, two-ply or multi-layered.

Reinforced -- contain fabrics (usually of synthetic fibers) in their basic composition. The fabrics are coated with rubber or plastic on one or both sides. Often the fabrics are simply saturated with these materials. The reinforced materials may also have a more complex structure, several layers of reinforcing fabric and various facings and saturated materials.

From unreinforced materials, they manufacture only small container casings, in which stresses do not attain significant proportions, and also soft linings which serve, mainly, to assure the structure's impermeability and protection against agressive interaction with the environment.

Dorpinghans [138] has compiled an illustrative table of chemical stability, temperature resistance and physiological harmlessness for the basic synthetic materials used in the manufacture of soft container casings (Table 4).

The thermal welding method is most often used for uniting films to each other. The majority of synthetic polymer films belong to the thermoplastic materials, and this means that they can be fused at a certain increased temperature. In thermo welding, the formation of joints is accomplished by heating the films to a viscous-liquid state and compressing it under a certain pressure with consequent cooling. The welding temperature must be somewhat higher than the temperature at which the materials become transformed into liquids but considerably below the temperature at which they begin to be destroyed.

Several kinds of thermal welds are used. They differ according to the methods of applying and removing pressure to the formation of joints, and according to the means of applying and removing heat.

During welding, the films can be compressed with the aid of flat sponges or between two rotating rollers. Linear, tapered and zigzag shaped joints are obtained by the second of these means. Machines based on this indicated principal of welding are widely distributed. They are economical and have sufficiently high productivity.

Certain kinds of welds are distinguished according to the means of applying and removing heat to the area of the joint.

Gas-flame welding is in principle similar to gas-flame welding of metals. The welding may be produced either by an open flame or by a stream of hot air or inert gas, which are used for welding polyethylene and polyamides.

Ultrasonic welding. The material is initially treated at the point of juncture with ultrasonic oscillations and simultaneously compressed by radiators, acting as electrodes, which transform electrical oscillations into mechanical. Ultrasonic welding is seldom used because of the complexity of the equipment.

Thermal contact and high frequency welding are the most widely used for thermoplastic films.

Thermal-contact welding takes place as a result of heat applied directly to the areas of the film to be welded. Employed for this, are either ordinary electroheaters where, the given temperature of the press remains constant during the entire welding process, or impulse heaters, in which the temperature depends upon the duration of the impulse of current and the amount of voltage applied to the heating elements. The impulse method of welding permits more rapid heating and cooling of the welded section of seam. Coatings of fluoroplasts, cellophane, parchment, tracing papers and silicone lubricant are used in order for the films not to adhere to the heating elements.

TABLE 4

Characteristics of Certain Synthetic Materials

Environments	High-pressure Polyethylene	Low-pressure Polyethylene	Polypropylene	Polyamide	Polyester	Polyvinyl-chloride	Polyvinyl-fluorine	Sulfochlorinated Polyethylene	Chloroprene Rubber	Nitrite Rubber
	Chemical Stability									
Mineral oil	0	+	+	+	+	0	+	+	+	+
Benzene	0	+	+	+	+	0	+	—	0	+
Benzol	0	+	+	+	+	—	0	—	—	0
Weak acids	+	+	+	+	+	+	+	+	+	
Concentrated acids	+	+	+	0	0	+	0	0	—	
Weak alkalis	+	+	+	+	0	+	+	+	+	
Concentrated alkalis	+	+	+	—	—	0	0	+	+	
Alcohols	+	+	+	+	+	0	+	+	+	+
Complex ethers	+	+	+	+	—	0	0	0	0	—
Ketones	—	0	0	0	—	—	+	0	0	—
Ether	—	0	+	+	+	—	0	—	—	—
Fluorohydrocarbons	—	0	0	+	0	—	+	—	—	—
Animal and plant oils	0	+	+	+	+	0	0	+	+	+
Limits of temperature-resistance	—20 +80	—20 +100	—20 +100	—30 +130	—40 +140	—20 +60	—20 +160	—40 +130	—40 +120	—40 +120
Physiological harmlessness	+	+	+	+	+	0	+	+	0	0

Legend:
Chemical stability: + - good; 0 - conditional, depending on thickness of material and physical conditions; - unstable.
Physiological harmlessness: + - yes; 0 - conditionally.

Rolling machines are usually used in direct thermal contact welding. The film is warmed up with the aid of thin metallic sheets, after which the joints are compressed by the conducting rollers and dropped into the area where they are cooled. Cooling is done by air or liquid circulating in the system.

Thermal-contact welding is the cheapest, simplest and safest method, and it assures a strength of joint equal (not less) to the strength of the basic material.

High frequency welding in recent years has received large dissemination because it is the most productive in comparison with other methods. Heating takes place in a short time by the interaction of an electrical field, created by high frequency currents, with heat thus being generated within the material to be welded and the material being heated uniformly. The joint may be cooled and hardened without removal of pressure, and it therefore comes out exceptionally strong and tight.

High frequency welding machines are produced with electrodes of various shapes, but the most widespread are machines with the upper electrode in the shape of a roller. The roller draws the material through and welds it. High frequency welding is used for films of polar polymers -- polyvinyl chloride, polyvinylidene chloride (saran), polyamides and others, and is not suitable for non-polar polymers -- polyethylene, polystyrol, etc.

Let us examine certain peculiarities of welding the basic types of films.

Polyethylene films are welded thermally at 110 to 150°C by the ordinary or impulse methods.

Polypropylene films also make good use of thermal welding, but at a somewhat greater temperature than the polyethylenes.

Polyvinylchloride films are easily welded with the aid of heated rollers, irons or high frequency equipment. Welding temperature fluctuates from 120 to 200°C, depending upon the thickness of the films. For joining films of up to 0.1 mm thickness, thermal contact welding is usually employed, but for thicker ones -- high frequency current.

Polyvinylidene chloride films (saran) are joined by thermal welding at heating temperatures of 155 to 165°C. It is necessary to regulate the temperature carefully during welding because saran has a very narrow interval between softening and melting temperatures. High frequency welding gives the best results.

Polyester films (lavsan and others) yield poorly to welding by ordinary methods. In order to obtain a strong joint, one must use glues of synthetic rubbers in the form of solutions, or glues based on polyesters, terephtalatum and sebacic acid and ethylene -- and diethyleneglycols. Special thermo-weldable films form good welds at a temperature of 149 to 205°C and pressure of 1.4 to 4.2 kG/cm^2.

Welding of polytetrafluorethylene films is difficult because at high temperature they do not have fluidity; metallic plates heated to 380 to 390°C and special pastes are used in welding them. During welding, and in heating polytetrafluorethylene above 205°C, poisonous gasses are emitted, and therefore good ventilation at the working area is necessary.

In all kinds of welding,a strong joint can be obtained only where the welding surface is carefully protected from dirt and covered, protecting the film from sticking together. In welding, the material must not be stretched.

Glueing of films is a less effective means of joining - - in productivity and quality of joint. As a rule, the joint obtained by glueing is less strong and non-hermetic. Many glueing materials are physiologically not unharmful. The chemical stability of glued joints is often lower than the stability of the basic material. Glueing of films is carried out in those cases where they cannot be welded or welding is limited, for example, with polyester films, assemblies not suited for welding.

Combined films, consisting of two or several layers of various kinds of films have recently been coming into even wider use in industry. Combined films combine the properties inherent in several kinds of filmy materials and the possibilities of their use are therefore widening considerably. For example,two-fold films of polyester and polyethylene, polyester and polyvinylidene chloride, and others, are being used. Also in use are such combinations as films with aluminum foil, with paper, etc.

Reinforced materials, as already noted, are being used for the manufacture of containers of rather large volumes.

Rubber fabric materials are being manufactured on equipment employed in the rubber industry: rolling mills, glue-smearing machines, presses, and continuous vulcanizers. In manufacturing film-fabric materials, pressing or impregnation is utilized. For example, polyvinyl chloride can be joined with fabric by means of heated pressing, where the softened plasticate or films are pressed into the intervening space between the fabric bindings, or by direct impregnation with plasticate in passing the fabric through a cold liquid paste, and by subsequent heated rolling. The impregnated fabric necessarily combines with the films of pure polyvinylchloride by means of hot pressing at 175°C.

Internal coatings are made as resistant as possible to abrasion and the external environment. Most often used for these purposes are rubbers of chloroprenes (nyrite, neoprene, etc.), sulfochlorinated polyethylene (hypalon and others), butyl rubber, polyvinyl chloride and others with a ply thickness of from 0.5 to 3 mm.

The internal coatings must assure stability toward the material with which the container is filled, and also its impermeability. Chloroprenes, divinylnitrile (SKN-18, SKN-26, SKN-40, Hykar, and others) rubbers, coatings of polyvinylchloride, polyester, polyamide, polyethylene, etc., with a ply thickness of 0.5 to 1.5 mm, can be used here.

Rubber coatings based on synthetic rubbers are found in most widespread use for soft container casings. The properties of such coatings have already been sufficiently well studied by industry, and the technology of their manufacture has been mastered. Plastic coatings are for the time being, less widely distributed because they are insufficiently proven in practice.

In order to establish a norm of allowable stretch in testing the strength of soft container casings, it is necessary to know the strength and deformation properties of their materials in various conditions of loading. Casing materials have their peculiarities, among which must be included the great capability for deformation, shifting when under small loads, penchant toward considerable decrease in strength under prolonged interaction with the load, high temperature, etc. In addition, the strength and deformation properties of the fabric differ in direction along the warp and along the woof, i.e., the fabrics are anisotropic materials.

Let us examine the main strength characteristics applicable to reinforced materials used for the most heavily loaded container casings.

Strength of material under single-axis expansion. Samples of the material, 200 mm in length and 50 mm in width cut out along the warp or woof and stretched between gripping devices, are used for testing. The tests are conducted on ordinary tearing machines (the R-5, for example) with a gripper movement speed on the order of 40 to 90 mm/min. The tearing strength (strength limit) and the limit (on tearing) relative to elongation. In the testing process, one may obtain a graphic relationship between stresses and deformations.

Strength of material under biaxial stress. Fabric materials are anisotropic, do not follow Hook's Law and are not subordinated to the principle of independence of the action of forces. The Poisson coefficient of these materials is variable and depends on the state of tension. Therefore, the fabric's deformation in any direction depends on the interrelationship of the forces acting on the warp and woof. The connection between the forces and deformations in fabrics can be expressed by two diagrams, one of which characterizes the elongation of the material along the warp, and the other -- along the woof. In the "tension - deformation" axes on the diagrams a series of curves are shown for the direction under examination, with each curve corresponding to the constant value of tension for the direction which it cuts.

A cross shaped sample, which is loaded on a special machine in two mutually - - perpendicular directions, is used for the test. Deformation is measured by an ordinary ruler on a previously laid out grid on the central part of the sample. Similar tests were first conducted by R. Haas and A. Dittsius [26]. With such tests, however, it is impossible to obtain data on the strength limit of the material because the sample tears due to the concentration of tension, equal to approximately 0.6 to 0.7 of the limit, at the corners of the cross when the load is applied.

The strength limit of a material under biaxial loading can be determined by means of the so-called pressuring through method, proposed by R. V. Pyatyshev. In this method, the material is superimposed on a base disc (or plate of any shape) and clamped to it by a round or oval ring with screw clamps. Water is pumped between the material to be tested and the disc through a special opening in the base disc. The material begins to expand and takes a shape close to that of a spherical segment within a round ring, and to that of a cylindrical surface with spherical half segments like paving blocks within an oval ring. As a result, only three correlations of tension on the warp and woof can be obtained; namely: in the spherical segment this ratio is equal to one, in the cylindrical part it can be ½ or two depending on the arrangement of threads. At the moment the material tears, the water pressure p and the point of flexure h are marked. The forces in the material at the moment of tearing are determined by the formulas:

$$Q_1 = Q_2 = \frac{p(r^2 + h^2)}{4h};$$

for an oval ring

$$Q_2 = 2Q_1 = \frac{p\left(\frac{a^2}{4} + h^2\right)}{2h},$$

where Q_1 and Q_2 -- longitudinal and cross section tensions;
r - the internal radius of the circular ring;
a - the width of the oval ring between the internal edges.

The strength of a material under biaxial loading is reduced somewhat because in this case, the thread of each direction, apart from the stretching forces, is under the additional load by the pressure of the transverse threads. For capronic fabrics, it is recommended that the coefficient of the material's strength reduction under biaxial loading be taken as equal to 1.3 to 1.4.

Strength of material under prolonged loading. Tests show that with prolonged loading the sample of material tears under small tensions (by two to four times) than under ordinary testing on a tearing machine. For capronic fabrics, the coefficient of the material's strength reduction is recommended at 2.0 to 2.5.

Fatigue characteristic of a material under cyclical loading, with preliminary formation of creases. During testing, the material must be subjected to the action of dynamic forces which arise at the moment creases are straightening themselves out. A soft container casing operates under similar conditions, for example, when it is being towed roughly. For capronic fabrics, it is recommended that the coefficient of the material's strength reduction under cyclical loading be taken as equal to two.

Strength of material under the action of the external environment (solar rays, temperatures, sea water, etc.) and of the cargo filling the container (petroleum products, etc). These problems are solved in each instance depending on the kind of material of the container and the existing environment.

It must be especially emphasized that not only the materials, but their joints as well, must be subjected to all kinds of tests because the strength of the material is usually decreased at the joints.

The allowable force Q_D in the casing, should be designated as a portion of the tearing force Q_r under single-axis loading

$$Q_D = \frac{Q_r}{p},$$

where p -- is the coefficient of reserve, represented in the form of the product of the strength coefficients enumerated above, in accordance with the operating conditions of the container.

Below, we examine the basic characteristics of rubber fabric materials used for the manufacture of soft container casings in the USSR. The characteristics of rubberized fabrics used for the manufacture of casings of serially produced and experimental soft containers of various sizes are given in Table 5. Materials A, B, V, Ye, and Zh are intended for petroleum products, and materials D and G -- for water. The characteristics of reinforcing capronic fabrics are given in Table 6. All of them have an interlacing of the four-ply matted satin type.

For external rubber coatings of fabrics, they use the following rubbers: nyrite (chloroprene), butyl rubber, a combination of KhSPE (sulfachlorinated polyethylene) with SKN-18 (divinylnitrile rubber) and nyrite with SKN-18. Used for internal coatings are divinylnitrile rubbers SKN-26 and SKN-40 regulated, butylrubber, and combinations of KhSPE with SKN-18 and SKN-26 with nyrite.

With the rubberized materials A, V, Ye, and Zh, a film of polyamide lacquer PKRT-3, which serves as an anti-diffusion layer for petroleum products, is introduced between the internal rubber coating and the fabric. As a result, the weight and density of the materials are reduced, which is clearly seen from a comparison of material B, produced without a polyamide lacquer film, with material A. It must be noted, however, that the material with the polyamide lacquer film requires greater expenditure of labor in its manufacture and the casing is therefore less technologically feasible to produce by industry.

TABLE 5

Characteristics of Rubber Fabric Materials Used for the Manufacture of Soft Container Casings

Rubber Fabric Materials	Width, cm (not less)	Thickness, mm	Weight, g/m^2 (not more)	Strength of a patch, kg/50 mm (not less)		Diffusion of petroleum products over 10 days, g/m^2 (not more)	Types of rubbers used for the rubber coatings	
				Warp	Woof		External	Internal
Material A	95	1,2—1,45	1700	200	190	100	Nyrite	SKN-26
Material B	95	1,9—2,2	2500	200	190	300	Nyrite	SKN-40 - Regulated
Material V	85	2,3—2,5	2700	560	520	100	Nyrite	SKN-26
Material G (experimental)	85	3,7—4,0	4800	790	700		KhSPE+ +SKN-18	KhSPE + +SKN-18
Material D (experimental)	115	3,8—4,5	4500	1500	1500		Butyl-rubber	Butyl-rubber
Material Ye (experimental)	85	2,3—2,5	2700	560	520	100	KhSPE	SKN-26
Material Zh (experimental)	95	2,0—2,2	1800	200	190	100	Nyrite+ +SKN-26	SKN-26 + + Nyrite

TABLE 6

CHARACTERISTICS OF CAPRONIC FABRICS USED FOR REINFORCING RUBBER FABRIC MATERIALS

a) Ткани	b) Ширина, см	c) Толщина, мм	d) Вес, г/м²	e) Прочность полоски, кг/50 мм		h) Удлинение, %	
				f) основа	g) уток	i) основа	j) уток
Capron 1528.	101	0,30	180	200	200	35	35
Reyd (experimental).	93	2,02	1160	1345	1290	35	35
Record (experimental). . . .	90	1,20	645	980	850	26	26
AP-2 (experimental).	97	0,86	400	520	560	35	40
Capron 1539.	95	0,35	180	200	190	35	39
TT (experimental).	96	0,52	250	350	380	31	35
AP condensed	96	0,72	330	375	500	30	40
K-8-3T warped.	126	1,43	755	1605	—	35	—
K-8-3T woofed.	126	1,05	585	260	1275	30	33
K-12-3T woofed	125	1,28	750	200	1400	30	27
Capron 23085/I (experimental)	100	1,50	900	1385	1265	42	35
Capron 23072/I (experimental)	100	1,60	1040	1280	1240	51	34

Legend: a) Fabrics, b) Width, cm, c) Thickness, mm, d) Weight, g/m², e) Strength of a patch, ' /50 mm, f) warp, g) woof, h) Elongation, %, i) w .p, j) woof

In order to strengthen the adhesion of the external and internal coatings with the capronic fabrics, the latter are saturated with special compositions. Derivatives of diisocyanides -- vulcapron (England), and desmodur (FRG) are used as such compositions. In the USSR, they use a 3% water solution of epoxide resin Number 89, which assures adhesion of rubber with capronic fabric within the limits of 1.5 kG/cm. Diisocyanides are not used in the USSR because they are toxic. The number of layers of capronic fabrics in multilayered rubber fabric materials can be varied (1, 2, 3 and so on), depending upon the requirement for assuring the strength of the casing. Typical constructions of rubberized materials B and D are shown in figure 2, b, and v.

The joints of soft containers are sealed over by covering surface strips of rubber, using SKN-26 nitrile rubber or butylrubber, and by rubberized tape materials.

The technological processes of assembling soft container casings depend upon the purposes and peculiarities of the materials used. The basic kinds of technological processes in the manufacture of containers are described below.

1. Manufacture of container casings from raw rubberized materials with their subsequent vulcanization in a vulcanizing boiler. In this case, the container is assembled out of sections of raw rubberized materials. Seams and edges are closed up with raw rubber and rubberized material on hot vulcanizing glue K-2-1. Then the container as a whole is vulcanized in a boiler with an air environment. This method is found in use in the manufacture of cushion like containers for petroleum products 2.5 to 50 m³ in volume.

2. Manufacture of container casings of vulcanized rubberized materials with cold setting glues. The seams of the sections are processed on buffing stands, and then the seams are sealed with vulcanized rubber and rubberized strips on cold setting glues S-12 and SN-123. The edge seam is straightened with raw rubber and pressed. This means is suited for manufacture of containers in volumes up to 250 m³.

3. Assembly of containers from separate sections with cold setting glues. Separate container sections are assembled from raw rubberized materials, seams

are sealed with raw rubber and rubberized strips on K-2-1 glue, and then vulcanized in a boiler. After this, the seams of the sections are processed on buffing stands, and the container sections themselves are joined with S-12 and SN-123 glues.

4. Manufacture of multi-layered small size containers with complex configurations on prefabricated forms. The container is assembled directly on a form from separate panels of rubber fabric materials and raw rubbers with K-2-1 hot vulcanizing glue. Then the container with the form together are vulcanized in a boiler, after which the form is taken out in sections.

5. Manufacture of container casings of vulcanized rubberized materials by direct pressing of edges and sectional seams in a press. The seams of the panels of vulcanized rubberized materials are processed on buffing stands, and then the unvulcanized rubber strips are glued to them with K-2-1 glue. The seams prepared in this manner are processed in a press. The sectional seams are pressed over first, and then the edge seams. Containers of 25 m^3 volume are currently made by such technology.

6. Manufacture of casings of large containers out of vulcanized rubberized materials by means of sewing the materials at the seams and subsequent pressing. The seams of the panels of vulcanized rubberized materials are processed on buffing stands and the panels are then assembled in pairs (with 60 to 80 mm overlap) with S-12 and SN-123 cold setting glues. The seams are stitched on heavy grade sewing machines with capronic threads in four to eight stitches, depending on the strength of the basic material. Stitched seams are sealed with raw rubber strips on both sides with hot setting glues K-2-1 and BK-10, and then pressed in the profile plates of the press. The panels assembled in pairs are then assembled in fours, and if necessary -- by eight and, finally, the last seams are sewn and pressed. Cylindrical and conical (end) sections of the container are made in this manner.

In foreign practice, stitched seams are shaped in a somewhat different manner. Before sewing the rubber covering, the selvages are torn from both sides, as a result of which the seam on the width of the band of fabric, which is also stitched, is stripped bare. The torn selvages of the covering are then covered on the seam and glued. Strips of rubberized fabric are also glued on top. All joints are made with cold setting glues.

Most promising are the technologies for manufacture of containers, numbers 5 and 6, because the basic technological operations in these are mechanized, and the quality of the seams obtained is high.

In figure 2, a, g, d, ye, zh, and z, are shown diagrams of the arrangement of cushion type soft container seams and the construction of joined seams used in the manufacture of soft container casings.

The overlap seam (figure 2, g) is the basic type of sectional seam, the amount of overlap of which is chosen in accordance with the required strength, and which varies within limits of from 40 to 100 mm.

If the casing is assembled from vulcanized materials and the seams simply pressed on a press, then in assembly the sectional and edge seams are glued with raw rubber. It is expedient to accomplish joining of edge seams with intervening film, as shown in figure 2, i, because it is better that the seams withstand the forces of movement than those of tearing.

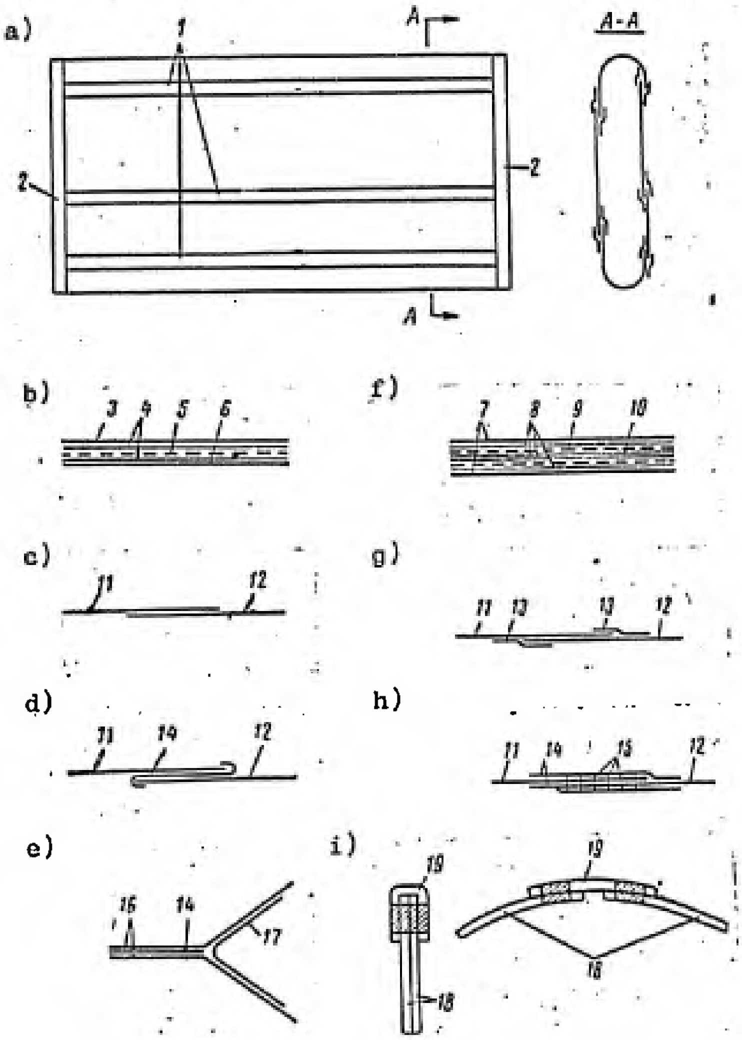

Figure 2. Construction of soft container casings: a -- diagram of the arrangement of container seams made of two flat panels; b) construction of rubber fabric material B; f) construction of rubber fabric material D; c) overlapping seam; g) sealing an overlapping seam; d) pressed seam of vulcanized materials; h) stitched seam; e) edge seam; i) edge seam with intervening film.

1- sectional seams; 2 - edge seams; 3 - nyrite rubber coating 0.5 to 0.6 mm in thickness; 4 - glue coating; 5 - capron 1539; 6 - nitrile rubber coating 0.8 to 1.0 mm in thickness; 7 - butyl rubber coating 0.55 to 0.65 mm in thickness; 8 - coating of nyrite rubber; 9 - capron K-8-3T; 10 - capron K-12-3T; 11 - upper panel; 12 - lower panel; 13 - rubber strip; 14 - raw rubber ; 15 - stitches; 16 - panels; 17 - rubber fabric band; 18 - panel of film; 19 - band of film.

CHAPTER III

SHIPBOARD ENCLOSED SOFT CONTAINERS

p.100-102. **Section 12. Basic Varieties of Shipboard Enclosed Containers.**

In designing soft shipboard containers,great attention must be devoted to preventing their dislocation during rolling of the ship. The container's construction and the manner in which it is secured is most frequently determined by this very consideration. Clearly, those containers whose movements are restricted by the rigid walls of a compartment are the least movable. Enclosed containers, thus, represent the most promising type for the merchant and fishing fleets.

Enclosed soft containers can be divided into three classes: stressed, clinging, and stressed-clinging. The class of a container is determined by the construction of the compartment and the interrelation between the sizes of the compartment and casing.

The class of stressed containers can include those which,when filled, fit tightly against the enclosure walls and compartment floor and have a stressed, convex upper surface (figure 15, a). Defined under the clinging class of container are soft containers situated in a completely enclosed rigid compartment and which, when filled, fit tightly against all of the compartment walls (figure 15, b), while in the class of stressed-clinging containers, a casing, located in a compartment, which has slots, ribs or traps in its walls; in these areas,the casing curves according to its stressed surface and does not abut against the walls (figure 15, v, g, d).

Containers of the stressed class are better suited than the others, for use in the cargo holds of ships, which are varied in size and shape. They allow stowage of several items per compartment, thanks to which the number of dismantable partitions in each hold does not exceed two to three. Their main shortcoming is the considerable load taken by the casing during rolling of the ship, which leads to an increase in deadweight on the container.

It is expedient to make containers of the stressed class in cylindrical shape. Their ends may be flat, spherical or pillow-shaped. In the latter case, after filling the container, the edge seam is disposed vertically or horizontally, in conformity with which the fittings must also be placed (figure 16). Cylindrical containers with flat walls, especially if the shape of the walls corresponds to the shape of the container's cross-section in its operating condition, apparently are proving to be the most ideal. The casing of such a container forms the least creases after being filled and operates in the most favorable conditions. Tests conducted in 1960 on the motorship,Yana, showed that such containers are highly convenient in operation. Their essential shortcoming is the difficulty of their manufacture.

Containers with spherical ends, apparently, should have qualities similar to those described above, although less convenient. One such container underwent tests in 1961 on the motorship, Polyus, and the spherical shape of its ends had no negative effect on its strength and operational characteristics.

Containers with pillow-shaped ends are less convenient in operation, but are simpler to manufacture. Tests on this kind of container in 1963 on the motorship, Neva, showed that the shape of the ends have an insignificant influence on the casings' operating conditions.

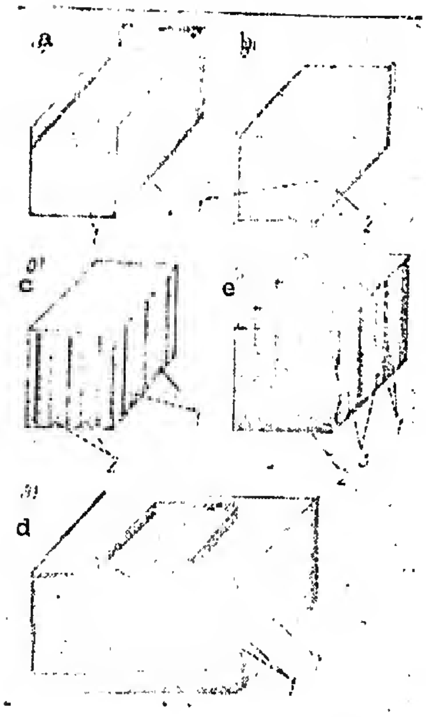

Figure 15. Varieties of shipboard enclosed soft containers: a-cylindrical, stressed class; b-pure clinging class; e, d-stressed-clinging class.
1-container casing; 2-compartment; 3-rigid edge.

Cylindrical containers of the stressed class can also be classified according to the shape of the cross-section of the compartment, which can be rectangular, trapezoidal or curvilinear. The following describes only the containers intended for stowage in a rectangular compartment.

The basic purpose of the casing in clinging-class containers is to ensure the impermeability of the compartment, whose construction must withstand the pressure of the filler and the load on the outside. The casings of such containers therefore, can be made of material that is less strong, which is an important advantage.

According to operating conditions, the containers of the stressed-clinging class, occupy an intermediate place between the first two classes.

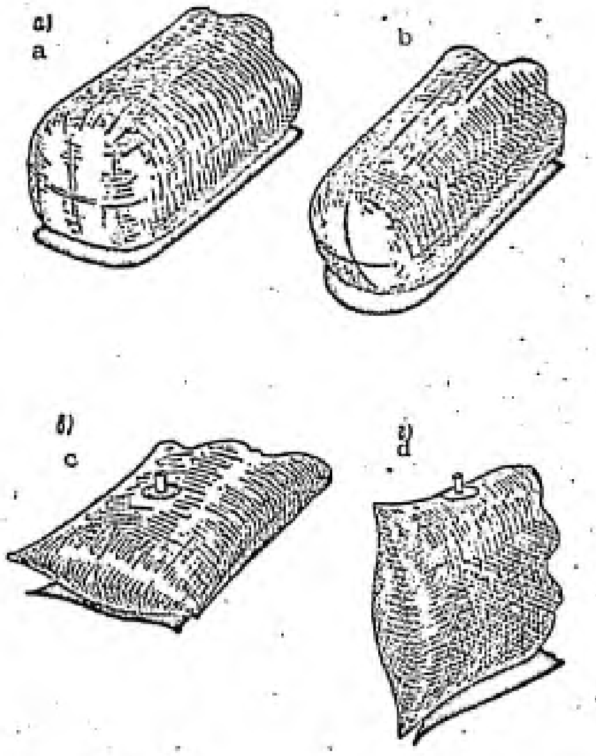

Figure 16. Varieties of ends on shipboard enclosed, soft containers: a-flat; b-spherical; c-pillow-shaped, placed horizontally; d-pillow-shaped, placed vertically.

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Section 14. Construction of Shipboard Enclosed Soft Containers.

Stressed Cylindrical Containers

In order to achieve normal operation of enclosed soft containers, they must be provided with a device for intake and discharge, to release air during intake, for regulating the pressure of the liquid in the container, for getting into the container in order to clean and examine it, and a safety device.

A soft container's shape and height are changed in filling and discharging, according to the amount of liquid and air within it. The pliability of the casing does not permit a heavyweight to be put on the container because it makes operation more difficult, when the ship is tossing, and can lead to breaking of joints.

A filled container is always under excess pressure. Shut-off valves must therefore be provided in the container's hose fittings to provide for intake and discharge hoses. For enclosed containers, simple, short hose fittings are worthless. Apart from those indicated, nothing special is required by the receptacle.

Discharging a soft container can be conducted by several means. If discharge is to be by a portable pump installed on the deck above, then a non-reversible ratchet-valve must be provided in the container's hose fitting. This prevents drainage of the liquid from the suction hose during the start or occasional stopping of the pump. A small amount of air gets into the container during the discharge process. Because of this, a hose fitting with a bell-shaped receptacle on its end must be fitted in the casing in order to assure normal operation of the pump. The length of the hose fittings must not be too great, otherwise, it will prevent the casing from collapsing during discharge.

If the container is to be emptied by means of a siphon, with the aid of a hose passing through the bulkhead, then the device becomes simplified because the need for a non-reversible valve is eliminated.

If the liquid is discharged by means of gravity, then a rigid hose with a valve on its end should be attached to a joint in the lower part of the casing. In such cases an enclosed area housing the receptacle valves, must be provided for within the cargo holds. Sketches of these devices are shown in Figure 29.

There is always a small amount of air in a container before filling; it also gets in the container during intake from a hose and in other ways. If the air is not completely removed from the container, then the liquid within it settles down, leaving an air pocket, causing increased movement during rolling of the ship. In metal tanks, it is recommended that the cross-sectional area of the air tubes be on the order of 100 to 150% of the intake tube's area. Tests have shown that extreme displacement of air from a soft container begins only toward the latter stages of intake. Therefore, although there is little air in the container, the cross-section of the air tubes must be of the same size as that of the intake tubes. Failure to observe this rule can make the intake process extremely difficult. This happened, for example, during the filling of an 18 m^3 - volume container on the motor-ship Neva. Intake had to be stopped several times because of the small, cross-section of the air opening, otherwise the casing might have burst from the water's pressure.

Air tubes must be open until intake is completed. Consequently, they must have a height not less than the height of the initial excess pressure. One or two tubes are installed on a container, and after it is filled, they are closed by means of lids.

The most important condition for safe transfer of liquid in shipboard soft containers is maintaining sufficient excess pressure throughout the entire cruise. Therefore, a regulating device must be provided on each container. Various methods of regulating excess pressure are shown in Figure 17. It is also expedient to have the simplest device on the container -- a water meter tube of transparent or semi-transparent plastic. In order to avoid tipping, the tube must be joined to the cargo hose fitting. It is convenient to connect it to the air tube on the intake-discharge fitting.

Just like any shipboard tank, soft containers must be protected and periodically inspected and repaired. For this they must be provided with necks with covers made of metal, plastic, or the same material as that of the casing. The latter are attached to the casing by studs on rigid metal or plastic rings. It is expedient to attach the necks to the intake-discharge fittings.

The safety device serves to protect the casing from pressures exceeding those for which it was designed. The simplest safety device is an open hose fitting on top, whose height is equal to the maximum height of a column of the liquid for which the casing is intended.

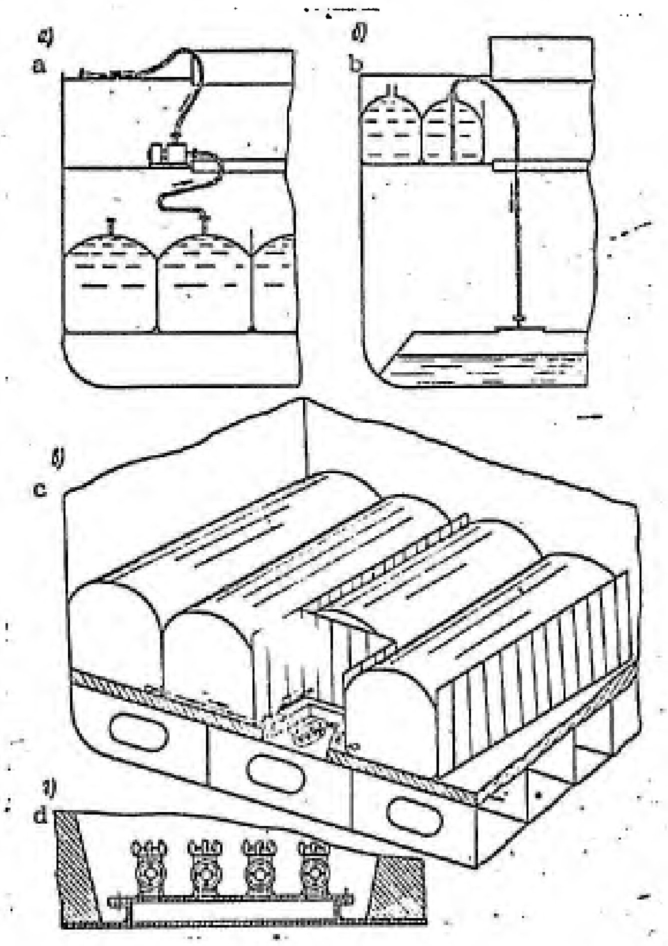

Figure 29. Sketches of the discharging of enclosed shipboard soft containers: a)by portable pump; b)by siphon; c)by gravity into a tank with double bottom; d)neck cover with hose fitting intakes and valves.

Along with the devices indicated, a small section for a drainage plug must be made in the lower part of the casing for draining off the remaining liquid that is not removed by the pump. A scheme for folding up and stowing an empty container must be carefully worked out -- the less space a container takes up, and the simpler the operation of folding up and straightening out a casing, the more effective its use. For this purpose, belts and straps must be fastened on the casing. The bond at which they are fastened must be sufficiently strong to withstand the weight of the casing and fittings and a small remainder of liquid (1 to 2% of usable volume).

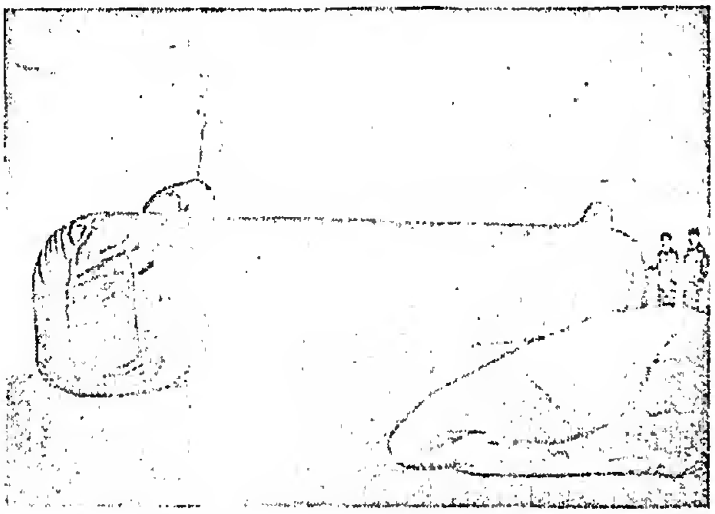

Figure 30. 35.5 m^3 capacity enclosed shipboard container of the stressed class, tested on the motorship Yana.

Let us get acquainted with several kinds of manufactured and projected cylindrical enclosed containers of the stressed class.

Experimental soft containers which have been tested in 1960, on the motorship, Yana, had a length of 15 m with a hold length of 13.6 m, a cross-section circumference of 6 m, and a useable volume of about 35.5 m^3 with a 1.5 m width (Figure 30). The weight of an empty container amounted to 80 to 90 kg. The container was made with two casings. The internal, impermeable casing (Figures 31 and 32) was welded by the division method from six longitudinal strips of V-118 grade polyvinyl chloride membrane 0.19 to 0.27 mm in thickness. The flat ends of the casing had the shape of the cross-section of the container in its filled condition. They were welded of two strips and joined to the cylindrical part by an overlapping weld. The casing had two hose fittings near its ends, which were also made of the membrane. The hose fittings were welded on to a flange made of the membrane which, in turn, was joined to the casing at the weld.

The outer casing, designed to take up the pressure of the liquid, was made of type 385 sail tarpaulin with a tear resistance on the warp of 40 to 44 kG/cm, and on the weft of 29 to 32 kG/cm. The casing was sewn together from transverse rings with offsetting of sectional seams (Figure 33). All joinings were made with capron thread in three-ply sail seam. Straps were sewn to the end walls of the casing for stowage of the container.

Actual tests showed that the shape of the container selected was appropriate and could be considered acceptable from an operational point of view. The lack of fittings for intake and discharging, and also of a drain device in the lower part of the casing for draining remaining liquid made cargo operations considerably more difficult.

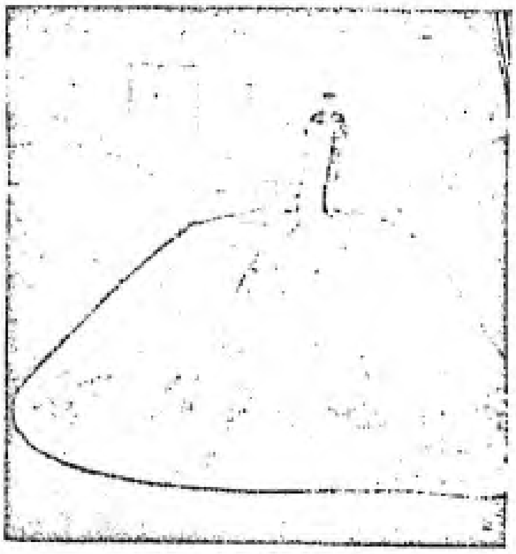

Figure 31. Internal polyvinyl chloride container casing, 35.5 m^3 in volume.

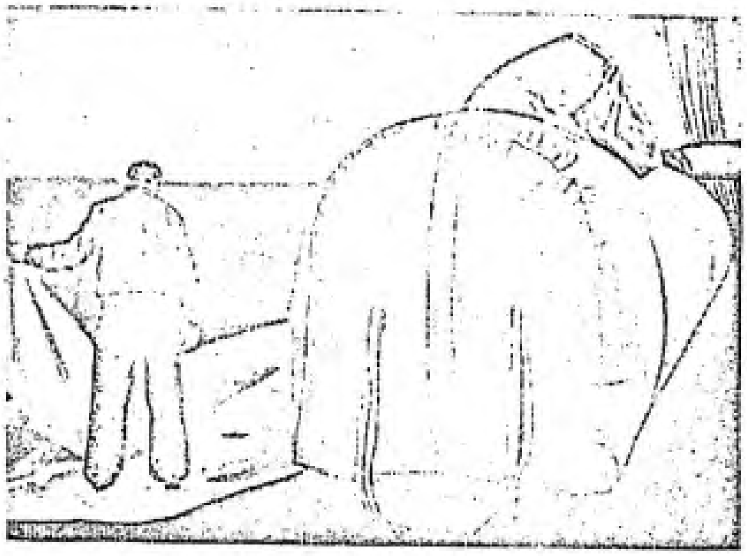

Figure 32. End walls of the 35.5 m^3-vomume container.

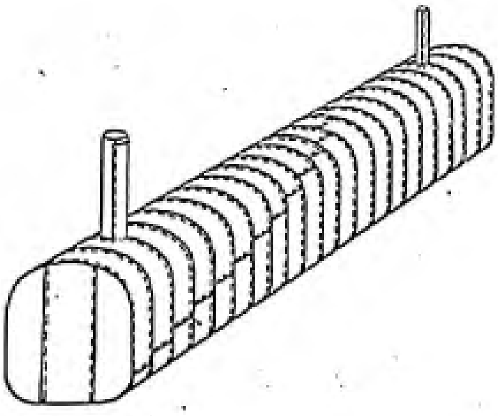

Figure 33. Sketch of a cutout of the outer casing of the 35.5 m^3-volume container.

In 1961, on the extended cruise of the steamship Polyus, a soft container with a volume of about 10 m^3, and having ends in the shape of truncated spheres was tested. The container was made of rubber-fabric material with a tear resistance of about 18 kG/cm. The two hose fittings on the container were closed by means of lids, and glass tubes for regulating the excess pressure were inserted through these. The circumference of the container's cross-section was 7.22 m, and the length of the container was 3.1 m. The container had no other additional fittings. It appeared that with the available space on the ship, the relationship between the dimensions of the container and compartment (relative circumference $\lambda = 4$), a container with spherical ends is completely suitable for use.

Two cylindrical containers of rubber-fabric material with a tear resistance not less than 40 kG/cm were tested in 1963 on two cruises of the motorship, Neva. The containers had the following dimensions: circumference of cross-section 5.4 m, length when empty 9.5 m. The casing with pillow-shaped ends was made of rectangular panels, joined along the circumference. The fitting, adapted for operating the container as an unsupported one, was situated in the middle of the width of the upper panel. Because of this, the container had to be placed flat in the compartment.

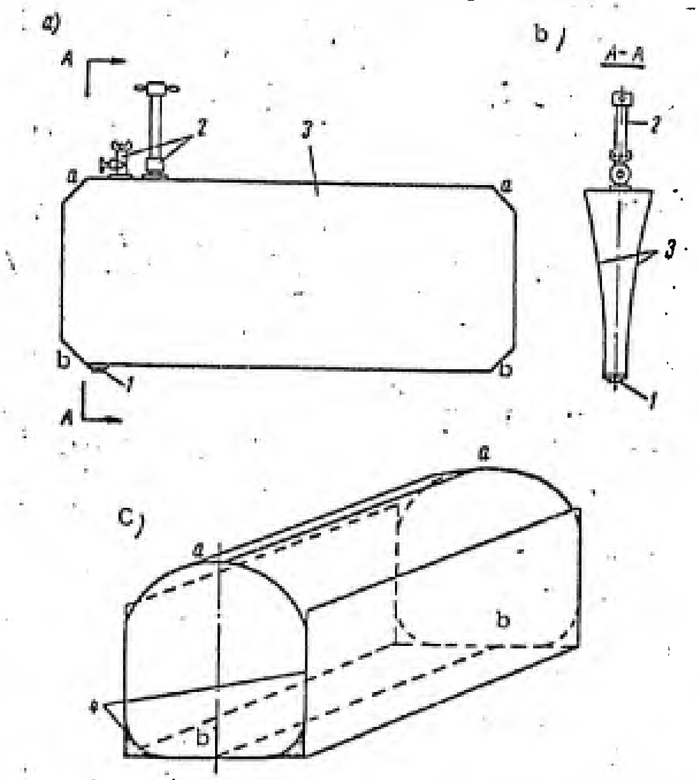

Figure 34. Sketch of a stressed class enclosed container with pillow-shaped ends: a-side aspect; b-cross-section; c-filled container in the compartment.
1-drain plug; 2-intake-discharge fitting; 3-casing; 4-compartment.

On the basis of these tests, a more perfect design (Figure 34) of an enclosed container, better adapted to shipboard conditions, was worked out. It was thus recognized that a container casing must be made of rubber-fabric material or reinforced membranes of increased strength (preferably 80 to 100 kG/cm at a volume of up to 25 to 40 m^3) and be installed in the compartment in such a way that the line of union of the panels a to a and b to b should, after filling the container, show up on the longitudinal, vertical plane of symmetry of the compartment. In this situation, the casing does not depend on its ends after it it is filled. Thanks to this, the straightening out of the casing in the compartment is facilitated, and the manner in which it operates in the region of the ends is improved.

It turned out to be expedient to place the entire fitting on the line joining the panels, and to mount the main fittings of the container on the neck (Figure 35). The intake-discharge fitting consists of a plastic vent with a "ROT" [Roth] type nut on its upper end and a plastic bell-shaped receptacle in the container for better flow of liquid. If discharge or filling is accomplished by means of a siphon or suction pump, a hose is simply attached to the "ROT" nut and the vent opened. If a centrifugal pump is used for discharge, then a non-reversible ratchet valve is mounted atop the vent or on the end of the suction hose. The fitting can also be made of light alloys.

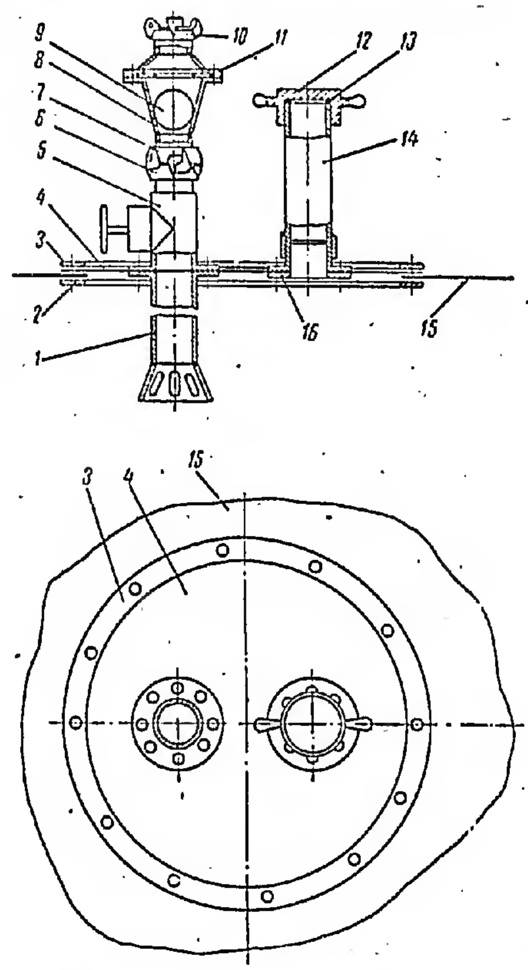

Figure 35. Intake-discharge fitting of an enclosed container. 1-receptacle; 2, 3-rigid ring; 4-soft casing neck; 5-polyethylene valve; 6,7,10-"ROT" nuts; 8-non-reversible ratchet valve; 9-valve ball; 11-grille; 12-blind flange of the air tube; 13-gasket; 14-semi-transparent air tube; 15-container casing; 16-flanged joint.

A polyethylene air tube with a blind flange on its end is located in the same neck, and in the event of damage, or in transporting the container empty, is removable. The opening is then closed by the same blind flange. A second air tube is attached directly to the casing on its other end. In the lower part of the casing, a drainage opening with a plug is provided, and straps are attached for folding up and stowing the empty container.

The Portolite firm's containers, which are described in more detail in chapter IV, also belong to the class under consideration. These cylindrical containers with pillow-shaped ends are intended for transport of liquids, primarily in the unsupported manner. However, the firm also envisions placing containers in the vans of trucks with firm sides, which would withstand the jolts of the container inside, i.e., the container operates in this case, as an enclosed container (Figure 36). It is evident that the container can thus also be installed in the ship's compartment. The firm puts out containers with usable volumes of from 2 to 23 m^3. The weight of an empty container amounts to 23 to 145 kg, respectively. They are manufactured of synthetic rubber 3 mm and over in thickness, and reinforced with nylon fabric.

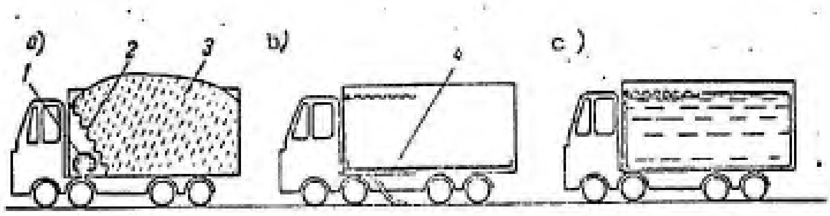

Figure 36. Sketch of the use of "Portolite" containers on truck transport: a-transport of bulk cargo in a van (rolled-up container is under the shield); b-preparing to fill a container with liquid; c-transport of liquid in a soft container.
1-rolled-up container; 2-collapsible shield; 3-bulk cargo; 4-container prepared for filling on the bottom of the van.

Other varieties of unsupported containers are sometimes used in the enclosed form. Often, the relative width of the compartment (usually the vans of vehicles) employed,is much larger than that which is recommended for shipboard containers. The value calculated for the relative circumference turns out to be very close to 2, and the containers, to avoid breaking against the compartment's sides, are filled with only a small excess pressure. As a result, vibration of the liquid is sometimes too great, which creates a danger of turning the vehicle over on turns and makes bursting it extremely difficult. To reduce the vibration of the liquid, several flexible partitions with openings are situated inside such a container, or wave-shaped curved panels are fastened to it.

Containers of the Clinging Class

Construction of clinging class containers is simpler than that of the stressed class. With containers which are filled aboard the ship, a soft lining of 0.2 to 1 mm thick membrane can serve as the hermetic casing. Such linings are welded of overlapped panels or manufactured by the blow mold method.

Forty-five to 210 liter metallic casks, with linings of polyethylene and polyvinyl chloride film, which are in widespread use at home and abroad, belong to this class of containers.

There are two openings equipped with polyethylene bushings, adjusting rings and threaded plugs,on the removal cover of the drum and lining.

Wooden casks with film linings are also in wide use in the Soviet Union. This permits use of bulk casks together with liquid-filled ones for transport of liquid cargoes and salted fish, and at the same time reduces the expenditure on staved wood by up to 1.5 times.

In small compartments, the lining is easily smoothed out by the pressure of the cargo. The container, therefore, can be filled from the top, with a second opening for air having been provided.

With clinging containers of large size, filling from the top becomes more difficult,because for this, the casing, must be hung on valves attached to the upper part of the compartment. In such cases, the liquid must be delivered to the casing from below. An air valve is not needed, but the air must be completely removed from the casing before filling. The casing must be sufficiently strong to be able to smooth itself out.

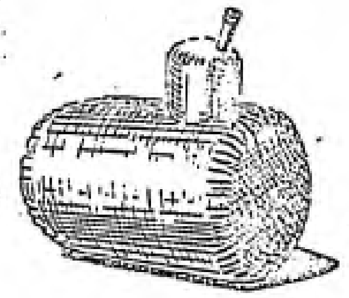

Figure 37. Polyvinyl chloride lining of a steel tank.

Clinging class containers are also used in railroad transport, in the petroleum industry, etc. Inasmuch as the casings of these containers have much in common with the shipboard ones,in operating conditions and design, let us present some information on several varieties of such casings.

In the FRG, a soft container has been patented which is intended for transport of liquids in railroad cars. When filled, the container occupies the entire space of the car.

The Ironflex AG is manufacturing internal and external casings of polyvinyl chloride membrane, 0.5 mm in thickness, for steel casks and tanks of various designs. The membrane is welded with overlaps, with a portable transporting apparatus. The internal casing (Figure 37) serves to protect the metal of the tank against corrosive liquids.

Use of small clinging,enclosed,containers (with volumes of 1 to 4 m^3) on fishing ships of the large, trawler,type is very promising. In the cargo holds of these ships, there are permanently fitted metallic stanchions with slots and other adapters for fastening partitions in the vertical and horizontal planes. The partition, made of aluminum-magnesium alloy or wood, serves to prevent intermixing of fish and protecting them from being crushed by their own weight. Thus, there are already a number of compartments in the hold in which clinging, soft containers can be placed.

Containers of the simplest construction, made from tarpaulin, were used several years ago by Far Eastern fishermen. The faculty of theory and construction of ships of the Vladivostok Higher Maritime Engineering School had some unpleasant experiences with a container of about 1 m^3 in volume on the BRT [large fishing trawler],Ogon', in the summer of 1962.

As a result, it was established that the casings used in these conditions must have a rectangular shape. A polyethylene valve is fitted in the lower part of the end wall. An air valve cannot be installed. The most suitable material for the casing is reinforced capron netting or fabric membrane of 0.5 to 1.5 mm in thickness. Probably, unreinforced membranes can also be used.

Use of large, clinging containers aboard ships is possible only when the compartments have smooth bulkheads, without parts that protrude from them. A number of proposals for use of cling containers, therefore, call for construction of ships with double bulkheads or empty compartments.

Containers of the Stressed-Clinging Class

It is impossible to draw a clear boundary between cling, stressed, and stressed-clinging containers. Containers placed in a latticed compartment closely resemble the clinging class. Such a compartment is assembled on the spot, in the hold by constructing partitions of pipe, braces, or partitions, and the containers may be of very large sizes. Thickness and strength of the casing are determined by the width of the openings between the racks and the height of the container (in oceangoing ships, also by the beam and length of the compartment, on which depends the amount of pressure developed when the ship is tossing). It is convenient to fill such containers from above, and therefore, it is necessary that air valves be provided, since the casing needs to be straightened out by air prior to filling. Simpler means of filling from below are not always attainable. In other respects, the casing is similar to a clinging one. On lateral bulkheads, the racks must be placed vertically, not horizontally.

Such containers combine the simplicity and low weight of the clinging type with the design and operating merits of the stressed type. Their use for transport of fresh water and taking on water ballast in the holds of bulk cargo and refrigerator ships is promising.

Containers of the Fermeture Ekler Ltd firm (France), made under license of Marston Excelsior (England), can serve as examples of enclosed containers used in conjunction with rigid compartments. These containers (Figure 38), having the shape of a parallelepiped, are contained in a metallic lattice frame. The containers are intended for transport and storage of liquids, and have a capacity approaching 20 m^3.

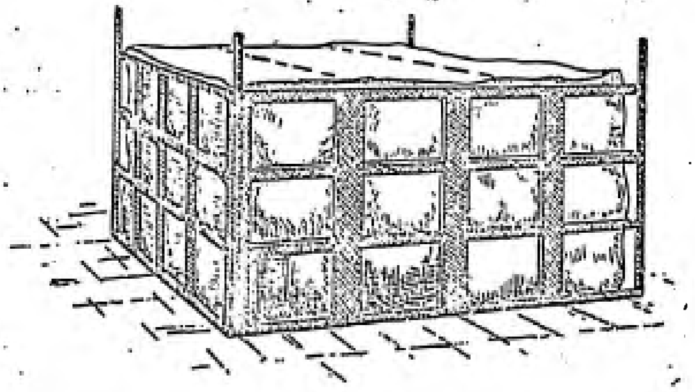

Figure 38. Stressed-clinging class container in lattice compartment.

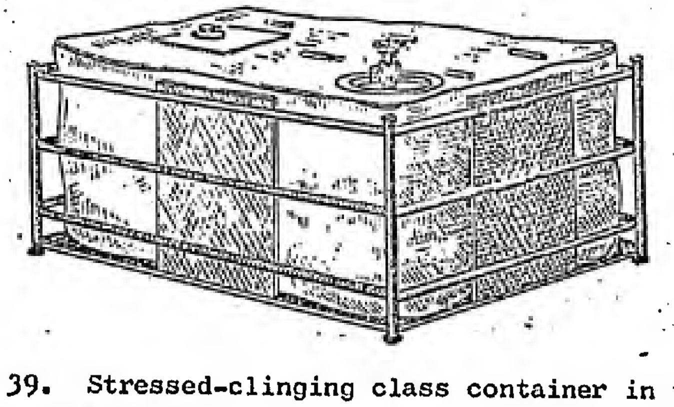

Figure 39. Stressed-clinging class container in tubular lattice compartment.

Containers made by the Citaf firm (Figure 39), also belong to this class. The rectangular casing of this container is made of synthetic rubber about 1 mm in thickness, and reinforced with synthetic fabric. The compartment is made of tubes with plate inserts in the middle. The top of the compartment is open. The firm makes containers of 5 to 14 m^3 in volume. The weight of an empty 5 m^3-volume container is 245 kg. The containers are used for transport of water, organic and inorganic liquids, and so on.

Containers of the kind examined above --syntainers-- are used in sea transports in New Zealand. They are filled from below and take up a volume of about 3.4 m^3 in the shape of a rectangular steel box, lightened by openings in the walls and cover. Similar containers were patented earlier in the FRG.

A patent was taken out in France on an analogous structure of an explosion-proof tank for liquid fuel. The empty fuel tank is blown out with air prior to filling.

Casings placed in compartments with a hatch in the top are similar to the stressed type in their operating conditions, and in their strength as well. Containers occupying the entire hold and having a stressed sector in the area of the hatch, can be considered as belonging to this type. Removal of such casings from the hold, and even folding them up into a packet inside the hold, must be very difficult because of their considerable sizes. It is most expedient not to remove such casings after emptying them, but to leave them in the hold and take on bulk cargo on top of them. True, this way requires careful working out of the questions of protecting the containers.

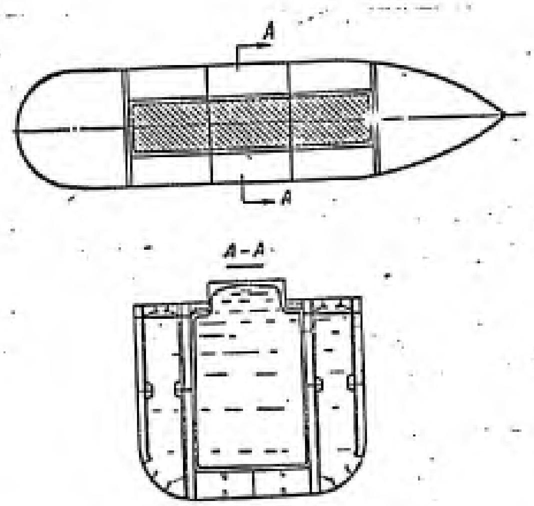

Figure 40. Sketch of a tanker equipped with soft containers.

As an example, we can bring up the proposal (see, [99]) to design a special tanker whose center compartments have double bottoms, cargo hatches, and smooth sides (Figure 40). The middle compartments must take on bulk or liquid cargoes loaded into a soft stressed-clinging container made to conform to the shape of the hold. Before loading, the container is moved off the drum and straightened out by pumping air into them. The filled container is forced against the sides and the floor of the compartment, but in the area of the widened shaft, apparently, has a stressed,convex section. From the description, it follows that in the transport of bulk cargo, the container must be removed from the hold. It is anticipated, that use of such containers will permit transport of bulk and liquid cargoes on a ship without cleaning of the holds. The design and operational aspects of this, as of many other proposals are, however, not worked out, nor is it stated what the strength and weight of the casing must be in order for it to withstand the pressure of the liquid during a storm; and how the casing will be emplaced between the high beams and below deck protuberances, and so on.

In the TsTKB of the MRF [Central Planning-Design Bureau of the Ministry of the River Fleet], two variants of a design for an all-purpose bulk cargo ship, with a length of 62 m, beam of 9.2 m and draft of 1.83 m, have been worked out for the transport of bulk and liquid cargoes in soft containers of the stressed-clinging class. The first variant was designed as a tanker, and the second as a bulk cargo motorship (Figure 41). The hull design of the all-purpose ship,in the area of the cargo holds of both variants, envisages three holds with telescopic hatch coverings. The main difference in the variants is in the fact that the tanker-type all-purpose motorship has an autonomous pumping system which will enable filling and discharging the container by the ship's own means. With the lack of a pumping device, the container is filled and discharged by shore equipment, with the aid of the cargo system aboard the ship.

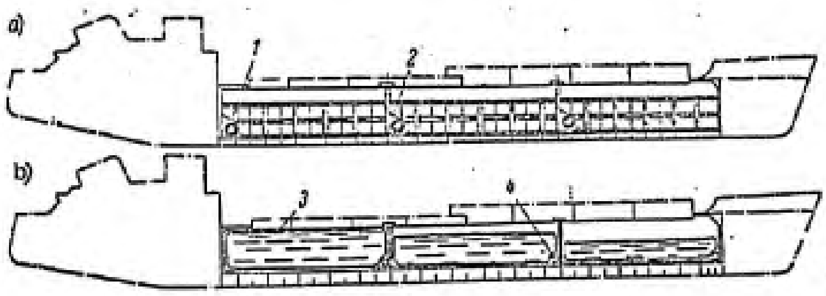

Figure 41. Design of an all-purpose river ship for the transport of liquid and bulk cargoes: a-as a tanker; b-as a bulk cargo motorship.
1-container wound on a drum; 2-protective housing; 3-container filled with liquid cargo; 4-drum without a container.

Placing of one enclosed soft container, and also a device for gathering up and straightening it out before filling, is planned for each hold. These devices are examined in more detail in section 17.

Use of some kind of rubber-fabric or polyamide film, reinforced with capron fabric, is suggested for the manufacture of the container casings.

The design of the container has been worked out on the basis of the following conditions:

a) stresses from the contents of the container are passed on to the flooring of the hold, partitions and sides. The top loading containers do not abut the rigid structures of the ship's hull;

b) empty containers must be easily stowed and gathered up for protection against any possible damage. Containers must be quickly and easily unrolled and made ready for taking on liquid.

Although, from the operational point of view, it is most expedient to have the casing material in the shape of a container which conforms accurately to the shape of the internal space of the cargo hold, it is not possible to create such conditions on standard ships of the open type. It is therefore necessary to use material with sufficiently high strength characteristics for manufacture of enclosed, soft container casings.

On the other hand, containers, which when filled, conform to the internal hold space are complex in their manufacture and unsuited for gathering up and stowing after emptying. Preference is therefore being given to containers of the pillow-shaped type, which are more convenient for operations.

The width of an empty stretched-out container amounts to 11 m, i.e., half of the cross-section circumference of the internal hold space, also including the distance between the longitudinal coamings of the hatch. The length of an empty container is 16 m, which corresponds to the longitudinal semicircumference of the hold; the weight of an empty container is about 1200 kg, and the useful volume is about 220 to 240 m^3 (200 t of fuel).

The design provides for installation of removable intervening posts between the frames below the stingers which duplicate the outline of the lower branch of the framework's frames. This is necessitated by the need to decrease the length of the baseless portions of the casing in the lower, more stressed part of the container. With use of stronger materials, the installation of posts might not be necessary.

The device for access to the inside of the container consists of a soft, hose fitting of about 0.5 m in diameter molded into the casing, similar to that shown in figures 30 to 33. The ends are double-sealed and a hose fitting approximately 0.75 m long is inserted through both layers from the inside by a pressure-cleat for hermetic sealing. In the hose fitting's loop, thus formed, a round wooden core or piece of tube is inserted in such a way that the hose fitting rests flush against it. Then the pressure cleat crimps the hose fitting by means of bolts in one of the surfaces of the steel ring, and forms a tight closure. Flattening out of the hose fitting and insertion of the rings is done across the container so that in rolling up the casing, the ring will be stowed parallel to the axis of the drum.

The device for connecting the container to the cargo main consists of a flexible hose fitting, welded to the containers after end, which is connected to the curved hose of the cargo mains by means of a length of steel tubing. Such an arrangement will permit the complete discharge of all remaining cargo by means of gravity, since after loading, the ship settles at the stern. In addition, after being rolled up on the drum, the container remains connected to the cargo system.

The device for preventing increasing pressure in the container upon heating of the cargo during the warm time of the year consists of gas bleeder tubes with safety valves and fire prevention devices. The gas bleeder tubes are attached to the container by means of curved hoses. In transport of bulk cargoes, the hoses can be removed.

A single wide, or several narrower bands, serving to join the container to the drum on which it is rolled up after emptying, are attached from below to the forward end of the container. In addition, at appropriate places on the container casing, louvered plates used for suspending the container are welded, securing it in heavy seas, and so on.

Container storage is provided at the stern bulkhead of the hold. There, a strong metallic cowl-type stowage housing is emplaced which protects the container from damage when the ship is used to transport bulk cargoes.

p. 158-177 Section 17. Operating Shipboard Enclosed Soft Containers.

Individual instances of operating enclosed containers have been elucidated earlier. Let us examine this problem in more detail.

Tests have shown that the main conditions for normal filling of an enclosed container are properly straightening out its casing and draining the air out of it.

If the casing is poorly straightened out, then in the filling process it forms creases which can no longer be straightened out. Because of this, the container's useful capacity is decreased. Besides, some of the creases might straighten themselves out during the voyage, which will lead to a drop in excess pressure and an increase in the liquid's mobility when the ship is tossing. This happened, for example, during the first test of one of several individual containers on the motorship, Neva. As a consequence of the casing being poorly straightened out, the container was filled up to only 50 to 60% of capacity and in a storm, the compartment walls experienced considerable pounding by the liquid.

The most effective means of straightening out a casing -- by inflating it with air before pouring -- was tested under actual operating conditions and has been completely proven. The shortcoming of this is the need for removal of a large amount of air from the container in filling it, which in itself, is a difficult operation.

A device such as the one shown in figure 56 has been suggested for use in straightening out a casing. It consists of cables stretched across the compartment, hooks situated along the longitudinal plane of the container, and straps attached to the casing. Prior to filling, the container is spread along the compartment, the cable stretched, and the straps set on the hooks. On filling the container, the straps support the casing in a semi-suspended state and in this way, the formation of creases is prevented. The straps are taken down off the hooks after filling.

They use a device with light metal arches which are inserted inside the compartment prior to pouring (figure 57) for straightening out stressed class containers. On the arches are suspended hooks, over which the container's straps are thrown. After attaching the straps, the hooks are raised and set on the compartment walls in the manner shown in figure 57. The casing is thus straightened out.

Straightening out the container can also be accomplished with the aid of pneumatic cross-sectional arches constructed with the container casing (figure 58).

All of these devices, have not yet undergone practical testing and it is therefore still too early to judge their effectiveness.

Small clinging class containers are easily straightened out by the pressure of the cargo during the filling process. Large casings with material of sufficient rigidity also straighten themselves out independently, but those with material of slight rigidity must be blown out ahead of time. Filling containers of semi-rigid construction, poses no difficulty.

If several cylindrical containers are located in a compartment, they must be poured simultaneously, otherwise, the empty containers will be pressed against the filled ones. For this purpose, the cargo holds must have a valve box and several hoses.

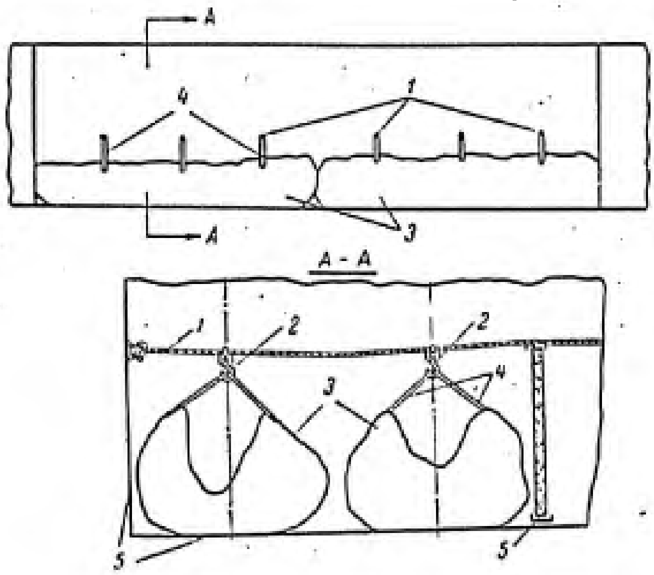

Figure 56. Device for straightening out a casing of an enclosed container with the aid of stretched cables.
1-cables; 2-hooks; 3-container; 4-straps; 5-compartment walls.

Discharging the container can be accomplished by pump, siphon or by gravity through a drain pipe. All of these operations should present no difficulties with devices that are in good working order and good organization.

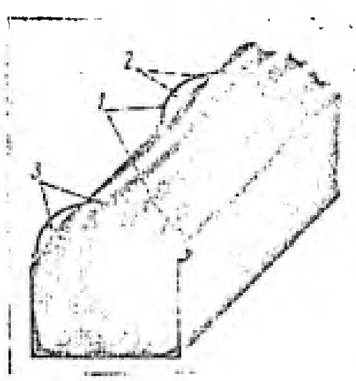

Figure 57. Device for straightening out an enclosed container casing with the aid of metallic arches.
1-arches; 2-hooks; 3-loops on the casing.

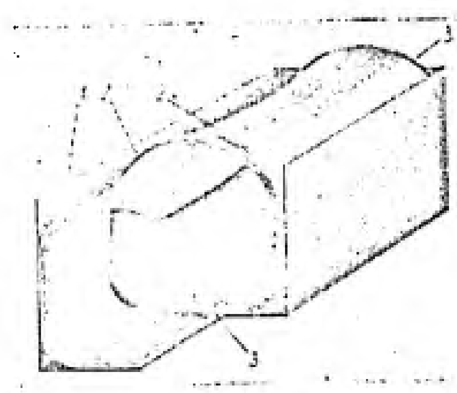

Figure 58. Device for straightening out an enclosed container casing with the aid of pneumatic arches. 1-compartment; 2-casing; 3-pneumatic arches in the operating condition.

Usually, when enumerating the properties of soft containers, they emphasize their small weight in comparison with metallic tanks of the same volume. But, if those of metallic construction are stationary, the soft ones must be moved about from place to place, stowed and rolled up. In this sense, only the very small stressed containers and casing linings can be considered light. A container of 15 m^3 or more capacity is hard for one man to lift. Thus, a rubber-fabric enclosed container of 18 m^3 useful capacity weighs about 130 kg, and one of 35 m^3 -- about 170 kg. Moving the containers about in a ship and lifting and lowering them, must be done by crane, boom, or special devices. Straightening out and even removing a large container is hardly possible with two or three workers.

The inside of containers must be washed and cleaned regularly. This is especially necessary in the transport of fresh water. The literature contains recommendations for cleaning containers by steam. However, they must be regarded cautiously because many of the synthetic materials do not withstand extreme temperatures. Apparently, in order to make cleaning possible, the container must be inflated with air. That, in any case, is what the authors did during actual tests.

Storage of a large number of huge enclosed containers aboard a ship is a complex task. Although, soft container material is meant to withstand low temperatures and the sun's rays, containers still must be stored in an enclosed space. It is not easy to find such space on a cargo ship. It is especially complicated to arrange storage of those soft containers intended for transport of fresh water during winter: if the space is not heated, the remaining water in the casing will freeze and, in being thrown about, may cause cracks in the material.

When operating enclosed soft containers, the need arises to conduct a series of calculations. Let us dwell on several of these.

1. Determining the amount of liquid in the container. The amount of liquid in the container can be determined most precisely and simply with the aid of a flow meter. If there is none, one resorts to an indirect method.

Estimating the useful and actual volume of clinging and stressed-clinging classes of containers presents no special complications, since their shapes are fixed. The volume of liquid in a stressed class,enclosed container can be determined by its three dimensions: width, V_o, height of the upper section, N_v, and height of the entire container, N:

$$W = LV\,(S_V V + N - N_V) + \Delta W.$$

The constant S_V is determined by the curve in Figure 19, with the correction for non-cylindrical ends ΔW obtained by comparing the calculated value of W against that which was precisely measured by other means.

The closest value is given by the formula

$$W = (0.5\lambda - 0.8)\,LV^2,$$

in which λ is the relative circumference of the container's cross-section.

2. Determining the excess pressure in a container. The excess pressure of the liquid in a container is a most important operational characteristic. It should be mandatory for operating instructions to indicate the amount of initial pressure prior to leaving on a cruise and the minimal allowable amount of pressure at the end of the cruise.

It is easy to determine pressure visually when the container has semi-transparent air or regulatory tubes; however, it is dangerous to have people near a container during a storm. For control of excess pressure, therefore, spring-loaded and membrane-type pressure gauges calibrated to a range of 0 to 0.3 kG/cm^2, and ensuring accuracy on the order of 1 cm on a column of water, can prove to be very effective. There are many varieties of pressure indicators which permit direct control over the pressure in containers. The advantages of these indicators' small size (see, for example, [17]), are their independence of the force of inertia, their ability to measure, their capability to record measurements on photographic film or paper, are to a considerable degree, provided by the electronic apparatus in use aboard a ship.

There is still no experience in sustained operation of shipboard enclosed soft containers. However, even the little information which we were able to obtain as a result of actual tests of several varieties of shipboard enclosed containers, and containers for other purposes but similar in operating conditions, are of interest.

In 1960, nine experimental shipboard stressed class, enclosed containers, whose construction is described in section 14, were designed and made by specialists of the Faculty of Theory and Structure of Ships of the Vladivostok Higher Maritime Engineering School. The containers were tested in December 1960, aboard the refrigerated transport, Yana. Since stressed class, enclosed containers had until then, not been investigated, either in the USSR or abroad, the basic aim of the tests was principally answering the question of the possibility of transporting liquid cargoes in such containers aboard bulk cargo and refrigerator ships.

All nine containers were placed in hold number three, which had deck dimensions of 13.7 x 13.2 m (figure 59). The sides, bulkheads and planking of the second bottom in the hold were insulated; only four beams at the corners of the hatch (except for the 0.8 m -- high sections at the bottom) and the below-deck framing were not covered with insulation. To decrease the drag of one container against another during tossing of the ship, tie-down supports made of removable tubular pillar-posts were installed between the extreme containers, and cable (sisal rope) Y-shaped tie-lines placed between the remaining containers in the row. The upper ends of the tie-lines were secured to girders, and the lower ones to I-beams laid across the hold. The beams were pressed down on the planking by two rows of removable beams whose construction is similar to that shown in figure 44. The beams were secured in the horizontal plane by bars nailed to the planking.

The work schedule provided for tests in port and at sea.

The tests in port were conducted in Zolotoy Rog Bay and their purpose was to test the possibility of filling and discharging the containers by shipboard equipment, and also to develop the most appropirate techniques for conducting cargo operations. After rigging the hold, the soft containers were laid out between the lashings and their hose fittings braced up toward the girders. The containers were filled in stages, one by one, to an excess pressure of 40 cm of a column of water. The containers contained about 320 tons of water.

The ship with the filled containers, spent three days in the roadstead, where it underwent insignificant tossing (force 3 to 4 sea), and then went across to the other shore of the bay. Here, water was transferred from the containers to a number of ships at anchor. The containers were discharged by an electric pump, with a capacity of 40 tons per hour, fitted on the 'tween deck.

After a second filling of the containers with 315 tons of water, the ship departed on its cruise. The hose fittings secured to the beams were not covered. They were used as safety devices. During the cruise, there was a force 5 sea. At the start of the cruise, the ship underwent a little rolling, and later, having changed course, some pitching. The containers successfully withstood the turbulence for one and a half days. The sections of the containers between the tie-lines were displaced by approximately 20 to 30 cm in the horizontal plane. A 15 to 20 cm-high wave developed in the containers, having been transported along the casings. On the whole, the behavior of the containers was completely satisfactory but the tight lashings gradually wore into the casings, although they did not tear them, and water was spilled in the hold. Here, it was discovered, how important it was to thoroughly screen the intake openings of the drainage system, so that they would not be obstructed by membrane pieces.*

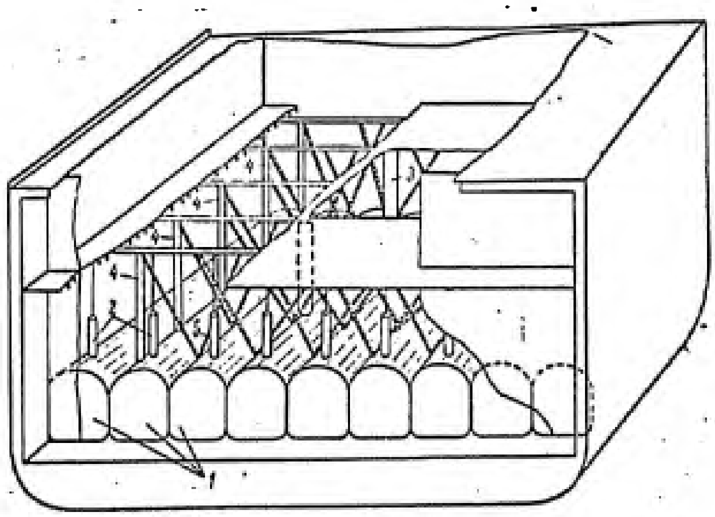

Figure 59. Sketch of the installation of soft containers on the motorship, Yana.
1-containers; 2-intake hose fitting; 3-permanent pillars; 4-removable pillars; 5-sisal rope lashings.

Despite the failure of the first tests, they made a number of important conclusions possible, namely: that filling and discharging containers can be accomplished without serious difficulties; that installation of posts, cables, and similar tight lashings for separating soft containers is impermissable; and that the shape of container used, was on the whole, appropriate.

Tests were conducted aboard the steamship, Polyus, in the fall of 1961, with an individual (see section 14) container of 10 m^3 capacity. The container was placed in a compartment 2.9 m in length, 1.48 m wide, and 2.27 m high, which partitioned off on deck atwart ships. The steamship, Polyus, on which the container was tested, cruised from Vladivostok to Provideniya Bay and back. The purpose of the tests were to test the operation of an individual container aboard a tossing ship, investigate the casing material's resistance to abrasion, and determine the forces acting on the container casing under various operating regimes.

Stresses in the casing were measured by 18 ohm resistance meters attached at nine points in the longitudinal and transverse directions. Because the available meters could measure relative elongation to no more than 2 to 3%, they were attached to a previously-filled container in order to widen the range of measurements. In this way, a meter's operating area was doubled in width. In the tests, the container's operating regimes were so chosen that the casing's possible relative elongation would not exceed the above-indicated limits.

* Translator's note: rubbed off the casings by the ropes.

The tests permitted the following conclusions to be reached.

With any kind of excess pressure in the enclosed container casing, longitudinal stresses were practically absent. For example, in the container tested, they were about 20 to 30 times smaller than the transverse stresses. This important result confirms the correctness of one of the main assumptions, made on the basis of analytical conclusions.

Examination of the container after the 5,500 mile cruise showed that, from the point of view of the material's resistance to abrasion, it is very safe to place containers in individual compartments. No appreciable fraying or other damages were noted on the casing.

The general conformity of the relationship between the casing's relative elongation and the relative excess pressure was confirmed by the data from the actual measurements; the deviation between the analytical curves and the experimental ones did not differ by more than 1.3 to 1.5 times, under corresponding pressures.

The tests aboard the motorship, Neva, were conducted in two stages in March and June 1963.

Initial tests were conducted with two serially-produced containers of 16 m^3 capacity, of cylindrical shape with pillow-shaped ends (see section 14), placed in individual adjacent compartments. The intake hose fitting of the serial container was made in the form of a goose-neck and located on a light cover over a neck at one end of the container. A rubber sleeve, with a branch through which the leads of pressure gauges specially prepared for these tests passed, was put over the goose-neck. The gauges were placed in pockets glued to the internal surface of the casing. Four gauges, two high- and two low-pressure, were installed in each container. The former were placed in the lower part of the container, and the latter in the upper part.

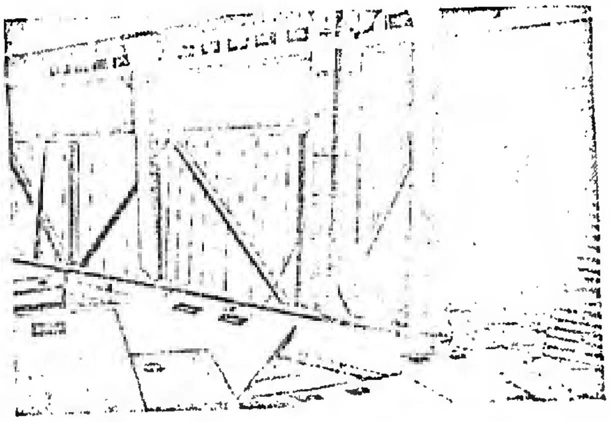

Figure 60. Compartment mounted on the motorship, Neva, for testing two enclosed containers of 18 m^3 capacity.

The compartment for holding the containers was fitted at the port of 'tween deck Number 2 side. It consisted of three longitudinal and two end trusses whose grooves were occupied by boards forming the bulkheads of two adjacent compartments (Figures 60 and 61). The upper longitudinal beams of the trusses were joined by five cross-piece connectors, and the lower ones by sheet metal panels. To eliminate lateral motion, the bottom of the compartment was chocked between a ribband and the longitudinal coaming of the hatch, while the top was secured to the 'tween deck by angled rods. The compartment was made dismountable.

The containers laid out in the compartment were filled from the city's main. The starboard side container was only 50 to 60% filled due to formation of longitudinal creases in the casing. The port side casing was inflated with air prior to filling, thanks to which it was filled normally. The largest excess pressure in the port side container amounted to 15 to 20 cm of a column of water.

After filling the containers, the ship departed on a cruise from Vladivostok to Bristol Bay (Bering Sea). The first days of sailing passed in comparatively calm weather. The observed turbulence of the liquid in the containers was insignificant, although in the container on the starboard side, the amplitude of the turbulence increased as the creases became straightened out.

Then, the ship got into a storm with a force 10 to 11 wind (force 7 to 8 seas) and the list approached 35 to 40°, which corresponded to its calculated value. Pitching was slight. During the storm, which lasted about two days, intensive motion of the liquid in the longitudinal and lateral directions was observed in the containers. It was more noticeable in the starboard side container (up to this time, its excess pressure had become equal to zero). Apart from this, longitudinal waves 15 to 20 cm in height were observed in the containers. Despite the slight pitching, the ends of the compartment underwent blows of greater force than the side bulkheads.

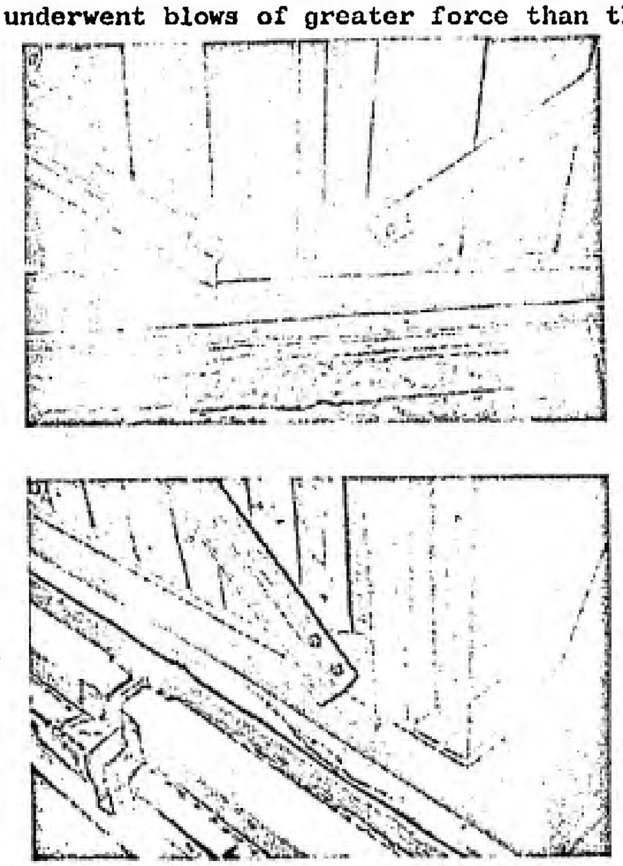

Figure 61. Angle joints of the compartment beams on the motorship, Neva: a-beam joints of the compartment's longitudinal bulkheads; b-juncture of the compartment's longitudinal and transverse bulkheads.

The cruise went on in relatively calm weather in the following days.

After arrival in Bristol Bay, the water was drained from the containers into the ship's tanks by means of a siphon. Not more than 100 liters of water remained in each container; it was drained directly by a pipe passed through the neck. The container resembled a roll of about 1 m in diamater and 1.5 m in length, in the stowed contition (Figure 62).

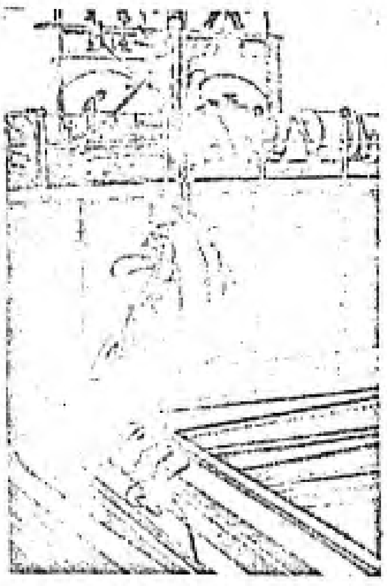

Figure 62. Lowering the rolled-up container into the hold of the motorship, Neva.

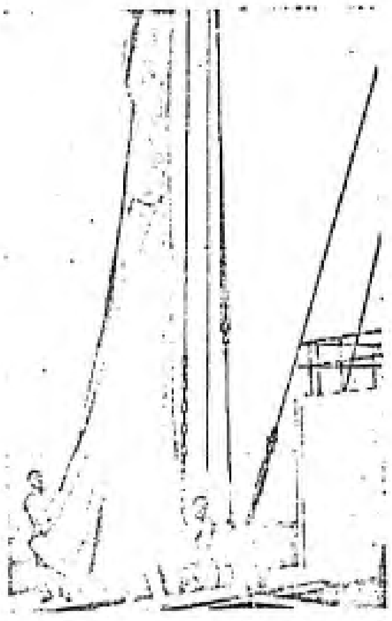

Figure 63. Draining the remains of water out of the container aboard the motorship, Neva.

In the second-stage of the tests, the middle longitudinal truss and bulkhead were removed from the compartment, leaving a single compartment in which both containers were placed. Tests were conducted on a cruise from Vladivostok to Korf (on the northeastern coast of Kamchatka).

It was decided to inflate the container with air prior to filling. Both containers were filled simultaneously. As they were filled, the air was forced out through an air valve. The largest excess liquid pressure in the containers amounted to a 10 cm column of water.

This time, the sailing conditions proved to be not completely propitious for testing the strength of the container casings. During the entire cruise, the sea did not exceed a force of 4, the angle of list 6°, and there was almost no pitching. The behavior of two adjacent containers differed little from the behavior of individual containers.

The containers were discharged in the same way as in the first tests. Then a boom lifted the containers out of the hold (Figure 63), the remaining water was drained, and the containers folded up into packets.

The tests on the motorship, Neva, permitted the following conclusions to be drawn. The excess liquid pressure in the containers did not exceed the designed value during turbulence. Changes in the excess pressure in force 4 to 5 seas amounted to 0.1 to 0.2 of designed values; 0.4 to 0.6 in force 5 to 6 seas; and over 0.6 (approximately up to 0.8) in force 7 to 8 seas. Containers placed singly and in twos in the compartment did not undergo significant damage from abrasion. After the tests (and the containers traveled over 4,000 miles in all) no fraying or damages were noted on the casings.

The actual tests described above showed the real possibility of transporting liquid cargoes in stressed, enclosed containers aboard bulk cargo and refrigerator ships.

The authors were not able to obtain detailed information on the results of tests of enclosed soft containers which had been conducted abroad at various times. Considering this, it will be useful to examine the results of operational tests of two,vehicle-mounted,enclosed containers of the firms Dunlop Ltd. and Fireproof Ltd. (England), which were conducted for a year. Operating conditions of vehicle-mounted containers are in many ways similar to the operating conditions of shipboard containers.

One container had a useful capacity of 14.5 m^3, and it had a rectangular shape. Its weight, when empty, was 280 kg. The container was fitted with an air valve, a hatch for cleaning, and an intake-outflow device. The hose fitting, to which the intake-outflow valve was attached, led inside through an opening in the bottom of the vehicle's body. The container was filled from below. When filled, the container occupied the entire bed of the vehicle, an area of 5.5 x 2.14 m, with 1.17 meter-high sides. The sides were secured along the top.

The second container had a capacity of 5.2 m^3, a pillow-shape, and its empty weight amounted to 76.2 kg. The loading-unloading device was located on the top of the container. The container's designed dimensions were such that, when filled, the container was stowed tightly between the sides; the height of the filled container was 0.69 m.

It is apparent from the description, that the first container is very similar to enclosed-type containers in its operating conditions; its relative circumference is not less than a third.

Both containers were made of nylon-reinforced rubber. The containers were transported on twenty-ton trucks, carrying salt in the containers on the first trip and latex on the return trip.

During the testing process, it was established that strong turbulence develops in liquids on turns and with speed changes when the containers are not sufficiently filled and when they contain air. The forces transmitted to the sides of the vehicle rock it in both the longitudinal and lateral directions. The tests also led to the conclusion that the use of rectangular containers is more economical, but it makes their stowage somewhat more difficult. These operations are considerably easier to conduct with a pillow-shaped container. Neither the casing material nor the seams were damaged in transporting a cargo of salt by container.

For eliminating the liquid's turbulence, the firm decided that in the future, it would be better to replace a single container with two of smaller dimensions. The containers will be stowed in the vehicle's bed one on the other.

Since, from the viewpoint of abrasion and damage, enclosed containers operate under the same conditions as soft packages, tests of the resistance to damage of such packages are of interest here. Many investigations have shown that with the use of appropriate measures (security of parts that protrude, and so on), the percentage of damage to soft packages made of membranous material is extremely small (about 1%). Consequently, the stability of enclosed containers, operating in more favorable conditions, should be fairly high.

Guaranteed operating life expectancies for enclosed containers still have not been established either in the USSR or abroad. In the opinion of a number of foreign firms, the strength of the material and parts of the soft containers produced by them,assures a normal container service life on the order of five years, and in certain cases, even ten to 15 years. A guaranteed service life of two years is being established for a number of Soviet produced containers, but in fact, it is proving to be higher. This is especially evident in the instance of soft, ship-supporting pontons, which are operating under tough conditions for five years and more.

In conclusion, let us consider several problems on the operation of the all-purpose river motorship, the design of which is described briefly in section 14.

This design envisages the conduct of filling and discharging containers by means of special cargo-handling systems. The cargo-handling system of the all-purpose ship designed on a tanker-type base is shown in figure 64. The sketch shows that the system will permit the conduct of cargo operations by both shipboard and shore equipment. The cargo-handling system on the other design does not have an autonomous pumping station and therefore, filling and draining can be accomplished only by equipment ashore. Each of the all-purpose ship's holds is provided with a rig for straightening out the container prior to filling, for facilitating and speeding up stowage of the container, and for ensuring its protection. Three variants of such rigs have been developed.

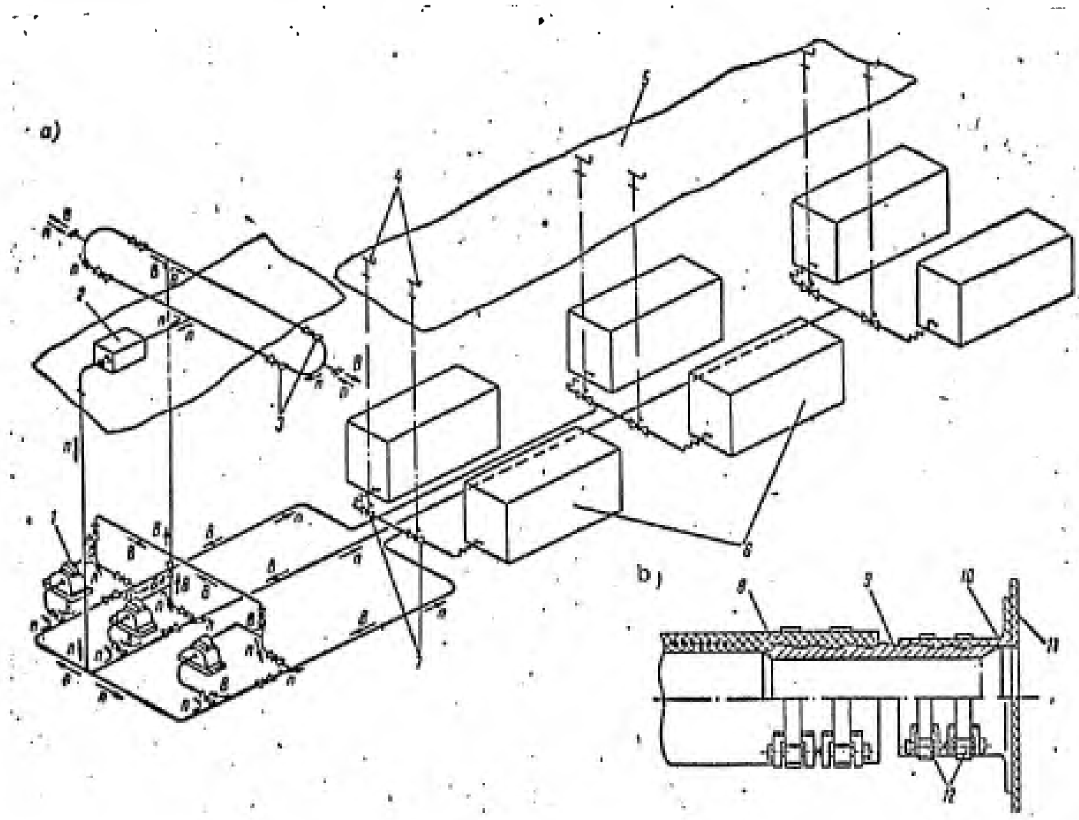

Figure 64. Sketch of the cargo-handling system of the all-purpose river ship: a-overall sketch of the system with a pump; b-sketch of the flexible hose attachment to the container.
1-pump; 2-filter; 3-wing bolts; 4-levers gripping the wing bolts; 5-deck; 6-soft containers; 7-wing bolts with grips; 8-flexible hose; 9-steel tube; 10-the container's hose fitting; 11-container casing; 12-clamps.

Variant 1. An empty container is gathered up by means of a drum (Figure 65), to which the casing is always tied by a flexible line. The drum is made in the shape of a cylindrical roller whose length is chosen on the basis of the width of the hold and the container being prepared for stowage. After discharging, the container remains suspended along its circumference in such a way that its upper half goes into the lower (Figure 65 c), thus preventing creases from forming when the container is wound up on the drum or filled.

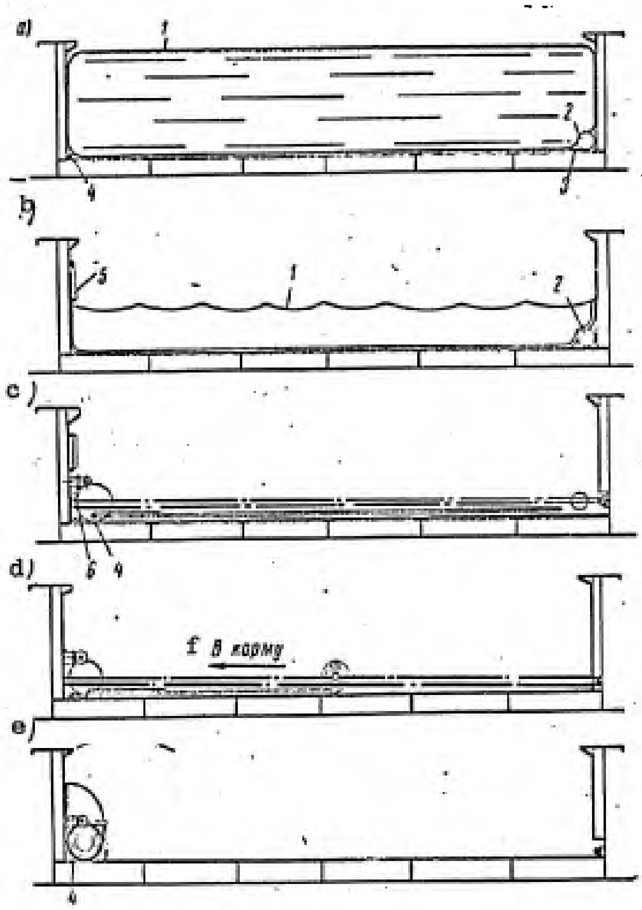

Figure 65. Sketch of the rig, with drum, for stowage and protection of enclosed containers (on the all-purpose ship): a-container filled with liquid cargo; b-discharged container; c-container laid out for winding on the drum; d-container being wound up on the drum; e-container wound up on the drum and covered by a cowl; f-to the stern.

1-container; 2-drum; 3-line connecting the container casing with the drum; 4-flexible hose for attaching the container to the cargo-handling system; 5-protective cowl in stowed position; 6-two manual winches for moving the drum.

To facilitate folding the container into a packet, its longitudinal selvages are fastened by clips inserted along louvers on two tubular ledges. The ledges are tied to two control rods located on the deck at the longitudinal coamings of the hatches. When the rods are turned, the ledges move simultaneously either upward toward the ship's sides or downward toward the diametrically opposite plane. Thanks to this, the container can be either straightened out or folded up in the hold, depending on the direction in which the rods are turned. Similar rigs are not provided at the transverse bulkheads because the selvages on the cross are shorter and it is not hard to take and fold them by hand.

A container prepared for winding up on the drum is shown in figure 65, c. The width of the packet must be less than that of the working part of the drum.

Inside each end of the drum are inserted cross-axes, on which freely rotating tags, with two eyelets on each, are hafted. Lines passing to two winches through blocks secured to the bulkheads, are clipped to these tags. The winches are fitted on one of the compartment's transverse bulkheads (Figure 65, d).

The lines are secured to the winch drums in such a way that when one line is winding, the other unwinds. A flange is provided on the drum so that the lines will not get tangled. The direction of the drum's movement changes according to the direction in which the winch is turned. When the drum is moved toward the stern, the soft container is wound up on it. On reversing the drum's movement, the container is unwound.

Use of two winches instead of one,permits control over the attitude of the drum in the hold, keeping it from getting disoriented. The drum and fully-wound container are secured to the after bulkhead of the hold and covered by a protective cowl (Figure 65, e). The weight of the drum is chosen so as to assure that it will roll without swerving and squeezing the remains of liquid from the container into the loading main. Preparing the container for taking in liquid cargo is conducted in the reverse of this.

Variant II. The discharged container is taken up by means of a drum on a bogie which are movable along the length of the hold (Figure 66). The bogie is a low carriage on four wheels with rubber-covered rims. A drum is fitted on bearings on the carriage's side framing. The casing is connected to the drum by a flexible line. The width of the bogie is such that the container prepared for winding up,fits between the wheels. Independent manual conveyors with gears are provided for moving the bogie along the hold. However, mechanical conveyors with remote control can also be fitted. Otherwise, the design and operating principles of the rig differ little from those examined previously.

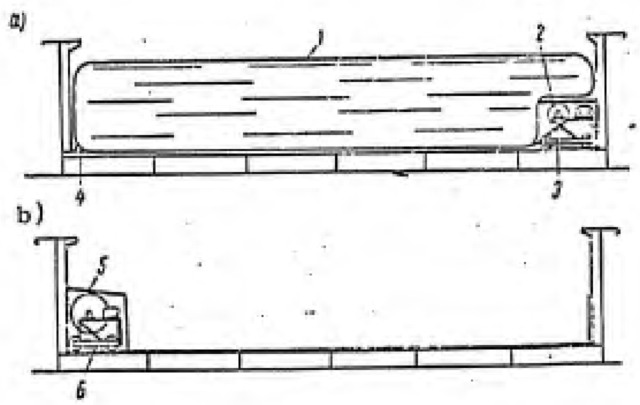

Figure 66. Sketch of the rig for stowing and protecting enclosed containers with a drum on a bogie that are movable along the length of the hold: a-transport of liquid cargo in an enclosed soft container; b-hold prior to taking on dry cargo.
1-container; 2-bogie; 3-line connecting the container casing to the bogie; 4-flexible hose for attaching the container to the cargo-handling system; 5-cowl; 6-bogie with a woundup casing.

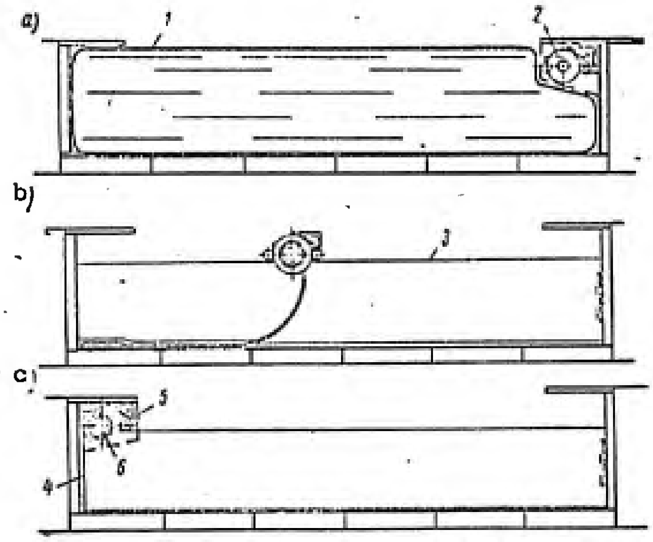

Figure 67. Sketch of the rig for stowing and protecting an enclosed container, with a drum on a bogie that are movable along the coamings of the hatch; a-transport of liquid cargo in a soft container; b-the container laid out after discharging is wound up on the bogie's drum; c-hold prior to taking on bulk cargo.

1-container; 2-bogie; 3-rail path; 4-flexible hose for connecting the container to the cargo-handling system; 5-cowl; 6-bogie with a woundup casing.

Variant III. The discharged container is taken up by a drum on a bogie which moves on rails laid along the coamings of the hatch. The bogie is a bridge truss with four wheels. A drum connected to the empty container by a flexible line is fitted on bearings on the side frames of the truss. The length of the truss corresponds to the width of the hold, and therefore the packet formed by the folded container must be somewhat less than this distance. Independent telpher-type manual conveyors are used for moving the bogie and turning the drum. Otherwise, the rig is similar to the previous ones.

Two men are required to service the rigs described.

CHAPTER IV

UNSUPPORTED SHIPBOARD SOFT CONTAINERS

Section 18. Basic Varieties of Unsupported Shipboard Soft Containers.

Soft containers are defined as unsupported when, after being filled, they are placed on a horizontal or near horizontal flat surface. Such a container is not secured by anything in stationary emplacements. When used aboard a ship, it is secured by belts, lashings or straps in order to prevent possible displacement of the casing.

Unsupported shipboard,soft containers operate under more difficult conditions than enclosed containers because in order to decrease their movements they are filled with greater excess pressure, since the stresses that arise when the ship is tossing are not absorbed by the bulkheads of a compartment but by the connections secured to the casing.

The use of unsupported containers aboard ships has a number of advantages over the use of enclosed containers. Almost no special kind of rigging is required to secure them. Unsupported containers of relatively large sizes can therefore be placed on any available space on the ship. Certain kinds of unsupported containers can be stowed in the hold like regular cargo. The process of filling and discharging unsupported containers is simpler than with enclosed containers. Small, unsupported containers can be loaded aboard ship after they are filled.

One can foresee that unsupported shipboard, soft containers will find use in the transport of various small amounts of liquid, bulk and thick-liquid cargoes, as reserve tanks aboard small ships or as additional containers in trimming ships prior to lifting them onto slipways, and so on. Small, unsupported containers of soft or semi-rigid design, are already being used instead of rigid crates in massive transport of sugar, bulk construction materials, and chemical products.

Among the different varieties of unsupported, soft containers for shipboard use, the most suitable are the horizontally-placed cylindrical, pillow-shaped, barrel-shaped, semi-rigid collapsible bag-shaped and mattress-like designs.

Cylindrical containers are most frequently made with pillow-shaped tubular ends, and less often, with spherical and conical ends. They are most adaptable to being placed in various shipboard spaces, and have the least weight and volume, when empty, in comparison with other kinds. At the same time, they also have the greatest mobility, due to which, their useful capacity cannot be very great (approximately 20 to 30 m^3 on seagoing ships, and several times greater on river craft).

Pillow-shaped containers, similar to the cylindrical ones in design and properties, can be made in somewhat smaller capacities.

Barrel-shaped containers are made in semi-rigid and soft constructions. The semi-rigid ones have cylindrical shapes with rigid bottoms. They have all the merits of rigid crates (the capability of being loaded aboard after being filled, of being stowed in stacks, of being rolled to different places) while at the same time, having a small volume after being discharged. Barrel-shaped containers of soft construction are also made in cylindrical shape, but with rounded bottoms. Their useful capacities are as much as 8 to 10 m^3.

Barrel-shaped containers are all-purpose, can be carried on any kind of transport, and therefore, are exceptionally promising.

Semi-rigid,bag-shaped containers of collapsible design have rigid bottoms and an additional rigid frame. The frame is made of hinge-joined sheet strips, tubes and rolls. Because of the frame, which absorbs a considerable portion of the stresses, these containers can have very considerable dimensions. They can be placed on the deck and in the hold of a ship. The frame assures the rigidity of the construction as a whole, and thus, it is simpler to secure the container than it is with a cylindrical one. Their main shortcoming is their large weight and volume in the empty condition (up to 1/3 of filled volume).

Mattress-shaped containers, embodying a cylindrical-shaped casing with cutouts secured internally by vertical tie-pieces, have still not been used aboard ships. However, the presence of the tie-pieces gives the container a small height and flat shape when filled, and the liquid achieves little motion even under low excess pressures, and with low-strength material. Mattress-shaped containers may find use for taking on small amounts of cargo, ballast, reserves, and also as soft crates stowed like sacks or bales in the hold. In designing such containers, special attention must be devoted to the ability to attach the tie-pieces to the casing.

p. 183 In order to check the correctness of the equations obtained, several series of tests were set up in which the relationship of longitudinal to transverse stress at several points on an unsupported container casing was determined. Tests were performed on container models made of polyvinyl chloride plastic 305 mm in diameter and 0.25 and 0.5 mm thick. The length of the models varied from 1560 mm to 500 mm. In addition, an actual pillow-type container 4.2 x 2.7 m in size was tested.

The material of the models was isotropic, and therefore the value Q_{pr}/Q was judged by the relationship of the relative longtiudinal and transverse elongation of the casing at a given point. The rubber-fabric material of the container is anisotropic. Measurements were first conducted on the entire container and then on a portion of the container separated from the remaining section by two beams tightly-pressed together, in this connection. They isolated a section geometrically representative of the container as a whole, but its casing was already oriented, relative to the internal stresses, perpendicularly to the first portion. By simple recalculation, it is possible to exclude the influence of the anisotropic material and to obtain data on the stress relationships which are close to actual fact. The elongation of the casing was everywhere measured by a flexible ruler. The container tested is shown in figure 72.

p. 184 The results of tests conducted at the beginning of 1964 by L. M. Mal'tsev, during a lengthy cruise on the steamship, Dzhurma, can provide several preliminary estimates of the order of these values. Five cylindrical polyvinyl chloride models with pillow-shaped ends with maximum diameters of 366 mm, and lengths from 800 to 2400 mm were tested. The models were placed athwart ships, but the angle of list did not exceed 7° during the entire cruise. Thus, the data obtained correspond completely with those calculated for the roll of the ship with the containers laid out lengthwise.

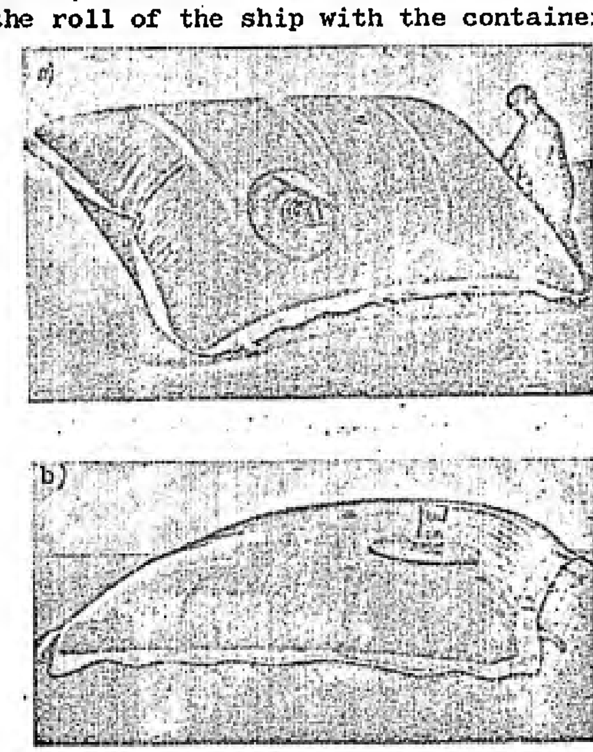

Figure 72. Unsupported container: a-with 4 m^3 capacity and pillow-shaped ends, which was tested by the authors in 1963, being checked for its impermeability; b- 4 m^3 capacity, in the operating condition.

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Section 20. Design of Unsupported Shipboard Soft Containers.

Cylindrical and Pillow-Shaped Containers.

The most widely used, of the cylindrical containers, are the varieties with tubular and pillow-shaped ends. This is accounted for mainly by the technological ease of manufacturing such ends. Containers with purely pillow-shapes differ little from analogous cylindrical ones, and will therefore be considered together with them.

The pillow-shaped ends are more favorable from the point of view of the casing's operation. Rigid planks, by which the panels in the tubular-end container are joined, prevent the casing from becoming deformed and give rise to additional stresses within it. The merit of tubular design is its suitability for securing the container, and its capability for lifting a filled container by means of straps inserted in frames attached to the rigid planks.

Spherical and conical ends are advantageous in those cases where the container operates under great excess pressures (which, generally speaking, is characteristic of shipboard containers); it is also effective to fit them on unsupported containers, which for different operating periods may be used as suspended, submerged or floating containers.

The ends of pleated-type clindrical containers, which are formed by drawing together the casing's edges along its circumference by means of a cord (Figure 82), are very simple in design. Such ends are made in containers which have an impermeable inner casing-liner and a strong outer casing. With ends of this design, it is easy to change liners.

Unsupported cylindrical containers, like the enclosed containers, must have devices for intake and discharge of cargo, letting out air, getting inside the casing, and lashing the container to the ship.

The intake-outflow device can be placed in various ways: on the casing's upper panel, along the line joining two panels, or at the edge of an end (in pillow-shaped and tubular containers), or in the center of an end (when its shape is spherical or conical). The simplest kind of such a device is the valve with a "Roth" or other type of nut on its end for attaching a hose or any standard hose fitting. Necks for cargo operations are useful on containers which must transport bulk or viscous liquid products.

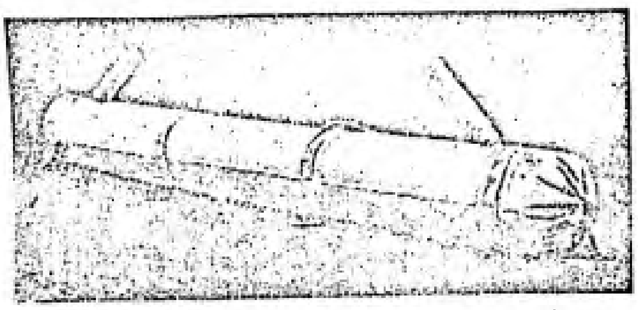

Figure 82. Unsupported container of 0.65 m^3 capacity, which was tested aboard the schooner, Zarya.

Shipboard unsupported containers, as distinct from those used ashore, require filling with great excess pressure. It is not difficult to create excess pressure if the container is filled by means of a pump or from a main under pressure. Otherwise, in order to create an excess pressure, the intake valve must be located on the end of a hose whose length corresponds to the required amount of pressure.

Discharging unsupported containers is easily accomplished by pump and gravity. To increase the speed of discharging liquid, the container can be lifted at one of the ends by a boom or crane after it is partially discharged. For this purpose, long containers can be rolled up gradually, and the short, pillow-shaped kinds,can be pressed down with a flat load. If the container is filled with a viscous liquid or bulk product, it can be discharged only by being suspended.

Because empty, unsupported, containers are easily straightened out, the amount of air that gets into them is small. For removing it, an air valve with a cross-section of about half that of the intake tube, is fitted on the upper part of the casing (usually in the middle of the length and width).

A neck on metal or plastic rings, with either a flexible or rigid lid, is fitted on the casing for cleaning and inspecting the inside. If the end is made in tubular design, a scarf joint with a locking plate is sometimes provided for access to the inside of the casing.

Small, pillow-shaped casings can be secured aboard ship by means of four straps inserted at the container's corners (Figure 83, a). The use of belts encircling the casing, which is supported by a frame placed beneath, is recommended for securing longer containers. Tests have shown that attaching belts to the casing, like straps, does not work because when the ship is tossing, the belts gradually break away from the casing even if they are put around it twice. Depending on how the container is placed, the belts are attached by various means (Figure 83, b, c, d, e).

It is useful to attach firm braces on the deck, or dunnage on both sides along the casing, in order to increase the container's overall stability when the ship is tossing from side to side.

A very convenient and reliable means of securing unsupported containers is with the aid of a strong grid (Figure 83, f). The grid is secured to the deck along one side of the container; after the container is filled, the grid is tightened down by lashings from the other three sides and presses the container to the deck. Such a device permits even containers made of relatively weak materials to be used aboard ship.

Let us review several completed, unsupported shipboard container designs. Until now, few have been made and tested directly for conditions at sea. However, a large portion of the containers of this type, which are being used for transport by truck, railroad, and for storing liquids on land, can also prove to be suitable as shipboard containers without essentially changing their design. During sharp stops and on turns, truck and railroad containers undergo stresses of about the same force as those acting on a container during the tossing of a ship. Along with the strictly shipboard types of containers,therefore, it will be useful to examine the most interesting designs of other kids of containers as well.

Of the cylindrical containers tested under shipboard conditions, let us first of all note the "Portolite" containers, made in England for transport of petroleum products, vegetable oils and other liquids aboard ships, on trucks and railroad cars, and also for storing these cargoes on shore. The containers have an elongated pillow-like shape (Figure 84, 85). A pipe fitting attached to the casing (Figures86, 87) serves for filling and discharging the container. Cleaning the container is accomplished by steam and washing materials.

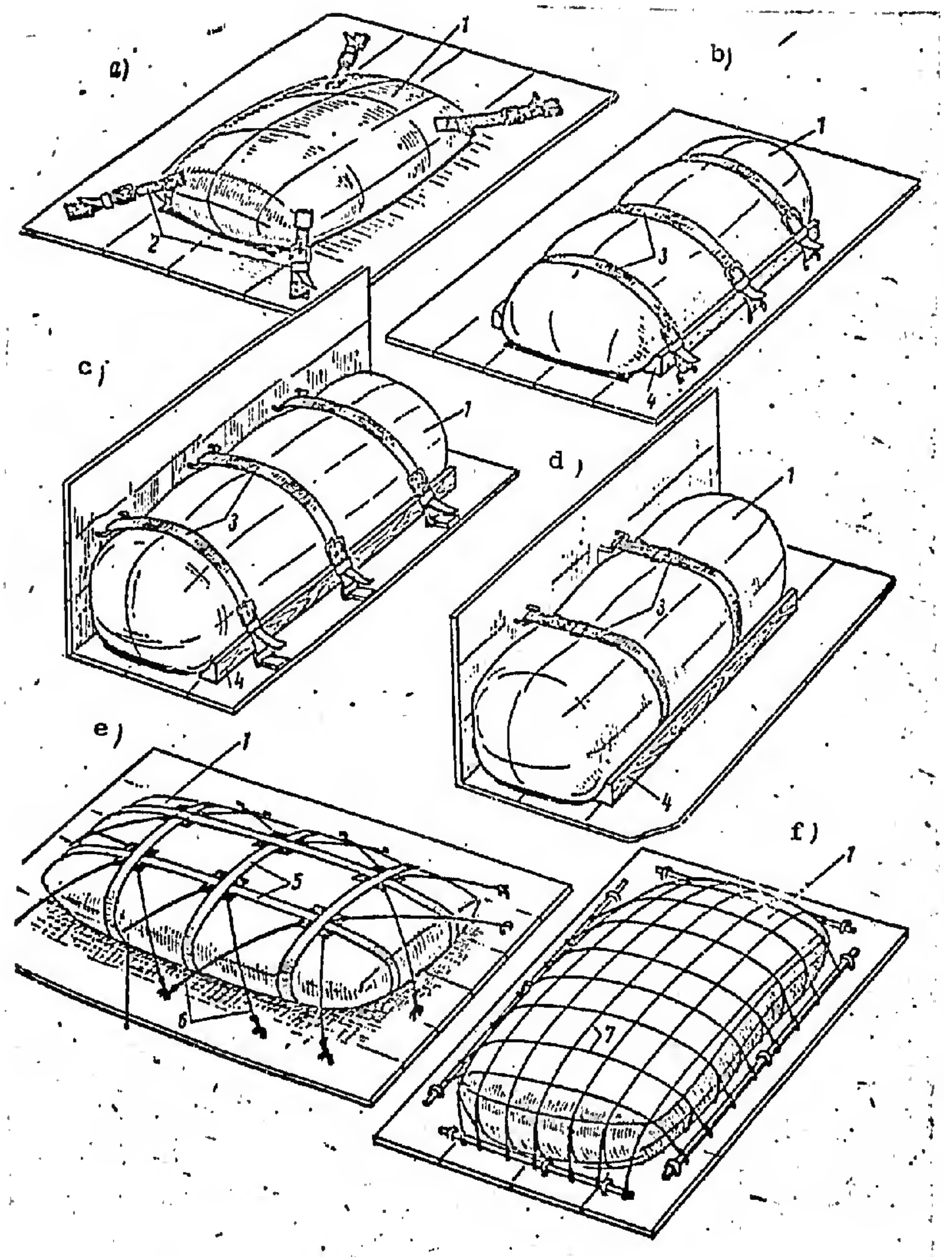

Figure 83. Means of securing unsupported, shipboard soft containers: a-securing small containers by straps at the corners; b, c, d-fastening and encircling belts; e-reinforcing bands with lashings; f-a securing grid.

1-container; 2-straps; 3-belts; 4-support braces; 5-reinforcing bands; 6-cables; 7-grid.

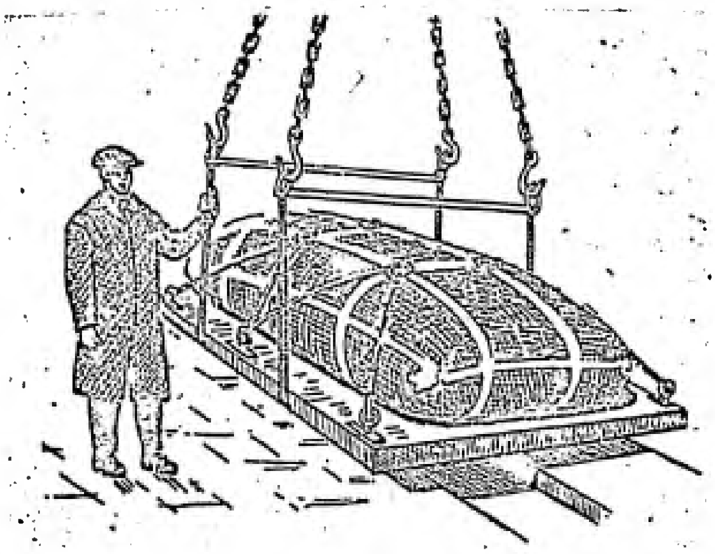

Figure 84. "Portolite" shipboard, unsupported container, of 3.4 m^3 capacity.

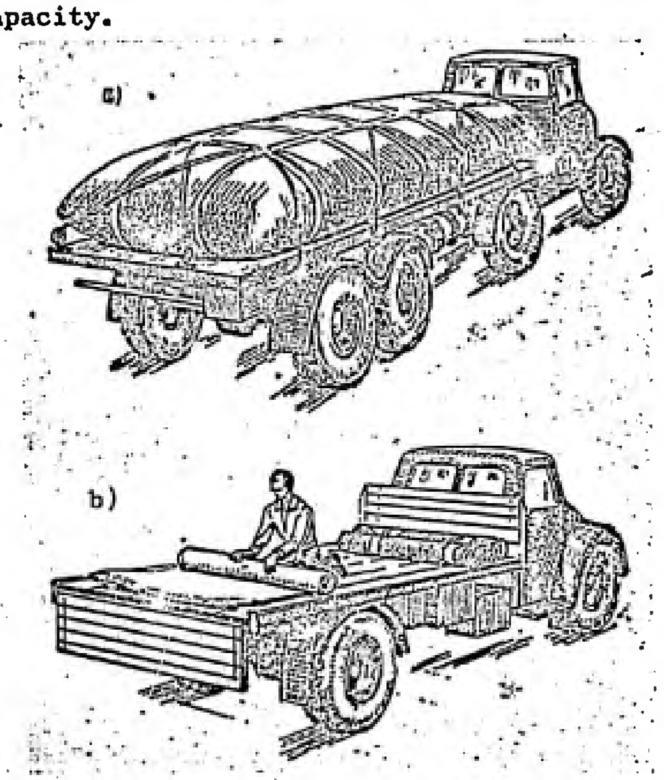

Figure 85. "Portolite" transport container, of 9 m^3 capacity: a-on a truck bed; b-rolling up discharged containers.

"Sealed tank" elongated, tubular-shaped containers (Figures 88, 89), for transporting liquid cargoes on the decks and in the holds of ships, on railroad flatcars and trucks, and also for storage ashore, are in series production in the U.S.A. The container is 10.7 m long, 1.4 m in diameter (when filled), and has a capacity of about 15 m^3. The empty weight of the container is 470 kilograms; it is 2.24 m long with a 0.65 m diameter when rolled up. The container is filled through a special fitting. The end joints are enclosed by metal panels in order to ensure strength and a hermetic seal. The container is secured by guy-wires.

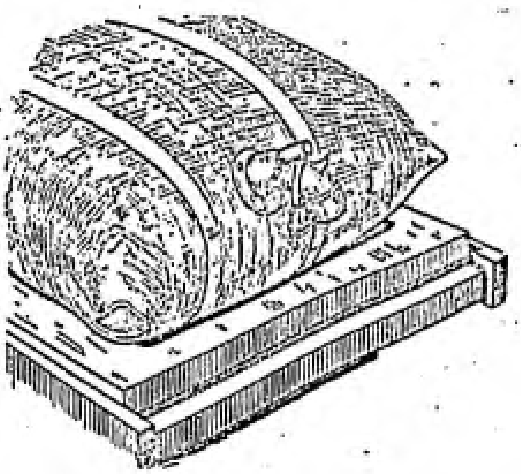

Figure 86. Intake-outlet valve of the "Portolite" container.

In 1960, two experimental, soft containers with drawn-up ends (see, Figure 82), for transporting fresh water on the deck of a ship, were designed and made in the Vladivostok Higher Maritime Engineering School and tested in two cruises aboard the schooner, Zarya.

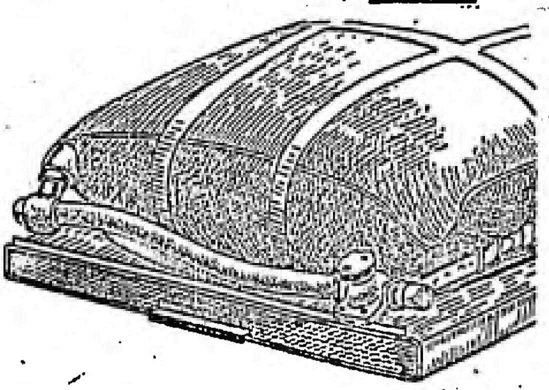

Figure 87. Variant of the intake-outlet device on the "Portolite" container.

The following dimensions were selected for these containers because of the available space on the ship: 4.46 m in length, 0.45 m in diameter, and 0.65 m^3 capacity at an excess pressure of 35 cm. The empty weight of the containers was 8 kilograms. The containers were two-ply (Figure 90): the inner casing was of Mark V-118 polyvinylchloride membrane 0.19 to 0.27 mm thick, and the outer one was of Article 385 sail tarpaulin. The ends of the inner casing were welded in wedge-shaped sections and drawn into a bundle by a cord. A hose fitting for filling and discharging the container was installed in the upper part of the casing. The inner casing hose fittings were welded and glued on a mandrel to flanges of the same material. The flanges were welded to the casing from within. A perchlor vinyl resin dissolved in dichlorethane served as the glue.

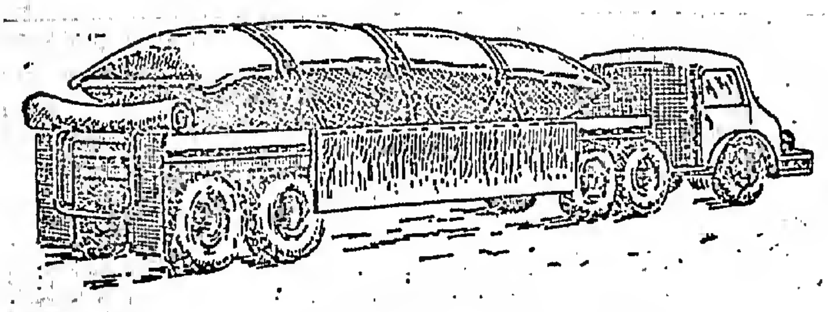

Figure 88. "Sealed tank" transport container.

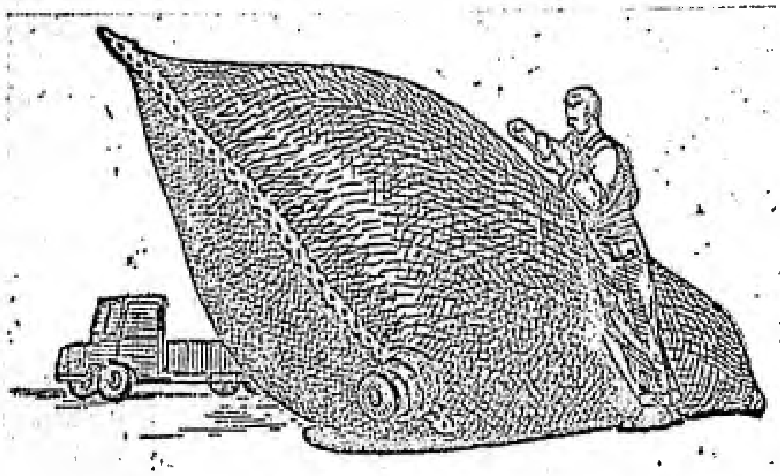

Figure 89. "Sealed tank" container of 15 m^3 capacity.

The external tarpaulin casing was sewn together with capron thread into a two-fold sail seam, and it was reinforced (beneath the straps) crosswise,by four tarpaulin belts. The intake hose fittings are sewn into pockets hemmed in the casing. Transverse cuts (since transverse stresses in the casing are greater than longitudinal) with secured edges were made in the casing for passing the hose fitting into the outer casing. At the ends, the tarpaulin's edges were wrapped up, stitched through, and tightened with a drawstring. Flaps, which cover the small openings that remain after drawing up the ends, are sewn to the inside of the casing.

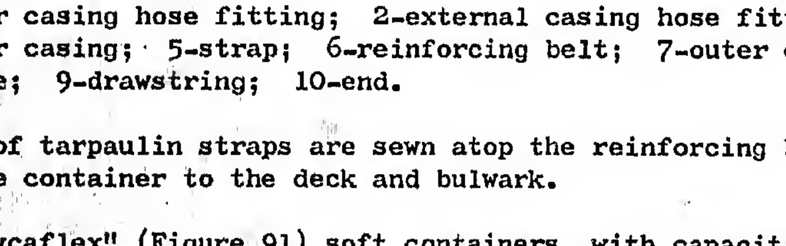

Figure 90. Sketch of the experimental soft container.
1-inner casing hose fitting; 2-external casing hose fitting; 3-pocket; 4-inner casing; 5-strap; 6-reinforcing belt; 7-outer casing; 8-valve; 9-drawstring; 10-end.

Four pairs of tarpaulin straps are sewn atop the reinforcing belts for securing the container to the deck and bulwark.

The "Hycaflex" (Figure 91) soft containers, with capacities up to 23 m^3, are manufactured in England. They are intended for transporting motor fuel, mineral and vegetable oils,medium strength acids, alkalis and other things on flatbeds and other means of transport. In special non-toxic makes, these same containers are used for storing water, wine, non-alcoholic beverages, and beer. Water does not spoil even under prolonged storage. During tests, filled containers of 4.5 m^3 capacity were slid down a 46 meter-long ramp with a 1:4 slope and received no damages of any kind.

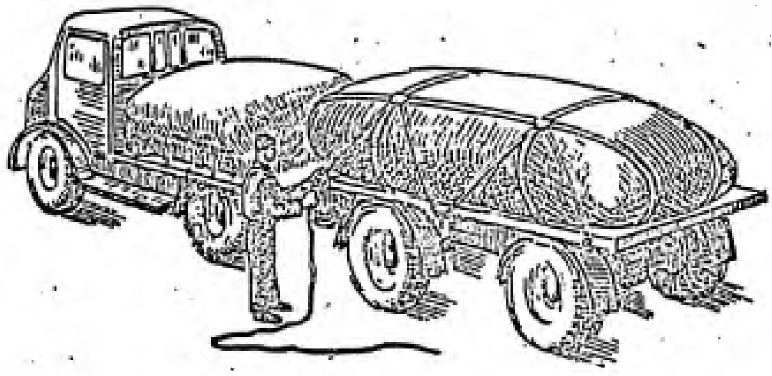

Figure 91. "Hycaflex" transport container.

Figure 92 shows a soft container, made by the Dunlop company, intended for transporting volatile liquids on semi-trailer trucks. The container is secured to the flatbed by nylon straps specially constructed along its body.

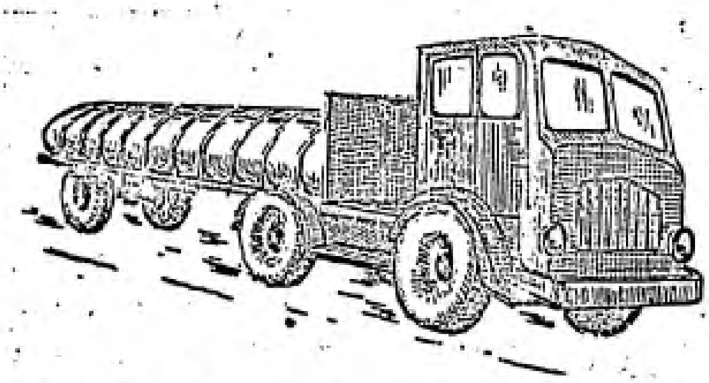

Figure 92. Dunlop transport container, of 9 m^3 capacity.

Soft containers of strong, nylon fabric (single- or double-ply), covered on one or both sides with synthetic rubber, are being manufactured in France. The containers are of 0.1 to 50 m^3 capacity, with the 1 to 15 m^3 ones used most frequently. Three types of these are made. The RS1 (Reservoirs souples) type is designed for storing liquids only. The casing is made of one layer of nylon covered by synthetic rubber. The container has a rectangular pillow shape. The RS2-type container casing is made of two layers of nylon fabric, also impregnated with synthetic rubber. These containers are used for transporting liquids at slow speeds and storage. They are in the shape of somewhat elongated pillows. The RS3-type (Figure 93) containers, which are intended for transporting liquids considerable distances, have received the most widespread use. These containers have internally-connected compartments for damping the turbulence of the liquid during transport. On the upper part of the casing, there are adapters for securing the container to the trailer. All types of these containers have two openings (for filling and discharging).

In France, they also manufacture containers under the name "Hacquard." Their capacity usually does not exceed 3 m^3, and their empty weight varies from 8 to 58 kilograms, depending on the size of the container. The containers can also be of greater capacity -- up to 5 to 10 m^3. They are used as transport containers (Figure 94).

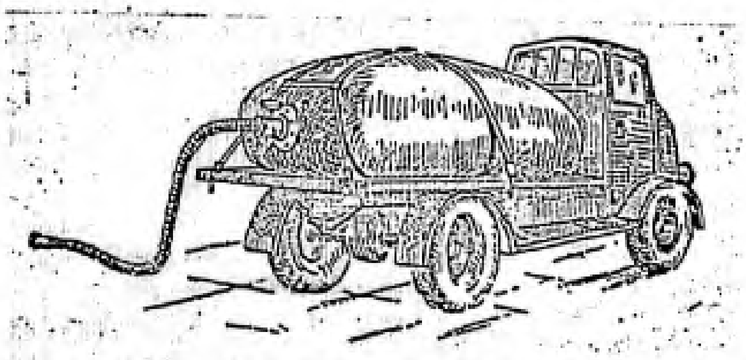

Figure 93. The "RS3" transport container.

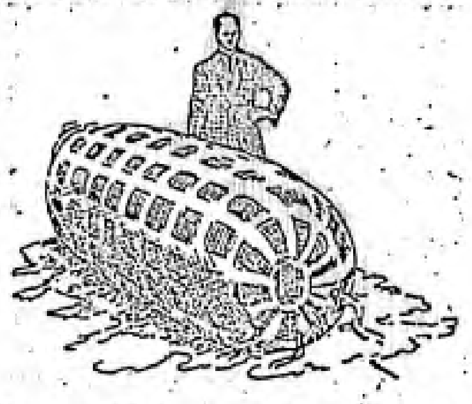

Figure 94. "Hacquard" transport container, of 2.5 m^3 capacity.

The "Van-Tank" (Figure 95) pillow-shaped,soft container for transporting and storing liquid cargoes was created in England. The container casing is made of dense nylon covered with vulcanized rubber. A replaceable liner of polyethylene is inserted inside the container through a hatch. The container is fitted through this same hatch.

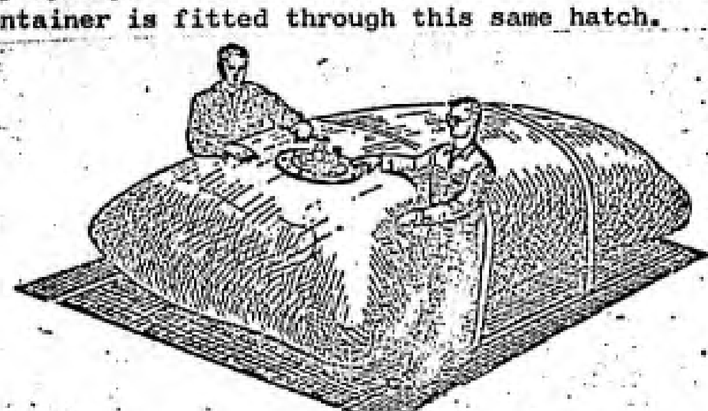

Figure 95. The "Van-Tank" transport container.

In the U.S.A., they make the cylindrical-shaped "Whale" container for storing oils, water and other liquids. The container's capacity is 60 m^3 and its dimensions when filled are: 14 m in length, 3.5 m in width and 1.8 m in height. Judging by these data, the container can also be used as a shipboard one in the river fleet.

During operations, the liquid in the cylindrical, unsupported transport, soft containers develops turbulence, which has a negative effect on the functioning of both the container itself and the means of transport. The "Stabil", from this point of view,(is the design of soft container for automotive transport, proposed in France),is of interest. In this container, rigidity is achieved by inflating the frame with air. The container is made of very strong nylon fabric. It has a semi-cylindrical shape, with inflated arches and longitudinal sleeves laid out inside. An empty 3 m^3 capacity container weighs about 30 kilograms. The container is secured to the flatbed by two longitudinal and two transverse metallic tubes, and special clamps. The rear tube is secured by guy-wires to the rear part of the flatbed, (Figure 96). When fully inflated with air, the frame of this container, as tests have shown, proves to be sufficiently rigid. Similar containers are made in from 2 to 10 m^3 capacities.

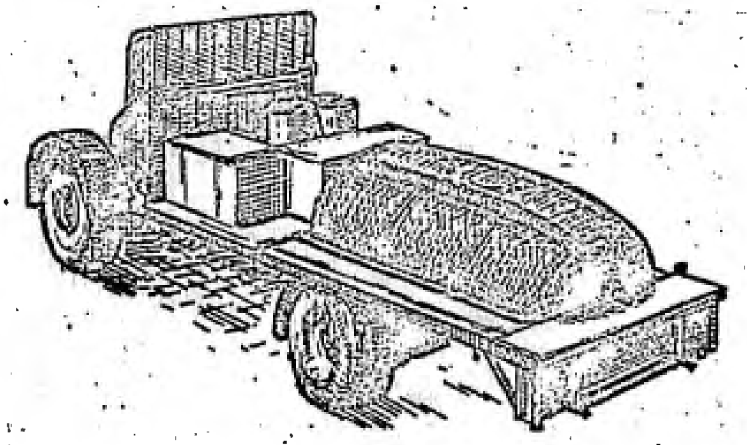

Figure 96. The "Stabil" transport container, of 2 m^3 capacity, with inflated arches.

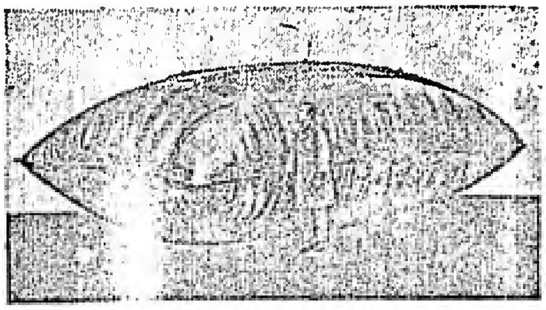

Figure 97. Cylindrical container with pillow-shaped ends, of 25 m^3 capacity, being tested for impermeability.

Shown in Figure 97 is a cylindrical container for storage of liquids ashore, with a 25 m^3 capacity. The authors tested the container in 1964. The distribution of longitudinal and transverse stresses along the casing were determined under conditions ashore.

Pillow type, cylindrical containers, named "Pillow" (Figure 98 and Table 9), are being produced in the U.S.A. for storage of petroleum products. Their capacities are 3.3, 11.4, and 37.8 m^3. It is evident from Table 9 that when filled, the containers do not have much height. Consequently, the degree to which they are designed to be filled is small. This compels one to think that the casing material is also not very strong. These containers can be used for river transport where the strength requirements for the container material are less rigid. Loading and discharging the containers is accomplished through a flexible hose, 102 mm in diameter, attached to the upper part of the casing.

A patent has been taken out in France on a soft container (elastic container) for liquid, viscous, and granular products. The container can be made in 5 to 10 m^3 capacities. In its furled-up state, it occupies about

1/10 of its full volume. The container is made in a tubular shape and consists of three casings (Figure 99). The inner one is made of non-toxic plastic material (for example, of polyethylene--for potable products). The second casing is made strong and impermeable, out of some kind of fabric impregnated or covered with plastic. The third, outer casing,is made similar to the second. Between the second and third casings, there is a network of strong threads (of nylon, for example) with 20-millimeter intervals. The container is provided with a tipped opening to which a hose fitting with a valve and plug are attached for filling and discharging. At the other end of the container, the second and third casings (together with the netting) are joined together by metal bands (Figure 99, b).

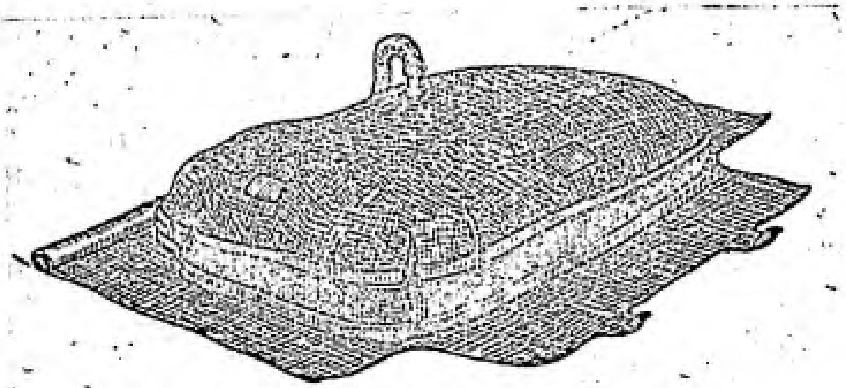

Figure 98. The "Pillow" stationary container.

Table 9

Parameters of the "Pillow" Type Container

Container condition	Capacity, m^3	Length, m	Width, m	Height, m	Weight, kg
Empty	3,3	3,20	2,26	0,07	82
	11,4	5,94	3,20	0,07	113
	37,8	12,93	3,66	0,07	327
Filled	3,3	2,74	1,83	0,61	-
	11,4	5,49	2,74	0,91	
	37,8	12,19	3,05	1,22	

For loading and unloading the container, it is gripped at the lugs by cables (for example, two 18-millimeter 5.5 t test nylon cables). The cables cross at the lower part of the container and are attached to rings on the metal bands. In order that the outer, stronger casing,absorb the stresses, the inner ones are made larger.

Containers of 1.5 m^3 capacity (operating capacity) made by the Krupp company, are used for either stationary storage or for transporting liquid and bulk cargoes (Figure 100). When empty, they take up a very small space and can be stowed in a special nylon briefcase 500 x 600 x 170 mm in size. The briefcase with container weighs 14 to 18 kilograms (Figure 100, a). The container casing is made of polyamide fabric covered on both sides with synthetic rubber. The material weighs 450 g/m^2. The material is stable under the action of mineral oils and sea water. If the container is used for transporting cargoes, then special attachments are fitted for this (Figure 100, b).

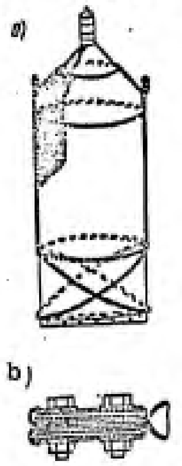

Figure 99. Sketch of the container patented in France: a-overall view; b-securing the ends (tubular).

Soft containers called "Flexitank" are intended for transporting drinking water, liquid products, gasoline, and so on. A 10 m^3 capacity container weighs 90 kg. Internally, it is divided by panels, and has steel cables mounted on it for being transported by crane. A 5 m^3 capacity container is shown in Figure 101.

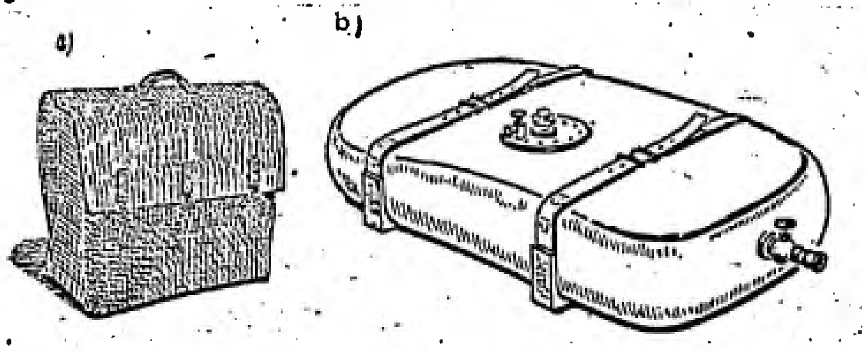

Figure 100. "Krupp" container: a-stowed; b-filled.

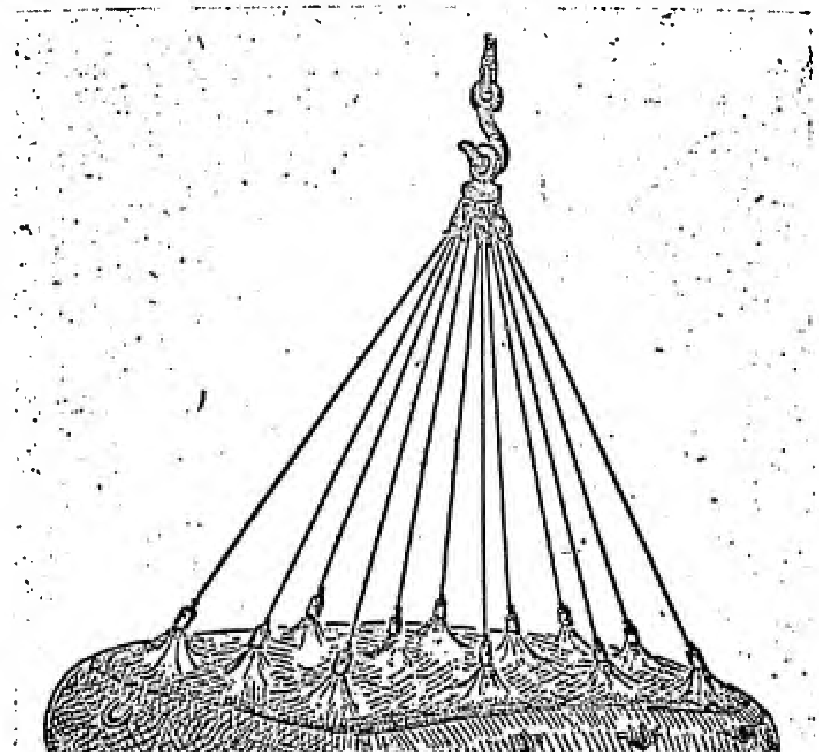

Figure 101. "Flexitank" transport container.

Cylindrical, Barrel-Shaped Containers

Whether of completely soft or of semi-rigid design, they are made with a soft,cylindrical casing and flat, rigid bottoms. These containers, when used in the vertical position at relatively low heights off the floor, have a number of advantages in comparison with flat-lying,cylindrical containers. In particular, they have a larger, useful capacity when filled with a small amount of excess pressure. At the same time, because of strength and stability considerations, the casings of cylindrical, barrel-shaped containers cannot be made with a large, relative height and large, overall dimensions (not more than 10 to 15 m^3). Such containers are used mainly as crates for liquid and bulk cargoes.

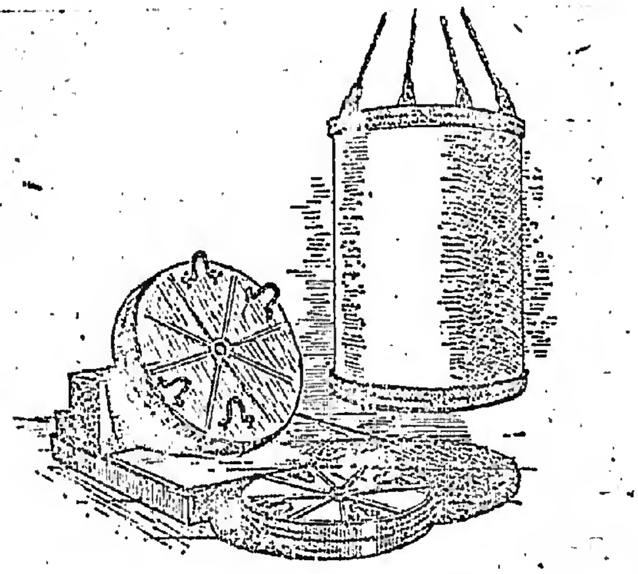

Figure 102. Native-built cylindrical barrel-shaped container of semi-rigid design.

The device for filling and discharging cylindrical barrel-shaped containers is of a design similar to analogous devices on rigid barrels: in the form of openings with threaded plugs, screwed spigots, or bottoms which open. A device for moving the container about by crane or fork-lifts is also provided. Rings or brackets to extend under the forks of the fork-lift are fitted in the bottoms for this purpose. When containers of this design are small and completely filled, they can be rolled like barrels.

Various cylindrical,barrel-shaped containers are now being manufactured and used in various countries. Let us examine several of them.

The semi-rigid folding, cylindrical container,shown in Figure 102 was created in the Scientific-Research Institute of Basic Chemistry. It is intended for transporting bulk and powdery products, including fertilizers, of the chemical industry. The container consists of two mettallic, moulded lids to which the rubber fabric casing is attached. The container's useful capacity is 1.5 m^3, its volume when empty is five times smaller, and it weighs 80 kg. The lid has rings for winding the slings of a crane around.

Another, similar type of container, the "Vario-Drum," intended for transporting liquid and bulk cargoes, is shown in Figure 103. The 1 to 2 mm-thick casing of this container is made of various grades of synthetic rubbers, reinforced with chemical fiber fabrics. It is shaped by means of stitching or winding. The casing undergoes only circular and vertical stresses. A removable lining is placed inside the container. The ends of the container are rigid and are made of polyester strengthened with fiberglass. The ends have loading and unloading hatches, 250 mm in diameter, with locks, a fitting for attaching compressed air, and lugs for lifting by crane. The container is moved about freely with the aid of automatic loaders.

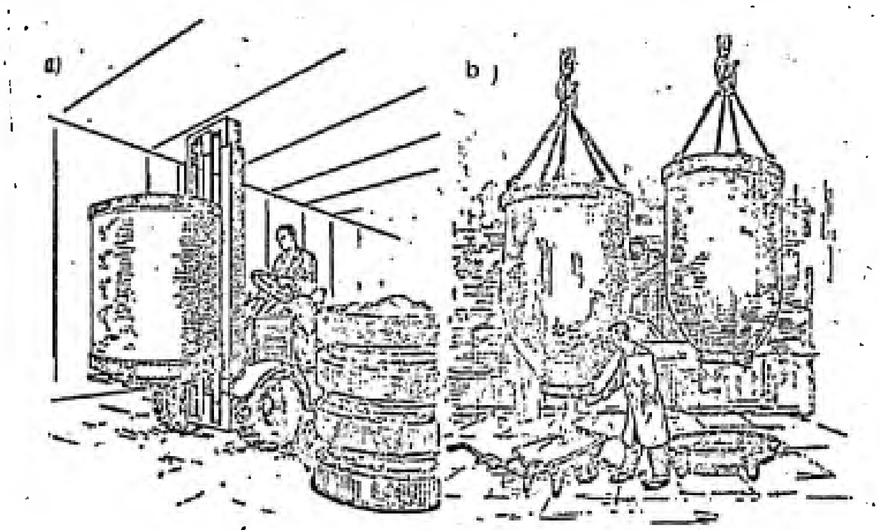

Figure 103. The "Vario-Drum" barrel-shaped container for liquid and bulk materials: a-moving by fork-lift; b-unloading of bulk cargoes.

The containers are put out in two variants. The first is intended for liquid and unsupported cargoes. An excess air pressure (0.1 atm) is created by means of a pneumatic device for unloading these containers. The second variant is intended for transporting hard to unload bulk cargoes, heavy fats, paraffins, etc. The bottom is taken off the containers(Figure 103, b), for unloading such cargoes. When empty, the containers are folded between their upper and lower lids. They are easily stacked and preserved against damage and soiling in this form.

Figure 104. The "Flexi-Drum" cylindrical,barrel-shaped container, 3.65 m^3 in capacity.

The containers' dimensions are such that they can be fitted in two rows in the van of a truck. They are 1.5 or 2 m^3 in volume, and weigh 75 and 80 kilograms.

The Highway Trailer Industries, Inc. (U.S.A.) company produces the "Flexi-Drum" soft containers, which are intended for transporting liquid and bulk cargoes (Figure 104). The container consists of a strong body and a light plastic removable liner. The body is formed of two, rigid molded plastic boxes, reinforced with fiberglass, and laterally-folding "concertina" shells made of the special Hi-Tex fabric, covered with flexible plastic. Filling and discharging the container is accomplished through hose fittings in the lids. The light, removable liners, permit use of the container for various liquids without cleaning or the risk of contaminating the cargo.

The containers are put out in three size-types: type one is 1.02 m in height, 0.99 m^3 in capacity, and weighs 48.1 kg when empty; type two is 1.75 m in height, 1.98 m^3 in capacity, and weighs 51.3 kg when empty; type 3 is 2.49 m in height, 2.97 m^3 in capacity, and weighs 54.4 kg when empty.

When empty, the containers are folded into 0.3 m - high discs with a 1.2 m diameter.

The A/B Packing and Handling Company (Sweden) is manufacturing "Big-Bag" folding, soft containers out of rubber-fabric material or membrane reinforced with fabric of synthetic fibers (Figure 105).

The container's casing material has great shear and tear strength, is chemically stable and does not change its qualities at temperatures from 35 to 120°C. The container is made in cylindrical shape, with its tapered funnel-shaped bottom ending in a hose fitting for discharging cargo. The casing is provided with accompanying circular steel pedestals which serve to safeguard the container, give it stability, and assure that it can be lifted by automatic loaders with forked claws (Figure 105, a). To lift the container without the pedestal, there is a special metallic fitting on top. It also serves for straightening out the container prior to loading (Figure 105, b). After the container is emptied, the casing is folded and stowed in the pedestal. The pedestals with folded casings are stacked, thanks to which an 85% saving in space is obtained when storing them (Figure 105, c).

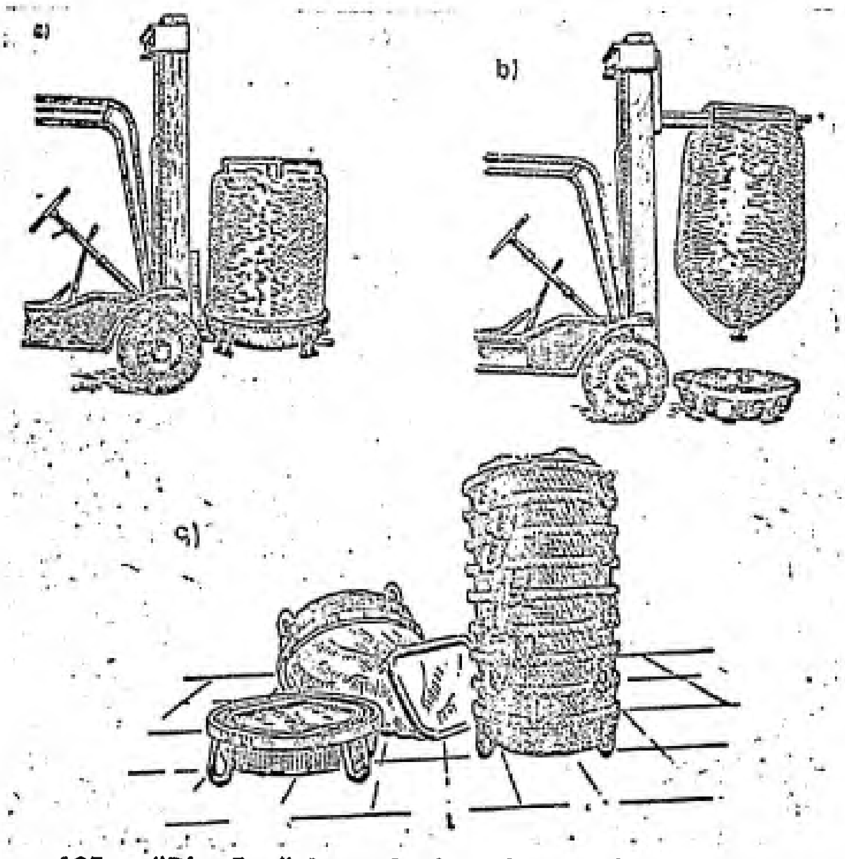

Figure 105. "Big-Bag" barrel-shaped container: a-lifting the container by fork-lift; b-discharging the container; c-stowing empty containers.

The containers are made in two size-types, 1.5 and 2.0 m^3. The containers with pedestals weigh 60 and 70 kg.

In England, the Fireproof Company manufactures 0.2 m^3 capacity, soft containers ,under the name "Hycaflex" which are intended for storing and transporting liquid cargoes (Figure 106). The container casing is made of especially strong rubber-fabric material ,covered with wear-resistant lacquer. A metallic disc with a 75 mm-diameter opening for loading and unloading the container, is attached to the casing. The opening is equipped with a packing ring to which a tightly-fitting lid is screwed on. The containers, intended for storage and transport of potable liquids, is made of a casing with a special covering. The standard container has the following dimensions: 60 cm diameter, 68.5 cm in length, and a casing thickness of 4 or 8 mm. Larger size containers, from 1 to 7 m^3, are made along with the standard one, of the same material. The 1 m^3 capacity container weighs 12 kg when empty.

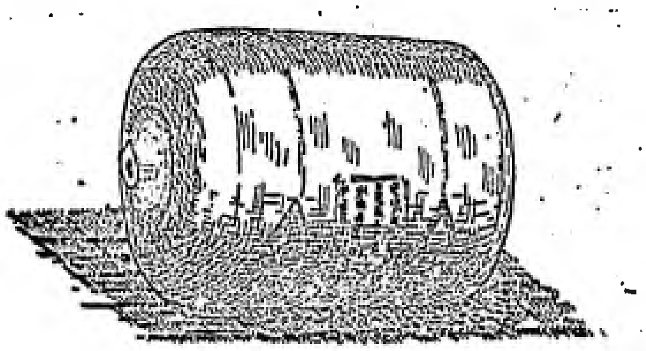

Figure 106. "Hycaflex" barrel-shaped container, 0.2 m^3 capacity.

The design of the "Sealdbin" type,soft containers (Figure 107), was rather well worked out. The containers have a cylindrical,barrel-shaped form. Their dimensions and certain other characteristics are given in Table 10. The containers are intended for transporting liquid and bulk cargoes. The casing is composed of four crisscross layers of fabric glued with synthetic rubber, and is 5 to 6 mm thick. The inner casing is made according to the physical and chemical requirements of the products transported.

A hook is attached to the upper part of the container (Figure 107; a) for conducting cargo handling operations. Inside the container, this hook is attached to the bottom by flexible steel cables. It is recommended that for loading the container without the risk of bursting it, the internal pressure not exceed 70% of the bursting pressure (see Table 10).

Table 10

Parameters of "Sealdbin" Type Containers

a Тип	b Параметры						
	c объем, $м^3$	d вес порожнем, кг	e высота, м	f диаметр, м	g давление при разрушении, атм	h допускаемое давление, атм	i вес, в кг, на 1 $м^3$ объема
1	0,2	17	0,7	0,6	4,2—4,9	2,94	85
2	1,4	59	1,37	1,17	2,6—3,1	1,82	42
3	2,0	82	2,04	1,17	2,1—2,8	1,47	41
4	8,5	225	2,44	2,18	0,8—1,4	0,56	26
5	10,5	260	2,44	2,44	0,8—1,4	0,56	24

a-type; b-parameters; c-capacity, m^3; d-empty weight, kg; e-height, m; f-diameter, m; g-bursting pressure, atm.; h-allowable pressure, atm.; i-weight, in kg per 1 m^3 of capacity.

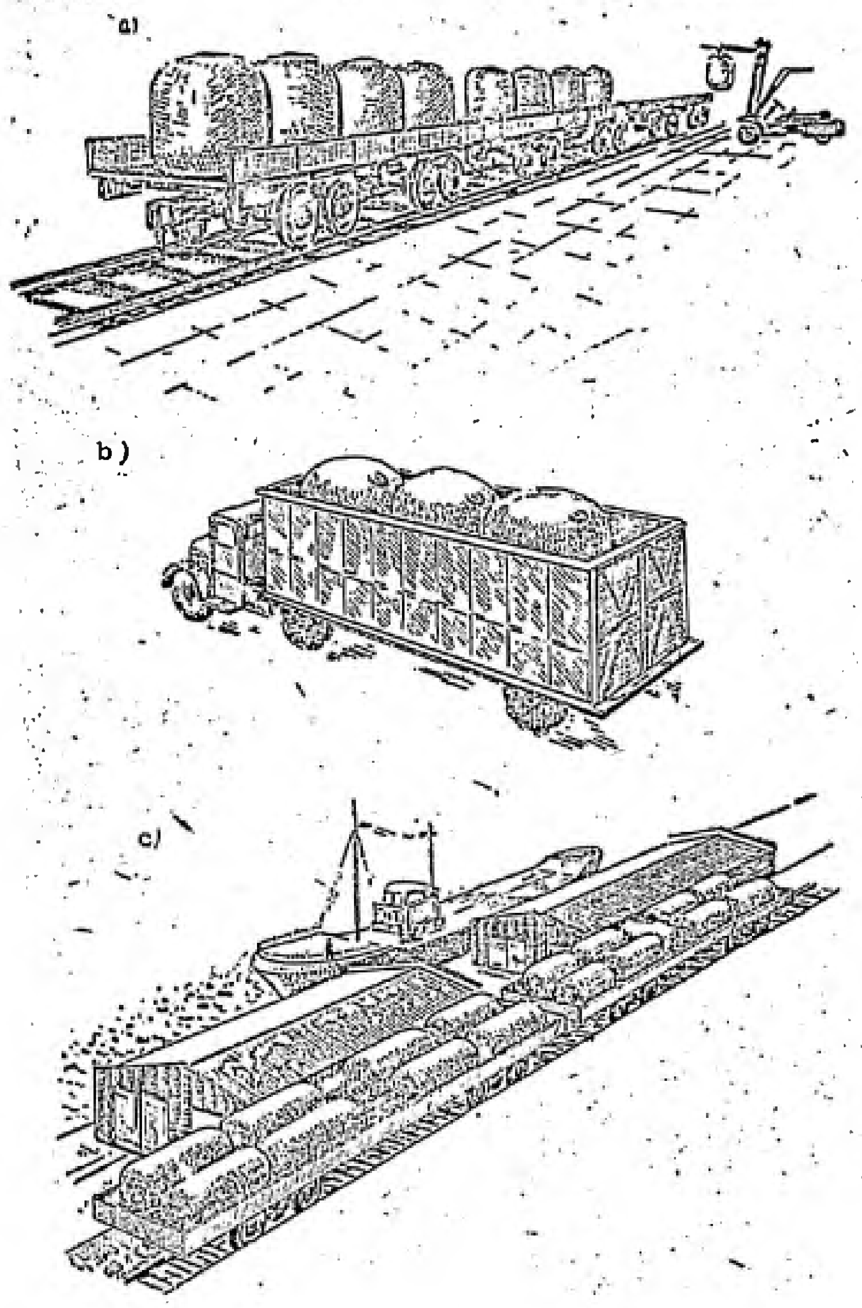

Figure 107. "Sealdbin" barrel-shaped containers: a-loading containers on railroad flatcars; b-8.5 m^3 capacity containers in a truck van; c-containers with sugar, of about 2 m^3 capacity, before loading aboard a ship.

The type one containers have one opening which serves for filling and discharging. The remaining types (two to five), have two openings for filling and discharging, and a one-way air valve. The openings for filling are located in the upper part of the container, and in the center of the bottom, for discharging. The openings are 150 or 203 mm in diameter. They are equipped with rubber packing rings to which hoses of various diameters can be attached.

All coverings are made to be hermetically sealed, and therefore, the container can be filled with compressed air in order to speed up loading operations. It is recommended that the container not be filled to more than 95 to 97% of full capacity, with the remainder filled with compressed air. The container is easily washed with soapy water, blown through with steam, etc. It is dried with hot air.

The "Sealdbin" containers are used for transporting liquid and bulk cargoes on sea, rail and truck transport. They are especially advantageous in cases when it is necessary to transfer cargoes from one type of transport to another. The containers enable such work to be mechanized easily. Figure 107, b, shows 8.5 m^3 capacity containers in the van of a truck, and Figure 107, c, shows 2 m^3 capacity containers with sugar on railroad flatcars. These containers are also used for storing cargoes in warehouses and in the open air.

In the U.S.A., 1.15 m^3 capacity, soft containers (Figure 108) are used for transporting bulk construction materials. They are of cylindrical shape, with a height of about 2.1 m and 1.2 m diameter. When empty, a container weighs 90 kg, and 2.8 tons when filled. The casing is made of 10 mm-thick rubberized nylon and fulfills a thousand-fold uses. The FRG is making 2 m^3 capacity containers for bulk cargoes, with casings of synthetic rubber reinforced with synthetic fabric (Figure 109). They are used on truck, rail and sea transport. An empty container weighs 90 kg.

A special ring, by which the container is lifted by crane or automatic loader (Figure 109, b), is attached to the top part of the container. If there is no crane or automatic loader, then the container is lifted with the aid of a loading board. The containers are secured by cables or chains on the flatbed or in the truck's van.

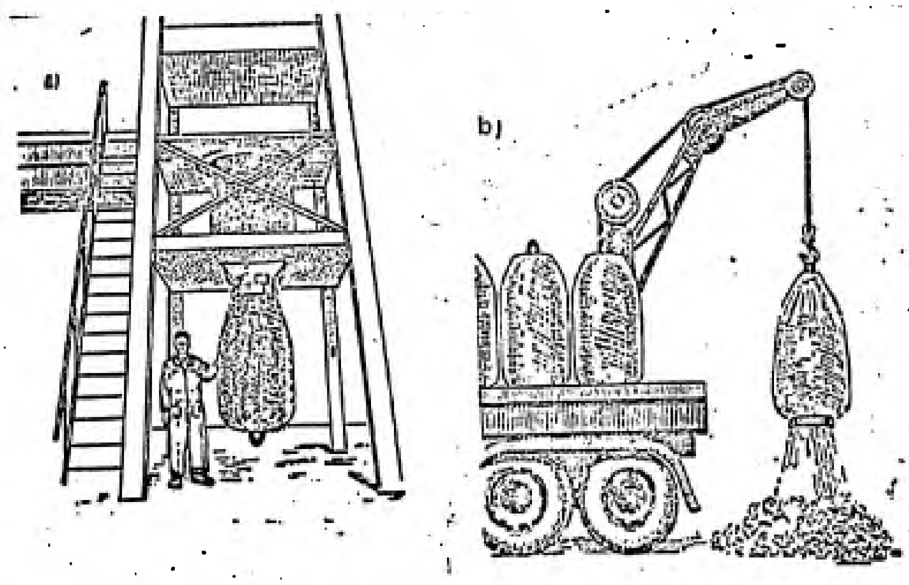

Figure 108. Containers for bulk construction materials, capacity of about 1.15 m^3: a-filling containers; b-discharging containers.

The container can be filled in two ways: with and without excess pressure. In filling without excess pressure, the empty container is raised on a hook in such a manner that its bottom touches the floor (Figure 110,a). Then the filling device and air hose are attached. The air hose is attached to a dust catcher or filter. When filling under pressure (Figure 110, b), an excess pressure of not over 0.03 atm is created inside the container. It is needed to preserve the shape of the container when filling. In order to fill the container to the maximum, it is tilted in a special cradle. A regulating valve is fitted on the air hose in order to maintain constant pressure in the container. After the container is filled, the loading opening is shut and the pressure brought up to 0.2 atm.

The container is unloaded by the action of the 0.2 atm of excess pressure. In addition, special, conical, self-unloaders are used, which with the aid of vibrators,speedup the unloading of bulk cargoes from the containers. Bulk cargoes which have become caked are loosened up by compressed air. Special canals, through which compressed air is delivered, are bored in the inside of the flange of the access opening for this. The valve in the top part of the container must be open.

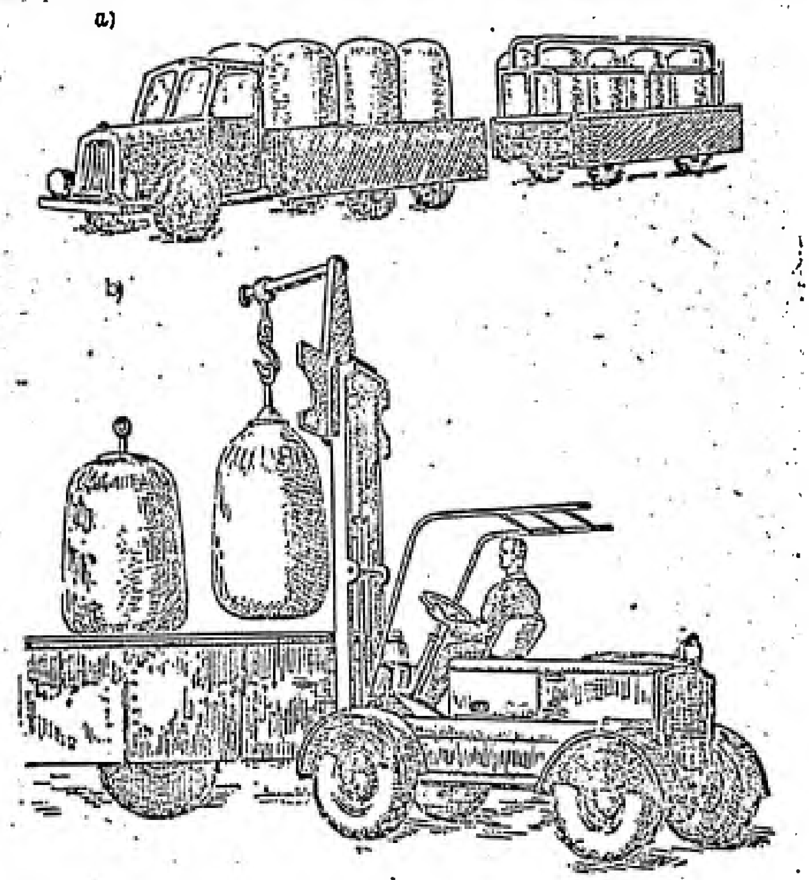

Figure 109. Barrel-shaped transport containers, capacity of about 2 m^3: a-containers on a truck and in a trailer; b-loading containers.

Still one more kind of soft container, the original ones from the point of view of transportation, must be noted. This is the so-called rolling container (Figure 111). These containers were made in the USA on order of the American Army's Transportation Corps. They are shaped like automobile

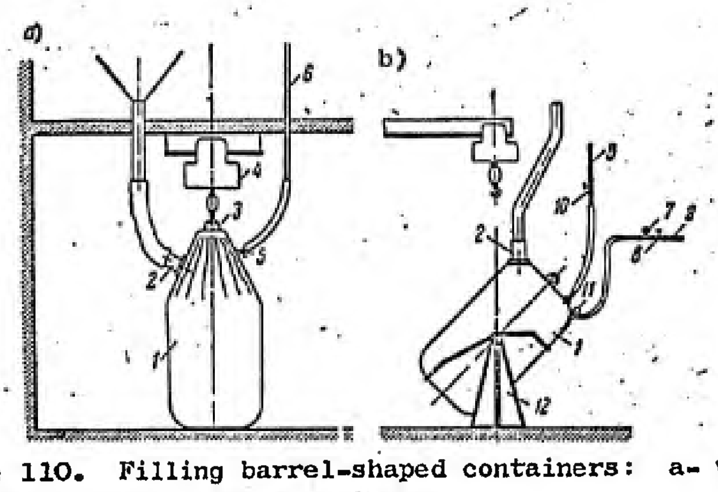

Figure 110. Filling barrel-shaped containers: a- without excess pressure; b-with excess pressure.
1-container; 2-intake hose fitting; 3-ring; 4-cargo lift telpher; 5-air valve; 6-pipe for removing air from the container; 7-pressure control gauge; 8-closed valve; 9-compressed air pipe; 10-air valve for regulating pressure; 11-dismountable pressure control gauge; 12-cradle.

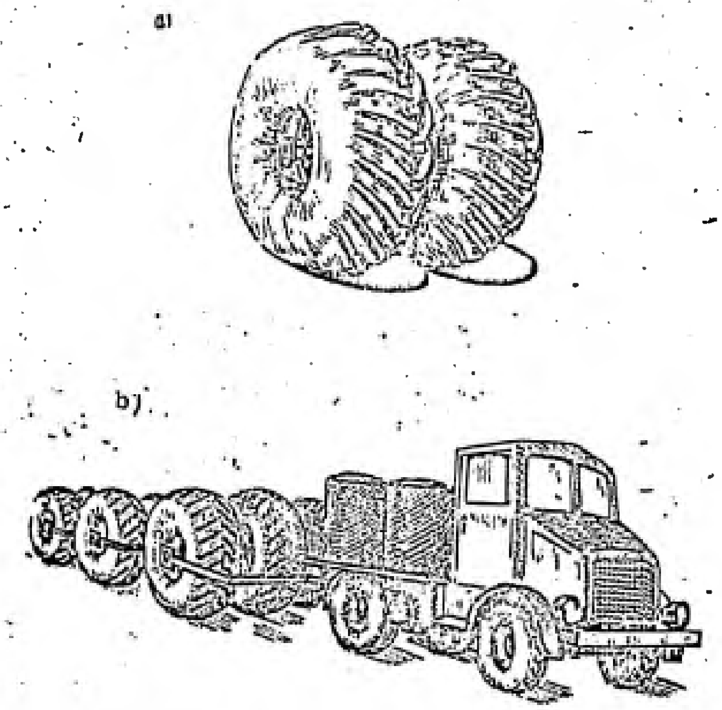

Figure 111. Rolling containers: a-a hitched pair of containers; b-transporting containers.

tires and their external surface is equipped with a thread of diagonal design (Figure 111, a). Each container holds 1.9 m^3 of liquid, had a diameter of 1.52 m and a width of 1.07 m. A hub is mounted inside the container, through which, it is filled and discharged and on which the breaking device is fitted. There are bearings on the hub, and therefore, with a special clamp, the container can be towed by any transport over various terrains with any slope (Figure 111, b), and also for small distances,on water. One man is strong enough to move the containers on an even surface. Filling and discharging is accomplished at a speed of 175 to 300 liters per minute. The containers are usually used in pairs. The container's material withstands transporting at temperatures of from 50 to 45°C.

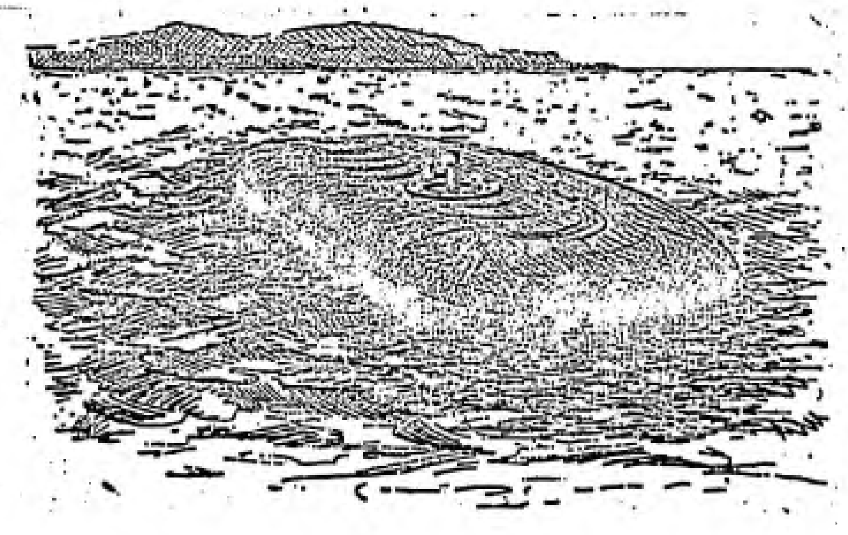

Figure 112. The "Fabritank" all-purpose container, 4.5 m^3 capacity.

Similar containers, obviously, can be used successfully for supplying fuel and water to sites which do not have access roads.

The "Fabritank" 4.5 m^3 capacity, soft containers, made in the USA of rubberized nylon, were used for transporting diesel fuel on the rivers of South America (Figure 112). Loading is accomplished with the container floating in the water. After loading, they were floated down with the river's current and then, at the destination, lifted onto the flatbed of a truck, by a vehicle crane and dispatched to the storage site. Empty containers were returned to the loading point on airplanes.

Folding, Crate-like Containers of Semi-rigid Design

The rectangular shape in (horizontal) cross-section of upright containers, permits better utilization of cargo holds and assures tighter stowage of containers. However, the soft casing cannot, by itself, maintain the flat shape of walls. Crate-like containers are therefore always made of semi-rigid design with bars, frame and other rigid parts making up the rectangular shape.

Folding, crate-like containers are made in the form of containers delivered aboard ship already filled, and in the form of huge containers which are filled directly aboard the ship.

As an example of the second type, one can point to the folding, semi-rigid, shipboard container put out by the English "Marstion Excelsior" Company. The container's frame consists of two square, rigid lids and several bars (Figure 113). The bars are joined to each other and to the lids by hinged elements made in the shape of large loops that fold inside the frame. The loops of the hinged elements have stoppers which limit the opening of the hinges. Lids, bars and hinged elements are made of aluminum alloy. The pintles and parts requiring strength are of light steel. The soft casing, made of four-ply,synthetic rubber (Figure 113, b), is placed inside the frame.

The container has a fitting for pouring and draining liquids which is located on the side of the bottom lid. A hatch for cleaning the container is located in the top lid. The frame is raised when loading. After fully loading, the hinged elements and bars are secured. In discharging, the entire operation is repeated in reverse order.

These containers can be constantly left in a ship's hold. Liquid cargo is transported in them one way, and dry cargo on the lids of the folded containers on the return voyage. True, 25 to 30% of the hold capacity, which is occupied by the empty containers, is not utilized on the return voyage. Protection of the soft container in transporting dry cargo is assured by the fact that the top lid presses on the bottom one, via the bars. The design of the container described here is calculated for tossing of up to 20° at a minimal interval of 8 seconds. The company puts out containers of 3.8, 13.1 and 19 m^3 capacity.

Certain of the company's publicity releases concerning the use of these containers evoke doubt. In particular, it is not clear how filling and discharging of a group of containers installed tightly, one against the other to the pipes of the hold, can be conducted if the fittings are located in the lower lid, access to which is impossible under such conditions.

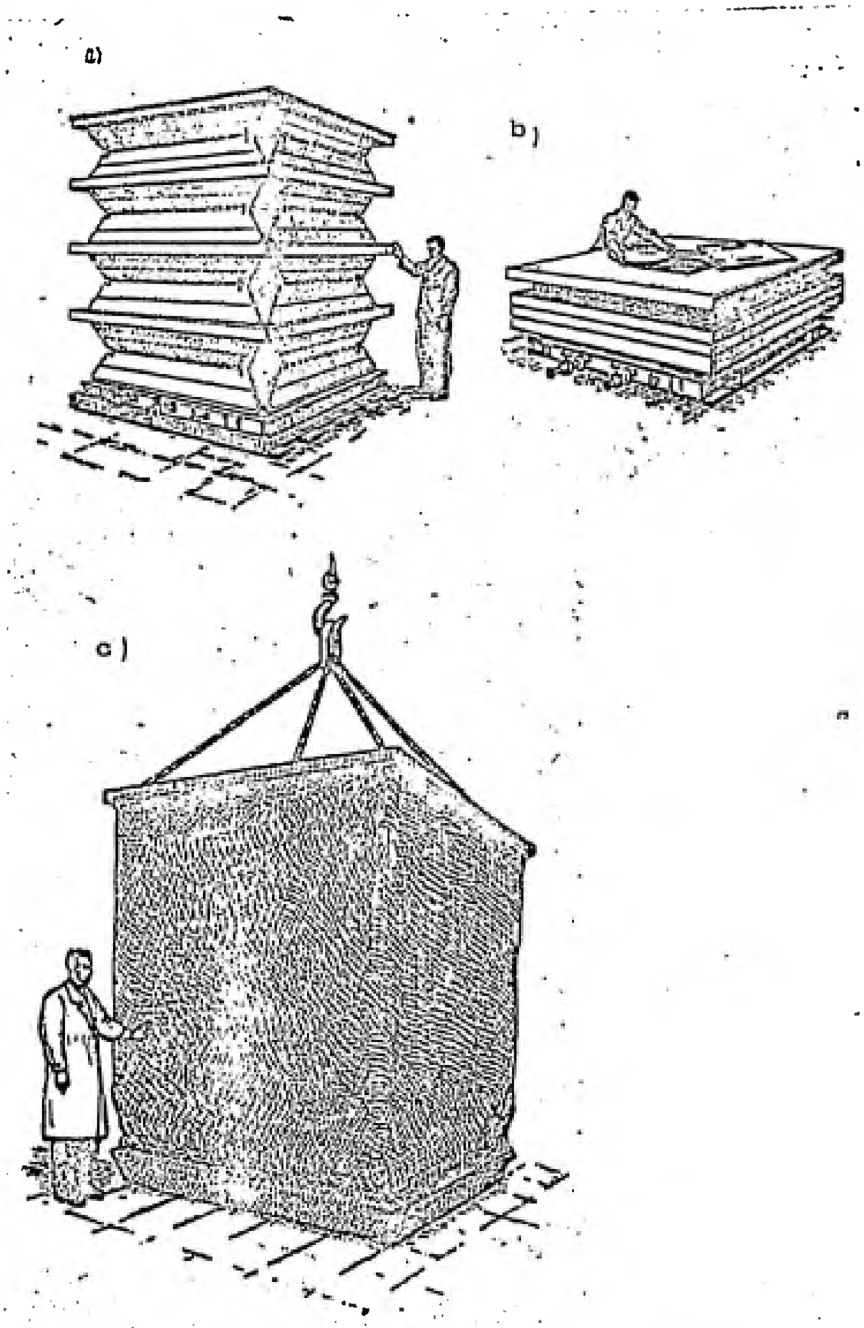

Figure 113. Folding, semi-rigid, shipboard container: a-filled container; b-empty container; c-inner lining.

Section 21. Operating Unsupported Shipboard Soft Containers.

There is very little data on operating unsupported shipboard containers. Various problems, such as filling and discharging the containers and securing them to the ship, have been examined above. Let us turn here, to the requirements for controlling the manner of operating containers of this type.

Strict adherence to the recommended, initial excess pressure, is even more important for horizontally placed cylindrical containers than for enclosed containers. If the degree to which the container is filled is insufficient, during tossing of the ship, it can burst or be torn from its lashings by the turbulence of the liquid. Excess pressure must be checked both directly after filling and after grooving the lashings around the container. It can be most accurately and simply measured with a portable, mechanical,pressure gauge.

When the container is elongated enough, the excess pressure is measured indirectly, for example,by the ratio of the container's height to its width N/V. The chart shown in Figure 69 can be used for this. It must be remembered, however, that this chart is sufficiently accurate only at relatively large,excess pressures.

Let us now dwell on the results of operational testing of several, free-lying, shipboard containers.

The "Portolite" cylindrical container, described above, was used for transporting liquid cargo on the deck of a ship in 1960. Loading and unloading containers were conducted on a special platform (see, Figure 84), which had been laid out on the cover of the forward hatch. Despite the fact that the ship underwent heavy rolling and pitching during the cruise, the container successfully came through the tests.

Two containers with drawn-up ends, whose design has been introduced previously, were tested in 1960 to 1961,during a magnetic survey of the Pacific Ocean on the schooner, Zarya. They were filled by means of a regular fire hose, creating an excess pressure of 36.5 cm of a column of water. At this pressure, the transverse stretching forces in the container were equal to 1.1 kg/cm, the greatest width 50.2 cm, the height 37.5 cm, and cross-sectional area 1550 cm^2. Measurements of these parameters on the containers, coincided well with those calculated by means of the chart (see Figure 69). Taking into account, the casing's stretching by the straps and trim during tossing, the calculated pressure obtained in testing its strength was equal to 70 cm, and the liquid's calculated specific weight (taking into consideration, inertia from tossing) 1.5 g/cm^3. The calculated forces amounted to 2.8 kg/cm, which provided the casing's tarpaulin with a five-fold reserve of strength.

The degree to which the container needs to be tightened by the straps, which amounted to reduction of the container's diameter by approximately 1/4, was made clear by the tests. Discharging the container was accomplished via the stern hose fitting, in which the end of a hose was inserted. For more rapid drainage, the opposite end of the container was raised a bit as it was being discharged.

The containers were operated during several months of sailing in southern latitudes, where the schooner frequently met stormy conditions.

The experience in operating soft, on-deck containers, confirmed their expediency for use as reserve tanks for fresh water and fuel on small ships which find themselves cut off from shore for prolonged periods of time. The containers proved sufficiently suitable in operation, in the opinion of the crew. Filling and discharging them,presented no difficulties. The containers were easily secured to the deck, did not take up much valuable space, and after discharging and drying,were folded up and stowed in available holds on the ship.

For the sizes of containers tested, the casing strength, corresponding to the strength of tarpaulin, proved to be entirely sufficient. It was established, however, that the material must have still higher resistance to abrasion and rot. Experience also showed that it is better to make the casing single-ply because this simplifies operation, and that lashings must not be rigidly joined to the container because they gradually get torn away during tossing of the ship. Intake hose fitting covers must be more reliable, but simpler.

Data on the operation of other designs of unsupported containers is still not available. However, the experience of truck and railroad transporting of barrel-shaped containers,permits one to expect that their use on river and sea transport will fully prove itself and present no great difficulties.

CHAPTER VI

ECONOMIC EFFICIENCY OF THE USE OF SHIPBOARD SOFT CONTAINERS

p. 249-265 The experience accumulated in recent years, the data from actual and laboratory tests, and the results of theoretical research,confirm the technical feasibility of transporting cargoes in shipboard,soft containers. The share such transport occupies in the overall volume of transport is still small. To a certain extent,this is explained by the fact that the economic problems of the use of shipboard,soft containers have still not been satisfactorily solved. The opinions of specialists regarding the economic efficiency of shipboard,soft containers are proving to be rather contradictory.

The purpose of this chapter is to make an initial approximation of the expediency and economic efficiency of using soft containers for assuming several of the tasks of the transport and merchant fleet. A portion of the data introduced (concerning refrigerator and all-purpose ships),is based on the results of specially conducted economic investigations. The remaining data is presented in order to estimate the anticipated effect, and therefore the relationships obtained from these, in particular, should be viewed as approximations.

A large portion of the numerical data is taken from the actual operations of the Far East transport and merchant fleet.

Section 26. Economic Efficiency of Delivering Fresh Water in Soft Containers Aboard Refrigerator Ships.

The development of fishing by fleets in remote areas of the Pacific and Atlantic Oceans,evokes rather complex problems of supplying the catching and factory ships with fuel and fresh water. As many as one hundred fifty to two hundred ships of various types are assembled in some expeditions, whose annual requirement for such cargoes amounts to 200 to 250 thousand tons.

Supplying the expeditions with fuel and water is accomplished mainly by the tanker fleet. The tankers, having delivered water or fuel to the fishing grounds and supplied the expedition's ships, return to their bases in ballast because,as a rule,there are no facilities suitable for taking cargo back in the holds of a tanker on the return voyage. Ballast runs by tankers sharply increase the cost of transportation. For example, the calculated cost of transporting a ton of water by a 1200-ton capacity tanker from Russkaya Bay (in Kamchatka) to the area of the Bering Sea expedition, amounts to 16.4 rubles, on which 6.5 rubles, or about 40%, is the portion taken up by the ballast run. The costs are shown in Figure 126,a.

The low norms for delivery of water (water delivery by an 8500-ton cargo capacity tanker, takes about 14 days) do not permit use of tankers of large capacity on these routes. At the existing large transport distances (1500 to 3000 miles),low-tonnage ships would be more economical. Tankers of from 400 to 1500-ton capacity are principally being used for supplying the expeditions with water, with the number of tankers on hand insufficient for assuring the expeditions a supply of water. Because of this, there is a constant shortage of fresh water not only for technological purposes, but also for the needs of everyday life in the fishing grounds. True, the requirements for water for te-.nological purposes are partially filled by equipping the refrigerator sh.ps with modern distilling devices. However, the number of these available in the fishing fleet is obviously still insufficient. Protracted use of distilled water for drinking is undesirable.

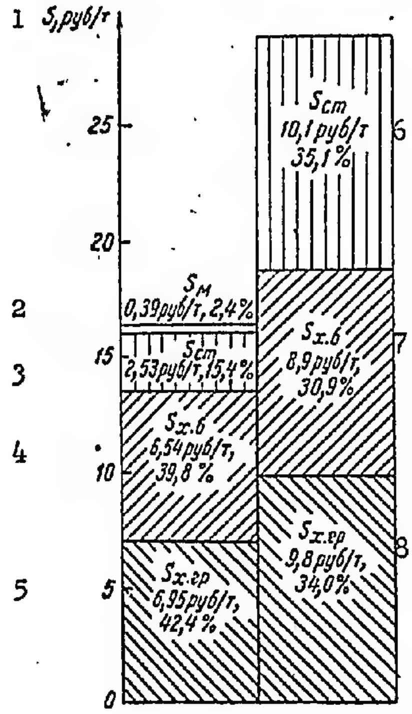

Figure 126. Breakdown of costs of transporting a ton of water by a 1200-ton capacity tanker (left, a) and transporting a ton of fish products by a Svetlogorsk class refrigerator ship (right, b).
1-S, rubles/ton; 2-$S_{Install}$ rubles/ton; 3-S_{anchor} rubles/ton; 4-S_x ballast rubles/ton; 5-S_x Cargo, rubles/ton; 6-S_{anchor}, rubles/ton; 7-S_x ballast, rubles/ton; 8-S_x Cargo, rubles/ton.

In these conditions, the use of refrigerated transports operating with the fishing industry, for delivery of fresh water, represents a huge reserve for assuring a water supply to the expeditions. As a rule, refrigerated transports go to the expedition's fishing areas in ballast or lightly loaded, so that for essentially half of their underway time, they do not perform useful work. Ballast runs of refrigerated ships, sharply increase the cost of transporting fish products, amounting to more than 30% of this cost (Figure 126, b). The loss from ballast runs by ships of the VostokRybKholodFlot [Eastern Fisheries Refrigerated Fleet], exceeds one million rubles per year.

Enclosed, soft containers of the stressed or cling class, can be used for transport of fresh water on refrigerated transports. The most numerous refrigerated transports, of the Kurgan, Svetlogorsk and Indigirka classes, can take about 250 to 370 tons of water in each of their cargo spaces. Based on considerations of stability, draft and overall strength, it is possible to take on water in two or three of the holds and one or two of the 'tween decks, which amounts to about 1000 to 1200 tons of water per ship. Thus, with the availability of enough units of the refrigerated transport fleet needed for supplying the expedition's ships, the entire volume of water transport can be fully assured. The refrigerated transport fleet of VostokRybKholodFlot is large enough, for example, that 80% of the requirement for supplying the expeditions' water needs can be satisfied.

The effectiveness of the use of enclosed, soft containers for fresh water delivery by refrigerated transports, depends essentially upon the remoteness of supply bases, the numbers and concentration of factory ships in one area or another, and a number of other local factors which must be taken into account by the method used for calculating economic efficiency. As an illustration, let us introduce some data to calculate economic efficiency in the case of the Bering Sea expedition, one of the largest in the Union.

The expedition's main base is the port of Vladivostok (a distance of about 2500 miles away), with an intermediate base for supplying water at Russkaya Bay, on Kamchatka (1150 miles). Let us compare the cost of delivering one ton of water by refrigerated transport and by tanker, for determining economic efficiency. Since the refrigerated transport delivers water incidentally, i.e., on a voyage which the ship would make apart from this expedition, then only those additional expenses incurred for this particular operation, should be considered in the cost of transporting water.

If we designate

Q - the amount of water, in tons, transported aboard the ship during the voyage;

r_e and r_o - allowance for depreciation, per day of operation, from the cost of the container and related equipment in the ship's cargo holds;

t_p - time for a complete (round-trip) voyage, in days;

R - expenditures per ship for additional time underway and in demurrage, connected with the transport and transfer of water,

then, the cost of delivering one ton of water can be calculated by the formula

$$S = \frac{(r_e + r_o)\ t_p + R}{Q} \quad \text{rubles/ton} \qquad (101)$$

With a cost of one soft container C_e, number of containers aboard ship n, cost of related equipment C_o, remaining container and equipment cost O_e, and service life of containers and equipment, (let us assume for the sake of simplicity, that they are identical) t_e, then the sum of the depreciation allowance per day of operation is equal to

$$r_e + r_o = \frac{nC_e + C_o - O_e}{t_e}. \qquad (102)$$

Expenditures on maintaining the ship during additional demurrage and underway time

$$R = C_{CT}t_{CT} + C_x t_x, \qquad (103)$$

where, C_{CT} and C_x - the daily cost of operating the ship at anchor and underway;

t_{CT} and t_x - additional demurrage and underway time.

To obtain the cost of delivering fresh water in stressed class, enclosed soft containers, let us do the calculations pertaining to Kurgan class refrigerated transport, of net cargo capacity D_r = 4,800 tons, which ply the route of the Vladivostok-Bering Sea expedition. Let us do the calculation for the cases where water is taken on in Vladivostok or Russkaya Bay (with a special stop).

Calculations have shown that the Kurgan class, refrigerated transport can take 1,185 tons of fresh water in 66 stressed class enclosed, soft containers of about 18 m^3 average capacity in holds number two and three, and 'tween decks Number two and three. Let us take as a guide, the cost of a container per ton of capacity, as being within 38 to 44 rubles, which will give us an overall cost of about 48,000 rubles for all of the containers. The cost of the removable bulkheads was obtained by actual calculations as roughly within 40 to 50 rubles per linear meter. On the whole, the cost per ship of the equipment, in the cargo spaces used for holding soft containers is equal to approximately 6,500 rubles. The overall cost of containers and equipment thus, amounts to 54,500 rubles.

From the foregoing, it is easy to conclude that there is no sense in economizing on the design of removable bulkheads and securing devices to the detriment of their operational qualities (their cost amounts to only 7 to 14% of the total).

If the remaining cost is taken as equal to 2% of the basic cost, and the service life of the container and equipment, in the absence of more reliable data, taken as equal to two years, then in accordance with formula (102), the depreciation allowance per day of operation amounts to 73.2 rubles.

A complete voyage takes 35 days in the given conditions.

The daily expenditures for maintaining a ship at anchor, we take as 2,600 rubles and 3,900 rubles underway.

Demurrage is determined by the need for taking on and discharging water, for assembling and dismantling equipment, for time to connect and disconnect hoses, and for preparing cargo holds to take on fish (cooling the holds down to the required temperature). There is additional underway time connected with calling at the base where water is taken aboard, if this is not taken care of at the main base.

A series of operations connected with water delivery can be combined with other work performed by the ship in its main mission. This can be determined by multiplying the theoretical time of the operation by a coefficient of incompatibility K. This indicates which part of the time of a given operation is accomplished without being combined with other work.

Table 11 gives a sample calculation of the demurrage and underway time of a Kurgan class, refrigerated transport in delivering water to the Bering Sea expedition. The following circumstances were considered in compiling the table.

It was assumed that in the event of taking on water at Vladivostok, the time for installing equipment and filling containers partially overlapped operations for unloading the ship (for example, while the hold was being unloaded, bulkheads were fitted in the just-vacated 'tween deck and containers were laid out along the sides). Similarly, in the cases where water was taken on at Russkaya Bay, it was considered that the operation could be conducted in the manner followed in Vladivostok.

In the fishing area, water can be rationally delivered to the tanks of refrigerated factory ships while fish products are being taken from them, since this will permit combining a considerable part of the operation.

As seen from the table, a ship spends an additional,estimated 44.4 hours, or 1.85 days, when water is taken on at Vladivostok, and all of this,is time at anchor. When water is taken on at Russkaya Bay, an additional 50.0 hours, or 2.08 days, is spent, of which 41.5 hours (1.73 days) is demurrage and 8.5 hours (0.35 days) is underway time.

Substituting all these values in formulas (101) to (103), gives the following values for the cost of transporting one ton of water: 6.2 rubber /ton when water is taken on at Vladivostok, and 7.1 rubles/ton when water is taken on at Russkaya Bay.

The actual cost of transporting one ton of water from Russkaya Bay to the area of the Bering Sea expedition,by tankers of from 650 to 8,500-ton cargo capacity amounted to 18.3 rubles in 1963. Thus, with the use of enclosed, soft containers, the cost of transporting water is reduced by 11.2 rubles, or 61.3%.

Additional losses of a refrigerated transport's operational time in transporting fresh water arise as a result of certain losses of carrying capability, which can play an essential role with refrigerated transports of insufficient tonnage. For calculating loss of carrying capability, let us take a coefficient of underway time $k_x = 0.50$, a coefficient of cargo capacity utilization $k_{rp} = 0.4$, ship's speed per day , $v = 300$ miles. The productivity per ton of ship cargo capacity per day of operation in this case is

$$\rho = k_x k_{rg} v = 0.5 \times 0.4 \times 300 = 60 \text{ ton-mile/ton-day},$$

and loss of carrying capability in ton-miles will amount to

$$\rho D_{ch} \Delta t = 60. \times 4800 \times 2.1 = 604{,}800 \text{ ton-miles.}$$

Let us take the distance of transporting a ton of fish as $l_{\pi} = 2{,}500$ miles. In that case, a Kurgan class refrigerated transport, taking on water at Russkaya Bay, and delivering it to the refrigerated,factory ships in the expedition's fishing area, will have on each voyage,a "loss of carrying capability" of

$$\Delta G = \frac{\rho D_{ch} \Delta t}{l_{\pi}} = \frac{604{,}800}{2{,}500} = 240 \text{ tons.}$$

Thus, a decision on the expediency of transporting water by refrigerated transports must take consideration of all the circumstances and pursue statewide, and not narrow, departmental, interests. Thus, losses of carrying capability for fish products by refrigerated,transports are tied in with losses of a certain portion of income by the organizations which own the refrigerated fleet. However, these losses may be fully offset by additional income from delivering water, perhaps even with a profit. Use of refrigerated transports for transporting water will permit, moreover, freeing a significant part of the tanker fleet for other operations. Computations indicate that fitting soft containers on three basic types of refrigerated ships will permit freeing a tanker fleet of about 15 thousand tons cargo capacity from the Bering Sea expedition. The savings in this way, over only a half year period,amount to 3 to 4 million rubles, which considerably exceeds all possible losses connected with delivering water by refrigerated ships.

Table 11

Increase of the Duration of a Kurgan Class,Refrigerated Transport's Voyage in Delivering Water in Soft Containers to the Bering Sea Expedition Area

Operation	a Время на операцию без совмещения, час.	b Коэффициент несовмещенности	c Время на операцию с учетом совмещения, час.
Taking On Water at Vladivostok			
Hose fitting	1,0	1,00	1,0
Mounting equipment	17,7	0,25	4,4
Filling containers (40 tons/hour)	29,6	0,50	14,8
Total	48,3		20,2
Taking on Water at Russkaya Bay			
Calling at and exiting from the bay	6,0	1,00	6,0
Maneuvering, mooring operations	2,5	1,00	2,5
Hose fitting	2,5	1,00	2,5
Filling containers (80 tons/hour)	14,8	1,00	14,8
Total	25,8		25,8
Delivering Water at the Bering Sea Expedition Area			
Hose fitting	6,0	0,20	1,2
Discharging (70 tons/hour, 2 pumps)	16,9	0,30	5,7
Dismounting equipment	17,7	0,30	5,3
Cooling the holds	12,0	1,00	12,0
Total	52,6		24,2
Total for taking on water at Vladivostok	100,9		44,4
Total for taking on water at Russkaya Bay	78,4		50,0

a-time for the operation without combining work, hrs; b-coefficient of incompatibility; c-time for the operation, with combining work considered, hrs.

It is thus possible to conclude that use of the refrigerated fleet for supplying water to fishing and factory ships of the expedition, has a number of economic advantages:

a) it assures the expedition's requirements for a fresh water supply;
b) it eliminates ballast runs by refrigerated ships, assuring more effective use of their tonnage;
c) it frees considerable tanker fleet tonnage from transporting water, which enables fuller satisfaction of the national economy's requirements for transporting other liquid cargoes;

d) it reduces the cost of transporting fish products;

e) if water delivery by refrigerated ships in soft containers is organized for an extended period, then, there is the possibility of changing the entire makup of orders for a new fleet. By decreasing the share of orders for the tanker fleet, the share of orders for refrigerated ships, it is possible to provide in advance, for equipping them with adaptations for installing removable bulkheads, simplifying their design and facilitate their use.

Section 27. Economic Efficiency of All-Purpose Ships Equipped with Soft Containers for Transporting Liquid Cargoes.

The design characteristics of tankers make it difficult to load them in more than one way, and as a result, they have a high percentage of ballast runs. So, according to the Ministry of the River Fleet, about 40% of the underway time of tankers, is spent empty (see [57]). These figures are growing to 50 to 60% in certain basins.

On lines where petroleum products and dry cargoes are not carried on the same trip, and in basins where delivery of petroleum is seasonal, it is proving to be more economical to use, in place of tankers, all-purpose ships equipped with soft containers for taking on liquid cargoes on one trip and dry cargoes on the return trip (see Sections 14, 17). Research conducted for the River Fleet by the TsNIIEVT [Central Scientific Research Institute of Economics and Exploitation of Water Transportation], has shown that there are many internal lines of this kind in the Soviet Union. For example, such lines as the following, might be promising for all-purpose ships:

	Initial trip	Return trip
Kandalaksha-Cherepovets	Iron ore	Oil cargoes
Kuyibyshev-Verkhnaya Kama	Oil cargoes	Superphosphate, Potassium salt
Kuyibyshev-Kandalaksha	Oil cargoes	Apatite concentrate

In connection with the opening of new oil deposits, many other lines are also appearing, for which the use of all-purpose ships is promising.

On several lines, the delivery of petroleum products is accomplished only during certain navigation seasons, and other cargoes are carried on these lines on the return trip.

Comparative calculations by TsNIIEVT have shown that on internal lines, 1700 kilometers long, the cost of transport and capital investment for an all-purpose ship, bulk cargo ship, and a tanker of about 600 tons cargo capacity, amount to the following figures

Ship	Cost of transport, kopek/ton-kilometer	Capital investment, kopek/ton-kilometer
All-purpose	0.19	0.88
Tanker	0.29	0.40
Bulk cargo	0.34	1.42

Similar data was obtained for ships of 1,000-ton and 3,000-ton cargo capacity (see [88]).

As can be seen, the cost of transporting petroleum products is 35 to 40% lower by all-purpose ships than by tankers. In comparison with a 600-ton cargo capacity tanker, an all-purpose motorship of the same cargo capacity, with an increase in cost of construction of approximately 10%, ensures a decrease in transport cost per ton-kilometer, for example, by 40% on a line 1200 kilometers long and by 24% on a 400-kilometer line, as well as a reduction of capital investment in the fleet by 28% and 12% respectively, on these same lines.

Design and construction of all-purpose, self-propelled and nonself-propelled ships are economically expedient and technically possible on all lines where the transporting does not require heating of liquid cargoes on one trip, and where these ships can be even partially loaded with different cargoes on the return trip. The requirements of the fleet can thus be reduced by more than 20%. Its construction requires 20% less steel than a tanker.

Section 28. Economic Efficiency of the Use of Soft Containers for Delivering Packaged Liquid Cargoes.

On the shores of the seas and oceans which surround the Soviet Union, there are a large number of points which are supplied exclusively by maritime transport. This is particularly characteristic of the Far East and Northern basins. The complex, widely-dispersed network of lumber and fishing,combines mountain mining enterprises and meteorological stations,creates a flow of a considerable amount, although in small lots, of a wide variety of cargoes. The transport of lumber, coal, packaged food and industrial goods predominate on these routes.

A large portion of these points are located in areas with shallow depths, which prevent supply ships from approaching the shore. Because of this, cargo operations are conducted, as a rule, in the roadstead. A number of points, including some very large ones, are located at river mouths. The approach to these points by ocean ships, because of the shallow depths, is possible only if they are greatly lightened. For example, the Kolyma River is so shallow that an Andizhan class ship can navigate it only with a loading coefficient of 0.4 to 0.5

Handling cargo in a roadstead is distinguished by great complexity and takes up much time. The diagram in Figure 127, showing the breakdown of operational time of an Andizhan class ship in transporting cargoes from Vladivostok to parts on Kamchatka, can serve as an illustration of this.

It is clear from the diagram that almost 50% of the operational time, or more than 70% of in port time, goes to demurrage in awaiting lighters and for meteorological reasons.

A particularly large amount of time is taken up by unloading packaged petroleum products. Fuel-lubricant materials are delivered by bulk cargo ships in welded metal barrels of up to 400 kilograms gross weight. The rules for transporting these cargoes by sea demand that loading and unloading work be carried out only in the daytime with strict observance of fire safety regulations. The barrels are offloaded by shipboard means onto barges and lighters, which are then towed to shore. Even in mild turbulence, shipping becomes dangerous and is limited.

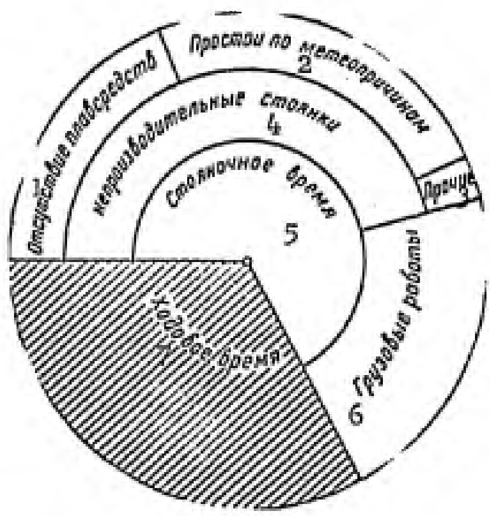

Figure 127. Breakdown of operational time for an Andizhan class ship in transporting cargoes from Vladivostok to the ports on Kamchatka.
1-lack of lighters; 2-demurrage for weather reasons; 3-standby; 4-unproductive time in port; 5-in port time; 6-cargo work; 7-underway time.

In this connection, it is useful to examine the problem of transporting petroleum products in soft containers. Cylindrical barrel-shaped, soft containers with rigid or soft bottoms, of the type shown in Figures 102 and 107, are best suited for this purpose. Such soft containers can be placed in the hold of a bulk cargo ship just like metal barrels. At the same time, they have a number of advantages over the latter. Soft containers with petroleum products in particular, having positive buoyancy, can be offloaded directly onto the surface of the water and later be towed to shore in small groups.

This kind of offloading technique promises a number of benefits. First, lowering containers onto the water can be accomplished even in unfavorable weather, thereby reducing demurrage for meteorological reasons. Second, the ship can be offloaded without depending upon the arrival of floating gear from shore. A group of soft containers secured by a cable can, until a tug arrives, be anchored near the ship. A ship's demurrage in awaiting barges and lighters is sharply reduced in this way. Finally, if the port is located at a river mouth, soft containers can be offloaded at a bar. Such partial offloading will permit the ship to enter the river and have the remaining cargo offloaded at the pier. This, in turn, permits a ship heading for similar ports to load up to the limit before departing on its run, i.e., to greatly increase its coefficient of loading.

The return delivery becomes cheaper because of the small volume of the empty containers. True, even with the use of soft containers, the problems of spoilage must be solved. One of the possible ways to solve this task is to transport empty containers in a tightly shut hold,filled with carbonic acid or other gas. Soft containers are not prone to giving off sparks and are safer than metal ones in regards to fire prevention. Let us examine some guideline figures, computed for several typical examples, on the possible economic efficiency of replacing rigid packaging with soft containers.

<u>Delivery of packaged petroleum products to shore points, where ships are offloaded in the roadstead.</u> From the point of view of the fleet's operation, the economic effect from the use of soft container packing is determined by the amount by which in port operations are reduced. The

gross index of cargo operations is increased by reducing ship demurrage in awaiting arrival of lighters and for meteorological reasons. The change in the amount of transportation efficiency due to the influence of increasing the gross index, can be determined by the formula

$$\frac{P_e}{P_{baz}} = \frac{D_{ch\ e}}{D_{ch\ w/o}} = \frac{T_{op\ e}}{T_{ch\ w/o}} \cdot \frac{I_e}{I_{w/o}} .$$

Here, the subscript "e" refers to ships operating with soft containers, the subscript "baz" -- without soft containers; $D_{ch}T_{op}$ is the tonnage-days of operating a ship; I - is the productivity of a ship, expressed in $\frac{\text{ton-miles.}}{\text{tonnage-days}}$

If the gross index of cargo operations is changed by m times, then the measure of ship productivity, I, is changed by i_m times:

$$i_m = \frac{I_e}{I_{w/o}} = \frac{m(\varphi + 1)}{m\varphi + 1} ,$$

where

$$\varphi = \frac{t_x}{t_{cT}} = \frac{k_x}{1 - k_x} ,$$

and thus

$$k_x = \frac{t_x}{t_x + t_{CT}} .$$

In these formulas, t_x and t_{CT} are the underway and demurrage of a ship;

and k_x is the coefficient of underway time.

The increase in carrying capability of a ship $\Delta I = (i_m - 1)\, I_{w/o}$. The increase in the volume of production $\Delta P = D_{ch} T_{op} \Delta Imr$.

Additional income from the use of soft containers $\Delta F = f_{cp} \Delta P$.

Here f_{cp} is the average weight of the tariff rate per ton-mile.

The economic gain from the use of soft containers $E\varphi = \Delta F - A$, whereby A is the depreciation allowance, according to the cost of the containers. Because in the given case, soft containers are the standard transport containers and are owned by the shipper or receiver, the economic gain for the shipowner is determined by the net income, i.e., $E\varphi = \Delta F$. In order to roughly estimate the amounts obtained, a calculation was made of the economic effect from the use of soft container packaging on one Andizhan class ship on cruises from Vladivostok to points on the shore of Kamchatka. The following figures were used: the work time over the year on the designated lines -- 265 days, the ship's cargo capacity was 4,000 tons, rate of progress was 240 miles per day, the coefficient of underway time was 0.3, and f_{cp} was one kopek/ton-mile. It was assumed, moreover, that the gross cargo operation index from the use of soft container packaging, increased by approximately 30%. Under these conditions, the economic gain over the year, for the one ship was calculated as amounting to 111,000 rubles.

Delivery of petroleum products to shore points located at river mouths. The economic gain for the work of the fleet, in this instance, is determined by the increase in ships' carrying capability from loading them more fully. The increase in the amount of transportation production during the period of operation is computed according to the formula

$$\Delta P = D_{ch}T_{op}\Delta I,$$

in which

$D_{ch}T_{op}$ - tonnage-days of operation;

ΔI - increase in productivity of a ton of cargo capacity in a day of operation.

The economic gain is equal to the additional income from transporting an additional increment of cargo

$$E_{\varphi} = \Delta F = f_{cp}\Delta P.$$

If it is assumed that the coefficient of cargo capacity utilization of an Andizhan class ship in sailing to river-mouth ports is increased by 30% due to use of soft containers, then the computations result in an economic gain on the order of 27,000 rubles for a group of ships servicing these lines.

In determining $\Delta I = (i_{\varphi} - 1)\, I_{w/o}$.

in which

$$i_{\varphi} = \frac{m(\varphi + 1)}{m + \varphi},$$

$$I_{w/o} = k_x k_B \gamma.$$

It is clear from the examples presented, that replacing metal with soft containers on bulk cargo ships in the transport of petroleum products will provide significant economic advantages. It is important to note that this does not require any kind of reequipping of ships or taking them temporarily out of operation, etc.

Section 29. Economic Efficiency of the Use of Soft Containers as Cargo Handling Equipment

The coasts of the far eastern and far northern seas, currently have a small number of ports and a poorly developed transportation network on land. This creates the prerequisites for development of a large number of port-points through which cargoes headed for the interior could be transshipped. A great amount of petroleum products, in particular, pass through the largest of the currently existing port-points which, as distinct from small-points, are delivered not by bulk cargo ships, but by tankers.

Great tension characterizes the work of the fleet during the navigational season because of the seasonal nature of the work due to the pressure of ice during a considerable part of the year, the lack of equipment at these port-points and the shallow depths of the approaches to them.

As a rule, port-points have an insignificant container capacity ashore and only one or two barges equipped for transporting liquid cargoes from the roadstead to the shore. The operating time of this floating gear,figures out to be several days a year and therefore it is inexpedient to increase the numbers of them. But at the same time, the existing means are clearly insufficient to ensure that tankers delivering petroleum products are off-loaded in good time.

It is possible to eliminate these difficulties by using, for cargoes of petroleum products, the bulk cargo barges and scows, which the port-points have in greater numbers than scows for handling liquids. Stressed class, enclosed, soft containers can be placed in the barge holds, and unsupported cylindrical, soft containers on the deck areas, for this purpose. Bulk cargo barges will, in this case, operate as liquid carriers only during off-loading of tankers, and be used for their primary purpose the rest of the time. After being taken off a barge, the soft containers can be used as floats or shoreside reservoirs for POL materials.

If a 55-ton cargo capacity fuel barge costs 11,500 rubles, the annual cost of its operation is 12,500 rubles, and depreciation allowance off the cost of soft containers of the same cargo capacity is 550 rubles per year (with an operating period of not less than four years for the containers under these conditions), then replacement of only one barge will produce an economic gain of about 22,000 rubles. This will amount to a highly impressive sum for the scores of port-points.

In addition, use of bulk cargo barges will permit increasing carrying capability of the tanker fleet. It is sufficient to point out that according to data compiled by the Far East Steamship Line, demurrage of tankers engaged in delivery of petroleum products to port-points on shore,currently amounts to about 28% of time at anchor due to waiting for lighters, and about 10% of time at anchor,awaiting offloading.

With relatively little time spent in transit between port-points, it can be assumed that demurrage will be decreased by approximately 30% due to the use of soft containers on bulk cargo barges and that the useful operational time of the tanker fleet will have been accordingly increased by 20 to 25%. Under existing norms for cargo handling, this is tantamount to increasing the carrying capability of the steamship line's tanker fleet by 10 to 12 thousand tons.

Section 30. Economic Efficiency of the Use of Soft Containers for Taking on Water Ballast.

The capacity of the majority of bulk cargo's ballast tanks and refrigerated transport ships is insufficient for giving them normal ballast. This is especially true when the engine rooms are situated aft, which is a characteristic of modern ships.

If insufficient ballasting is still permissible when cruising in calm weather, then with a 4 to 5 force sea and a fresh wind, the seaworthiness of a ship becomes sharply decreased. During pitching, a ship with small draft will have its propeller stripped, the load on the engine will become unequal, and the wear on the deadwood structure will be increased.

Inadequately ballasting a ship, coupled with stern trim, will cause another extremely negative phenomenon -- slamming, or hitting the bow (sometimes the stern) of the ship on the water, giving rise to considerable general and local stress at the hull seams and breaks in the pipes and electrical systems.

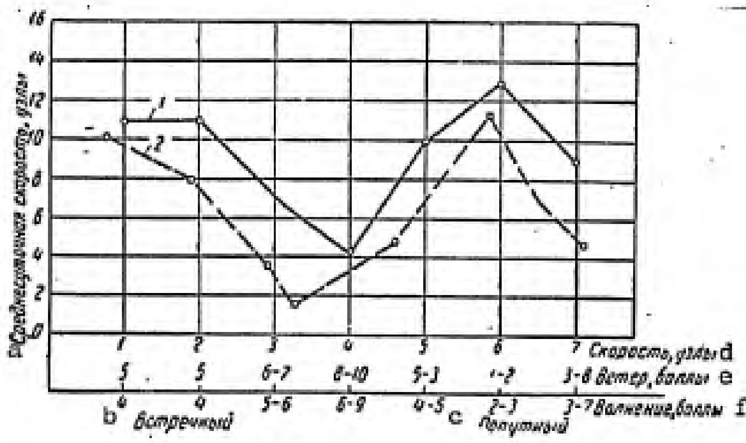

Figure 128. Actual progress of the motorship, Sinegorsk, on a ballast transit from Nagayevo Bay to Poronaysk.
1-Average daily speed; 2-minimum speed in a day.
a-average daily speed, knots; b-headwind; c-following wind; d-speed, knots; e-wind, force; f-sea force.

With a small draft, a ship has a larger sail area resulting in increased drift and yawing. Resistance to the ship's movement increases.

As a result of all these factors' action, a ship sailing empty in a stiff wind and turbulence will have its advance considerably reduced, often not exceeding 3 to 4 knots in a storm; and sometimes the ship even has to cease its forward movement and turn into the wind. Figure 128 illustrates the foregoing; it shows the actual progress of the motorship, Sinegorsk, in ballast from Nagayevo Bay to Poronaysk.

Ships of the Far Eastern Basin, where the hydrometeorological conditions are extremely rigorous suffer most because of insufficient ballast tank capacity. Here the average month's wind force is 6 during the fall-winter period, and the average chance of storms amounts to 25 to 30%. In the northern part of the Pacific Ocean, north of the 40th parallel, the chances of 6 to 9 force sea is 20 to 25%.

Water ballast very often must be taken on directly in the cargo holds in order to alleviate the condition of a ship during a storm. This operation, however, because of the large width of the hold, leads to a large drop in the ship's stability, which is very undesirable in such a situation. Moreover, if all wooden equipment -- battens, removable covers, partitions -- are not removed from the hold, then after taking on water they will be floated and broken up during the turbulence. Cases have been observed when, after a storm, it proved to be impossible to pump the water out of the hold by means of the ship's pumping system because the intake hose fittings were jammed with splinters. On refrigerated ships, whose holds are compartmented, this means of ballasting is generally not suitable.

The use of huge, soft containers for taking on water ballast can prove to be very effective in these conditions.

On refrigerated ships, soft containers can almost always fulfill the function of either ballast or cargo tanks for transporting fresh water.

Their design is therefore determined mainly by the second function. Improving a ship's ballast can be considered as a by-product of increased efficiency from the installation of soft containers. Certain refrigerated ships, the Kustanay class for example, have such bad ballast systems that the use of soft containers on these ships can be justified by this reason alone.

The type and design of the soft containers depend upon the required ballast capacity, and the dimensions and designs of the cargo spaces. Stressed class, enclosed containers can be used on ships of all types. Since the containers are intended for occasional, and not constant operation,and if they tear on a bulk cargo ship, this in itself,will not involve serious consequences, the container casing can be calculated with a minimal reserve strength. This will permit increasing the container's operating width and decrease the cost of reequipping the hold. Computations indicate that with casing material with a tear resistance of 40 to 50 kG/cm (approximately the strength of tarpaulin) 12 soft containers of up to 40 m^3 capacity can be stowed in a hold with dimensions of 16 x 20 m, thus taking on 400 to 500 tons of water in the hold.

The economic benefit from using soft containers for ballasting a ship, results from increased speed of a ship in ballast and the facilitating of the operations of shipboard equipment and machinery. By raising the average ship speed, the amount of transportation available is increased. In this case, the formulas used for computing this are of the same kind as those described in Section 28. Economic effect is determined by the formula

$$E_{\varphi} = \Delta F + E_p - A.$$

In it, ΔF is the additional income from cargo carried in the time saved;

E_p is the saving of resources for repair of ships, obtained from easing the ship's situation in a storm;

A is the depreciation allowance for the cost of the container and equipping the holds.

Let us give an example.

Let us determine approximately,the economic effect which can be obtained by the use of soft containers for ballasting a group of Andizhan class ships of the Far East Steamship Line. For this purpose, let us take the net cargo capacity of the ship D_{ch} = 4000 tons, the overall operating time of a fleet of ships as 2100 days, average distance as 240 miles per day, coefficient of underway time k_x = 0.46, loading coefficient k_{op} = 0.65, productivity of a ship without containers $I_{w/o}$ = 71.8 ton-miles/ton-days, and a depreciation allowance of 14 rubles per day of operation for one ship.

Let us assume that the average speed of a ship is increased by 10% as a result of better ballast. Then

$$E_{\varphi} = \Delta F - A = 259,200 - 29,400 = 229,800 \text{ rubles.}$$

The savings in resources for ship repair is not taken into account here because of the absence of any kind of data.

As can be seen, the economic efficiency of the use of soft containers for ballasting ships is large enough, even though very conservative figures were used in the computation.

In conclusion, it must be emphasized once again, that the computations and views expressed regarding the economic efficiency of shipboard, soft, containers under various operating conditions, must be considered only as preliminary estimates, and that actual practice will provide these with their essential corrections.

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