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TECHNICAL AND ECONOMIC RESULTS AND PERSPECTIVES OF THE APPLICATION OF SYNTHETIC RUBBER IN THE TYRE INDUSTRY[1]

by

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United Nations Industrial Development Organization

International Petrochemical Symposium on the Development of the Petrochemical Industries in Developing Countries

Baku, USSR, 20 - 31 October 1969

[illegible]

SUMMARY

TECHNICAL AND ECONOMIC RESULTS AND PERSPECTIVES OF THE APPLICATION OF SYNTHETIC RUBBER IN THE TYRE INDUSTRY[1/]

by

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for the Tyre Industry
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1. Experience gained by the Soviet Tyre Industry in using synthetic rubber

1.1. The necessity for the Soviet State in the first years of its existence to have its own rubber and to be independent of natural rubber import resulted in developing commercial synthesis of rubber and provision of a general purpose synthetic rubber big mass production in the U.S.S.R. in 1932, i.e. much earlier than in other countries (Germany, 1937; U.S.A., 1942).

1.2. The Soviet Union also has the priority in the use of SR in truck tyre production. This task was solved in three stages:

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a) in 19[illegible] [illegible] rubber;

b) in 19[illegible] [illegible] [illegible] butadiene-styrene rubbers;

c) in 19[illegible] [illegible] [illegible] [illegible] and [illegible].

On all [illegible] [illegible] [illegible] widely [illegible] [illegible] natural rubber(NR).

1.3. [illegible] [illegible] [illegible] [illegible] complicated [illegible] [illegible] [illegible], [illegible] research and development [illegible] [illegible] [illegible] rubbers, [illegible] [illegible] properties, synthesis [illegible] [illegible] [illegible] mastering of new [illegible] [illegible], [illegible] [illegible] and equipment; creation of [illegible] [illegible] [illegible] [illegible] of [illegible] proving methods [illegible] [illegible] etc.

1.4. Tremendous [illegible] [illegible] [illegible] truck tyre production has [illegible] [illegible] [illegible] [illegible] the tyre industry and permitted [illegible] [illegible] [illegible] [illegible] and perspective [illegible] [illegible] [illegible] [illegible] tyre manufacturing.

2. Future of the [illegible] of [illegible] and [illegible] [illegible]

Natural rubber (NR) [illegible] [illegible] [illegible] the general purpose rubber [illegible] [illegible] [illegible] especially in the countries producing natural rubber.

At present, however, [illegible] [illegible] increased requirements for tyre properties in service [illegible] [illegible] [illegible] resistance, low temperature properties [illegible] cracks formation [illegible] natural rubber by itself can in no way satisfy these demands without the addition of synthetic rubbers.

We regret that some of the pages in the microfiche copy of this report may not be up to the proper legibility standards, even though the best possible copy was used for preparing the master fiche [illegible] ...llection of [illegible]

[illegible] the chemical [illegible] polymeric [illegible] and other [illegible] Many dozens [illegible].

[illegible] is determined mainly by [illegible] transport.

[illegible] for the period [illegible] Soviet tyres the dominant [illegible] while in the [illegible] and in Western [illegible] first place.

[illegible] accordance with the structure [illegible] ~~[illegible] is heavier~~ compared to [illegible] Western Europe.

[illegible] the world and [illegible] Western Europe [illegible] the volume of which tyre [illegible].

[illegible] the Soviet tyre industry [illegible] a significant [illegible] tyre production [illegible] example, the initial mileage [illegible] has increased more than twice.

[illegible] increase in the volume of [illegible] improvement [illegible] and an increase in labour pro- [illegible] mechanization [illegible] flow lines, for the whole [illegible] solved in conjunction with simultaneous [illegible].

[illegible] the country from the natural rubber import by [illegible] rubber industry and its application to tyre [illegible] direction [illegible] tyre industry.

[illegible] of synthetic rubber by the Soviet tyre industry [illegible] stages in accordance with the main [illegible] development of the range of synthetic rubber.

The first stage ([illegible]) was characterized by the mastering of sodium-butadiene rubber (SKB) polymerized in mass which was the first synthetic rubber manufactured in the USSR.

The second stage ([illegible]) was a period of mastering of emulsion styrene-butadiene (and butadiene-methylstyrene) rubbers.

The third stage [illegible] in [illegible] was marked by the mastering of solution stereoregular rubbers (isoprene and butadiene).

A brief survey on the mastering of synthetic rubber by the Soviet tyre industry is considered to be useful because it was the first to develop truck tyres based on SK and gain great experience in this field.

Overcoming the difficulties appearing in the course of mastering of each type of rubber expedites solution of the problems occurring at the succeeding stages of mastering new tyre materials in mass tyre production and promotes technical progress in the industry.

Investigations of the properties of sodium-butadiene rubber (SKB) and the development of methods of the production of rubber goods based on it began prior to the commissioning of the first big synthetic rubber factories in the USSR.

The task was extremely complicated because a new synthetic rubber in contrast to natural rubber did not possess building tack, and rubber compounds containing no fillers upon vulcanization exhibited the tensile strength which was 10 times lower compared to that of the natural rubber gum vulcanizates.

It was the investigations of the properties of the new elastomer that made clear the necessity of using higher levels of active fillers for non-regular rubbers. This discovery was later used for other synthetic rubbers. Great attention was paid from the very beginning to synthetic rubber stabilization, to the influence of catalyst residues on its properties and to the establishment of rubber standards.

The new synthetic rubber possessed some advantages over the natural rubber i.e. SKB required no decrystallization and labour and power consuming mechanical plastication.

Compounds based on SKB are less liable to scorching and reversion compared to those based on NR. Rubber compounds based on SKB have higher thermal and oxidative ageing resistance.

Extensive research on this rubber and development work conducted at the pilot plant ... in the laboratories of the ... Research Institute of the Rubber Industry and ... the ... Factory "..." showed that it was possible to manufacture practically the whole range of rubber goods from synthetic rubber ... of ... and performance properties being significantly ... to those of natural rubber.

The tyre factories started the commercial application of SKB rubber for tyre production in 193., long before this task was attempted in any other country.

An increase in the volume of production, broadening the range of tyres and an improvement in quality of tyres made of SKB rubber was accompanied by the development of formulations of tyre compounds, the methods of their processing, and technological equipment in accordance with the specific properties.

Changes in formulations led to the necessity of intensive theoretical and experimental study on the development of tyre rubber vulcanizates possessing pre-determined properties.

The investigations were conducted on the structure and properties of rubbers and rubber compounds, the problem of vulcanization which was considered as a complex of physical and chemical aspects, the problem of increasing the abrasion resistance of rubber compounds and the bond strength in the tyre construction and also on the dynamic properties of tyre components and of an article as a whole, on the theory and calculation of tyres.

The examination of the automobile tyres containing SKB in the tread and ... in carcass and breaker under very severe conditions of testing in the Kara-Kum desert in 1933 and 1936 proved the high durability of tyres made of synthetic rubber.

In 1946 the development of SKS and butadiene-methyl-styrene rubber in tyres was started in the USSR.

The introduction of these copolymer rubbers presented a new stage in the work of the development of truck tyres based on S... For the first time an attempt was made to develop a truck tyre made of 100% S... which should not be inferior to the tyre made of ... blend.

At the first stage much the same design was used for tyres based on

... the reinforcing [illegible].

[illegible] factors [illegible] butadiene [illegible] their elast[illegible] [illegible] rubber [illegible] important [illegible] reinforcing material.

[illegible] of tyre[illegible] replaced the [illegible] of tyres [illegible] load [illegible] developed and introduced.

Simult[illegible] and choice of [illegible] of rubber [illegible] polymerization, [illegible] extended [illegible] and the whole system of vulcanizing, stabilizing [illegible] ingredients.

[illegible] difficulties [illegible] the [illegible] processes and equipment, especially [illegible] the [illegible] cumbersome procedure of the [illegible] destruction.

Already in late forties and early fifties theoretical and research work was intensified which paved the way to solving the main scientific [illegible] determination of the influence of the [illegible] structure on the properties of the finished articles and of the influence of the tyre [illegible] on its behaviour in service.

All the program of research, design and experimental work on the development of truck tyres based on [illegible] using [illegible] in carcass and breaker compound and [illegible] and [illegible] in tread compounds which was started in 1946 was completed in 1952-1953, then the Soviet tyre factories started mass production of tyres based on [illegible] for trucks with a load capacity of 2.5-4 tons.

Extensive service testing proved that truck tyres made of [illegible] were not inferior to tyres containing up to 47 [illegible]. This was due to the tremendous work done on improving all the tyre materials, designs, processes and equipment.

[illegible] important [illegible] pre [illegible] partial and later of [illegible] complete [illegible] synthetic [illegible] the production of [illegible] types [illegible] our [illegible].

[illegible] the [illegible] the [illegible] of the [illegible] tires, for [illegible] aircraft [illegible].

[illegible] synthetic [illegible] general [illegible] which [illegible] with the discovery [illegible] were [illegible]. Later [illegible] rapid development [illegible] production of stereoregular rubbers [illegible] the [illegible] of natural rubber.

At present the [illegible] production of synthetic stereoregular rubbers [illegible].

Synthetic polyisoprene [illegible] types with high cis-1,4 content [illegible] tensile [illegible] compared [illegible] natural rubber [illegible] strength of rubber compounds [illegible] of additives in rubber compounding [illegible].

[illegible] somewhat inferior to [illegible].

On the other [illegible] rubber possesses better processing properties [illegible] typical scheme of processing of conventional natural rubber [illegible] factory [illegible] 5 operations: discharge [illegible], bale heating, [illegible], bale cutting and plastication, whereas [illegible] of synthetic polyisoprene only one operation is needed [illegible] of rubber in the form of briquets, which [illegible] film wrapped (new types of [illegible], which have superior processing properties compared to those of conventional types [illegible] produced in limited amounts).

Better flow of synthetic polyisoprene and rubber compounds based on it [illegible] results were [illegible] production [illegible]

[illegible] diverse conditions, [illegible]

[illegible]

[illegible] were unable to [illegible]

[illegible]

[illegible] will

[illegible] production, [illegible]

[illegible] compound [illegible]

[illegible] only [illegible]

[illegible] in the production of other types [illegible] for [illegible] commercial [illegible] for [illegible] and [illegible] to use [illegible] the [illegible] the production [illegible] important [illegible] levels [illegible] such [illegible] structure [illegible]

[illegible] they were [illegible] for automobil[illegible].

[illegible] countries [illegible] However, even for [illegible] replaced [illegible].

[illegible] result [illegible], the [illegible].

[illegible] technical, [illegible] of [illegible] surpassed [illegible] development of [illegible] and [illegible]

[illegible] using [illegible] broad, the [illegible] predominantly with high cost [illegible].

If the Soviet tyre industry were producing heavy-duty tyres according to the U.S. standards of synthetic rubber use, then taking into consideration the Soviet tyre park, the USSR would have needed 62 % of natural rubber of the total rubber consumption, whereas in 1965 the Soviet industry consumed 27.5 % of NR. [illegible] the [illegible] of consumption of NR for the production of tyres in the USSR for 1960-1975 are shown in Fig.3.

Prior to the discovery of stereospecific polymerization and use of stereoregular rubbers in tyre manufacture for the tyre industry a task was set to develop tyres based on [illegible] which would not be inferior in quality to tyres containing great amounts of NR.

The production and application of stereoregular rubbers by the Soviet tyre industry for the first time provided an opportunity of setting a new and more important task of manufacturing tyres based on 100 % SR that not only would be equal to tyres containing some additions of NR, but would surpass them in their qualitative characteristics. Therefore the stereoregular synthetic rubbers present a new material helping to solve a completely new, more complicated problem of developing tyres having a mileage close to that obtained by a truck prior to capital repairs.

This task became much more complicated due to the simultaneous increase of requirements to tyre performance characteristics: an increase in load capacity, durability at higher speeds, improvement of tyre dynamic properties and other technical and economic parameters, i.e., a weight reduction, a reduction in specific fuel consumption for tyre rolling, a total increase of tyre wear resistance and service life and a reduction in the cost of tyre running per km.

The production of new high elastic synthetic stereoregular rubbers will grow at a much higher rate compared to the production of SBR.

Abroad in the production of tyres synthetic rubbers are used in the blend with NR. In the USSR the task was set to reduce the share of NR in the total rubber consumption. In the future five years (1971-1975) even in case of retaining the present NR import level its specific ratio in the total rubber consumption should inevitably be reduced while the total rubber consumption will increase significantly.

In connection with this the ratio of projected capacities of the Soviet synthetic rubber industry for the production of cis-polybutadiene and cis-polyisoprene differs from that in foreign countries. Abroad 70-80 [illegible] of the capacities for the production of stereoregular tyres still belong to cis-polybutadiene. In the [illegible], in the perspective, isoprene rubber will play a predominant part in the ratio of the capacities for the production of cis-polybutadiene and cis-polyisoprene.

The task of application of stereoregular rubbers in the production of tyres based on 100 [illegible] superior in quality to those containing [illegible] is being solved in close connection with principal changes in the tyre design, replacement of cross-ply tyres by radial tyres and a basic modernization of technological processes and equipment in the tyre industry.

Therefore, the technical revolution in the tyre industry is based on [illegible] factors:

1. stereoregular rubbers,
2. radial tyre design,
3. automation, mechanization and flow lines used in the main technological processes.

In contradistinction to Western Europe introducing radial tyres containing an increased amount of [illegible] (compared to the content of [illegible] in cross-ply tyres), the Soviet Union is developing radial truck tyres based on 100 [illegible].

Severe requirements of precision while manufacturing modern tyres based on [illegible], radial tyres in particular, can be satisfied only by means of using a high level of mechanization and automation of all the preparatory, building and vulcanizing processes. Such processes are developed and are being introduced into the tyre industry of the [illegible].

All the applied developments are intimately associated with the extension of theoretical investigations and calculations. The change in the range of reinforcing materials and the systems of textile cord treatment plays a very important role in the improvement of tyre quality.

Cotton cord has been completely rejected, a conventional rayon cord is being increasingly replaced by a high-strength rayon cord, mainly by a synthetic one - a polyamide, in the first instance.

The use of steel cord in radial tyre production is growing.

All the types of cord made of chemical fibres are impregnated by dipping solutions based on synthetic latices (butadiene carboxilated, butadiene-styrene etc.) and synthetic resins.

Research work is conducted on the modification of [illegible] compounds for cord treatment without dipping.

All the work on developing tyres based wholly on modern synthetic rubbers accompanied by the most advanced radial design and technological [illegible] in the tyre industry led to marked improvement of tyre [illegible].

The tyre factories of the [illegible] producing [illegible] large commercial [illegible] cross-ply and radial truck tyres based on 100 [illegible] which are not inferior to tyres based on [illegible] in performance including tyres for trucks with [illegible] capacity up to 10 tons and higher. In the perspective the tyres based on progressive synthetic rubbers must be better than tyres based on [illegible].

It is worth mentioning that half of the vast length of automobile roads in the [illegible] comprises unimproved roads. As a whole, the road conditions in the [illegible] are much more severe than in the [illegible] and in Western [illegible]. Therefore it often happens that the import tyres containing [illegible] designed for driving on good roads prove to have lower durability on [illegible] Soviet roads than the Soviet tyres.

The Soviet radial tyres based on 100 [illegible] testing on mixed roads have shown a mileage of 100 000 to 150.000 [illegible] on improved roads.

Thus, the Soviet radial tyres based on 100 [illegible] practically [illegible] inferior in mileage to imported tyres containing large [illegible].

The tremendous work on the application of [illegible] in truck tyres has [illegible] an important impetus to technical progress and enabled to establish [illegible] requirements for the properties and promising range of [illegible] for tyre production.

The current five years (1966-19[illegible]) present a new phase [illegible] application of synthetic rubbers - the increasing mass production of tyres with the [illegible] of stereoregular rubbers: polyisoprene ([illegible]) and polybutadiene ([illegible]) [illegible]

Higher investments per 1 ton of stereoregular rubbers and a higher cost of 1 ton of new rubber types are compensated for by a higher tyre service life, and their use provides a considerable saving in the national economy.

With the use of more effective initial oil and gas raw materials and more effective methods of synthesizing, as well as with further expansion of the production of rubber types SKI-3 and SKD the expenditures involved in their production will undoubtedly be considerably lowered.

In spite of the predominant development of synthetic stereoregular rubber production in the nearest future styrene-butadiene and methyl-styrene-butadiene rubber will remain in use among the main tyre rubbers in the Soviet Union. One of the most promising directions in their production will be the manufacture of carbon black-oil rubber (extended by carbon black and oil at the latex stage).

The advantages of the application of carbon black and oil extended rubbers consist first of all in the better distribution in the rubber of the carbon black, introduced into polymers in the process of their production, and in better utilization of its inherent reinforcing properties and thus in increased tyre wear resistance and mileage. With the use of the oil and carbon black extended rubbers the labour productivity increases and the conditions of work in the mill rooms of tyre factories become much better. The mixing cycle is reduced to approximately half and the power consumption for this process, the most power - consuming process in the tyre industry, decreases sharply.

The production of oil - and carbon black-extended rubbers is naturally not restricted to styrene-butadiene rubbers, obtained by emulsion polymerization and extension at the latex stage. Carbon black and oils are also to be introduced into the stereoregular rubbers at the solution stage.

In parallel with other rubbers produced on a large scale the tyre industry consumes some other materials characterized as rubbers, produced on a medium scale, first of all butyl rubber for inner tubes, for bladders of vulcanizers and for curing bags.

Summarizing general results of the introduction of SR into the mass production of truck tyres it should be noted that the task of manufacturing truck tyres of high quality of 100 % SR was the most important task for the whole period of the development of the tyre industry.

This task was solved simultaneously with the development of the range and of new types of synthetic elastomeres, including stereoregular elastomers, and of the principles of formulating rubber compounds, based on 100 % SR. Closely connected with it wide complexes of works on improving and mastering new tyre constructions by using improved and new reinforcing

materials [illegible]
machin[illegible]

[illegible]
and [illegible]
inven[illegible]

[illegible]
repr[illegible]
[illegible]
the [illegible]
for [illegible]

[illegible]
factories [illegible]
and [illegible]
combinat[illegible]

[illegible]

[illegible]
[illegible] shown in [illegible]

Table [illegible]

World [illegible]

Years	[illegible]	[illegible]	[illegible]	[illegible]
[illegible] production	[illegible]	[illegible]	[illegible]	[illegible]
[illegible] production	[illegible]	[illegible]	[illegible]	[illegible]
Total	[illegible]	[illegible]	[illegible]	[illegible]
Including	[illegible]	[illegible]	[illegible]	[illegible]

[illegible]

[illegible] of 1[illegible] countries in the total production of S[illegible] for 1968 is as follows (thousands of tons)

[illegible] - 91[illegible]
[illegible] - 3[illegible]
West Germany - [illegible]3
[illegible] - [illegible]3[illegible]
[illegible] - [illegible]3
[illegible] - 1[illegible]
Holland - 1[illegible]
[illegible] - 1[illegible]5
Brazil - [illegible]
Mexico - 35
Australia - 3
Spain - [illegible]7
Belgium - 25
South African Republic - 25
India - 2[illegible]
Argentina - 23

[illegible] of rubber consumption by tyre industry of several countries are given in Table 2.

[illegible] seen from Table 2 the tyre industry of several countries has steadily [illegible] the level of the S[illegible] share and has brought it up to 57-7[illegible] of the total rubber consumption in tyre manufacturing, whereby this refers to countries, [illegible] more than [illegible] of rubber, used by all foreign countries (excluding [illegible] countries).

The general trend of the development of S[illegible] rubber production and of the [illegible] replacement of [illegible] by [illegible] is explained by several factors.

Table 2

[illegible] consumption by tyre industry of foreign countries

	1950	1955	196[illegible]	1965	1967	1968
USA, total, thous. of tons	331	975	1011	1327		1632
including S[illegible] "	347	552	682	966		1229
[illegible]	42	57	67.5	73	-	75.5
England, total, thous. of tons	131	147	159	193	199	
including SR, "	-	11	74	105	113	
[illegible]	-	7.5	46.5	54.5	57	
France, total, thous. of tons	66	93	126	161	137	
including [illegible] "	3	10	49	84	105	
[illegible]	5	11	39	52	56	

	1950	1955	1960	1965	1967	1968
Including [illegible] thous.of tons			26	58		75
[illegible]			37	525		57
Japan, total, thous.of tons			92	183		301
Including S[illegible] "			22	92		175
[illegible]			22	49		50
Canada, total, thous.of tons	47	57	64	101		112
Including S[illegible] "		26	39	69		79
[illegible]		46	61	62		70

The problem of the future of natural rubber in the world market has been often discussed.

In recent years an extensive work on the modernization of Hevea plantations, on the improvement of NR quality and dispatching forms has started.

During 1951-1967 the average yield of NR in West Malaysia increased from 504 to 1053 kg/ha, and on experimental sites - up to 2-3 tons/ha. The introduction of synthetic hormones and stimulation of rubber forming in the plant may increase even more the NR yield. At present the production of an improved type of NR, so called Standard Malaysian Rubber (SMR) having stable viscosity and the best dispatching forms is expanded.

In recent years the production of NR is increasing. So, during the decade of 1950-1960 NR production increased by 7 %, and during 1961-1968 - by 24 %. One should however bear in mind, that even in the most optimum cases the total demand for rubbers will grow faster than the increase of NR production. Therefore, further expansion of SR production is inevitable. The geographic factor is also important; NR production is restricted to several tropical regions, whereas SR synthesis is possible practically at any place, where the products of petrochemical industry can be delivered. The non-tropical countries interested in being independent of NR imports will speed up the development of their own SR.

As for the quality of rubber, the advantages of stereoregular synthetic rubbers over natural rubber have been shown above, the possibilities of science and engineering in the synthesis of elastomers and further improvement of their properties being much greater compared to the possibilities of improving the NR quality.

Synthetic rubbers are more uniform compared to natural rubber, and in principle even under maximum standardization of NR this advantage remains in future.

NR remains a low price rubber only as long as the direct rubber producers on the hevea plantations (i.e. workers and owners of small plantation estates) receive low wages. With the growth of the liberation movement in the countries of South-Western Asia this situation should change. Besides, with the potential growth of population the need in larger areas for food agriculture will increase. Already at present the coco-trees seriously compete with hevea on rubber plantations.

In different forecasts for 1975-1980 the possible production scale of NR is estimated as 2500-3500 thous. tons, the production scale of SR - from 5750 to 7500 thous. tons. Thus, according to the most optimum forecasts, the share of NR for 1980 will make about 30 % of the total rubber production, provided there will be no important social-political and economic changes in a particular system by that time.

It is however undoubted that natural rubber retains its role as one of the first-class rubbers of general purpose for tyre production, especially in countries manufacturing natural rubber.

Table 3

Structure of rubber consumption by tyre industry (%)

	[illegible]	[illegible]	Butyl-rubber	Neo-prene	Stereo-regular rubbers	Others	Total SR	Total rubber
USA, 1960, [illegible]								
Total tyre industry	24.6	54.3	1.1	0.4	16.2	-	75.4	100
England, the 1st half of 1960								
Car tyres	30.6	51.5	0.7			7.2	69.4	100
Truck tyres	68.5	16.7	-			10.8	31.5	100
Tractor and agricultural tyres	37.2	61.0	-			1.8	62.8	100
Scooter and bicycle tyres	63.3	36.4	-			-	36.4	100
Others	72.0	28.0	-			-	28.0	100
Tubes	9.0	-	91.0			-	91.0	100
Tread compounds for retreating	28.0	72.0	-			-	72.0	100
Other tyre repairing materials	33.3	66.7	-			-	66.7	100
Total tyre industry	41.7	45.3	5.6			7.4	58.3	100
India, 1958, [illegible]								
Total tyre industry	29.4	53.9	4.0	0.2	12.0	0.5	70.6	100

As table 3 shows the share of [illegible] in the total quantity of rubbers, consumed by the tyre industry of the [illegible], [illegible] and [illegible], makes 45-55 [illegible]. Stereoregular rubbers-synthetic and natural make 41 [illegible] in the [illegible] and [illegible], only [illegible] makes 42 [illegible] in England.

The great share of [illegible] is explained by considerable predominance of car tyres in the range of tyres produced in these countries. In the countries with a heavier tyre range the share of rubbers with high elasticity must be much greater.

The share of butyl rubber in the [illegible] and in [illegible] (4 [illegible]) is less than in England (5.6), because in American countries the production of tubeless tyres makes about 87 [illegible] of the total production of vehicle and agricultural tyres, whereas in England it makes 65.

The share of chloroprene rubber makes only [illegible].2 - [illegible].4 [illegible].

In accordance with growing requirements to rubbers for tyres one can expect that in highly developed countries the share of [illegible] will decrease with the growing consumption of stereoregular rubbers.

Among the new promising tyre rubbers [illegible] is of great technical and economic interest. The low price, very accessible raw materials - ethylene and propylene, the lowest density (0.86 - 0.87) in comparison with 0.91-0.94, very high chemical resistance, including ozone resistance - all these advantages are combined with a good complex of tensile and elastic properties, close to the level of properties of styrene - butadiene rubbers.

The high prices of the third comonomer - diene, technological difficulties of [illegible] treatment, its insufficient compatibility with other rubbers (except butylrubber) however do not allow its wide using in tyres or consideration of this elastomer as a mass tyre rubber as yet. In the near future it apparently will be used as a special ozone resistant and heat resistant elastomer, valuable in manufacturing of separate parts, e.g. bladders bicycle tyres, as inhibitor of ozone cracks in sidewalls etc.

In the tyre industry of the [illegible] and abroad research and pilot plant works on different new elastomers for tyres are carried out, e.g. on styrene - butadiene rubber obtained by polymerization in solution and on many other rubbers.

Great attention is paid to the futher improvement of synthetic latices and synthetic resins for cord impregnation, since cord rubberising without impregnation for the present is still at the development stage.

In conclusion it should be noted, that the demand for rubbers for tyre manufacturing has an assured future, since in the next decades an intensive development of automobile industry in most countries of the world, and especially in the developing countries, is in prospect.

Fig. 1 Production of vehicle, tractor, agricultural and scooter tyres in the USSR for 1950-1970.

Fig. 2 Production of truck, tractor and agricultural tyres in several countries in 1967.

Fig. 3 Reduction of NR consumption for tyre manufacturing in the USSR for 1960-1975 (1970-1975 preliminary data).

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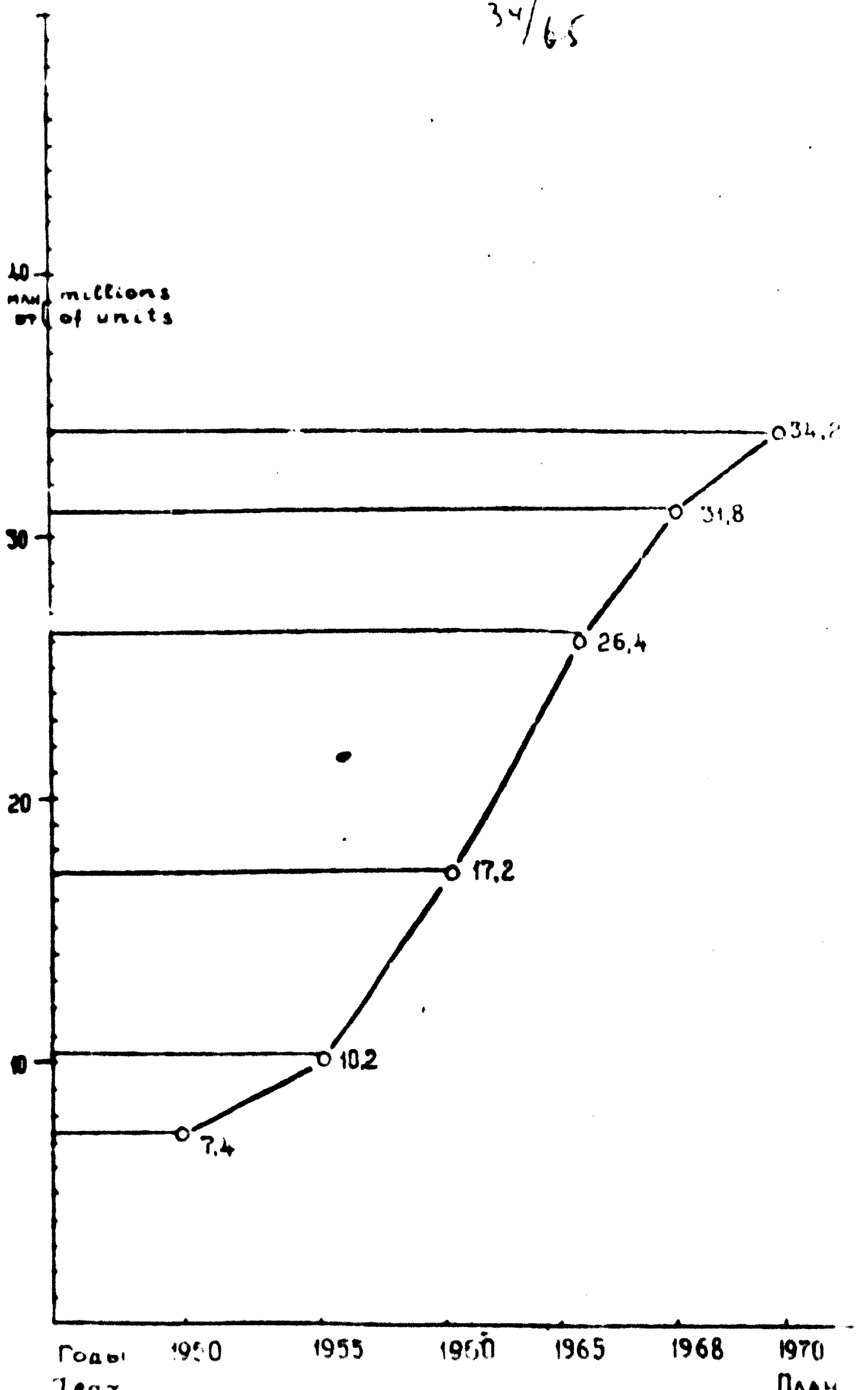
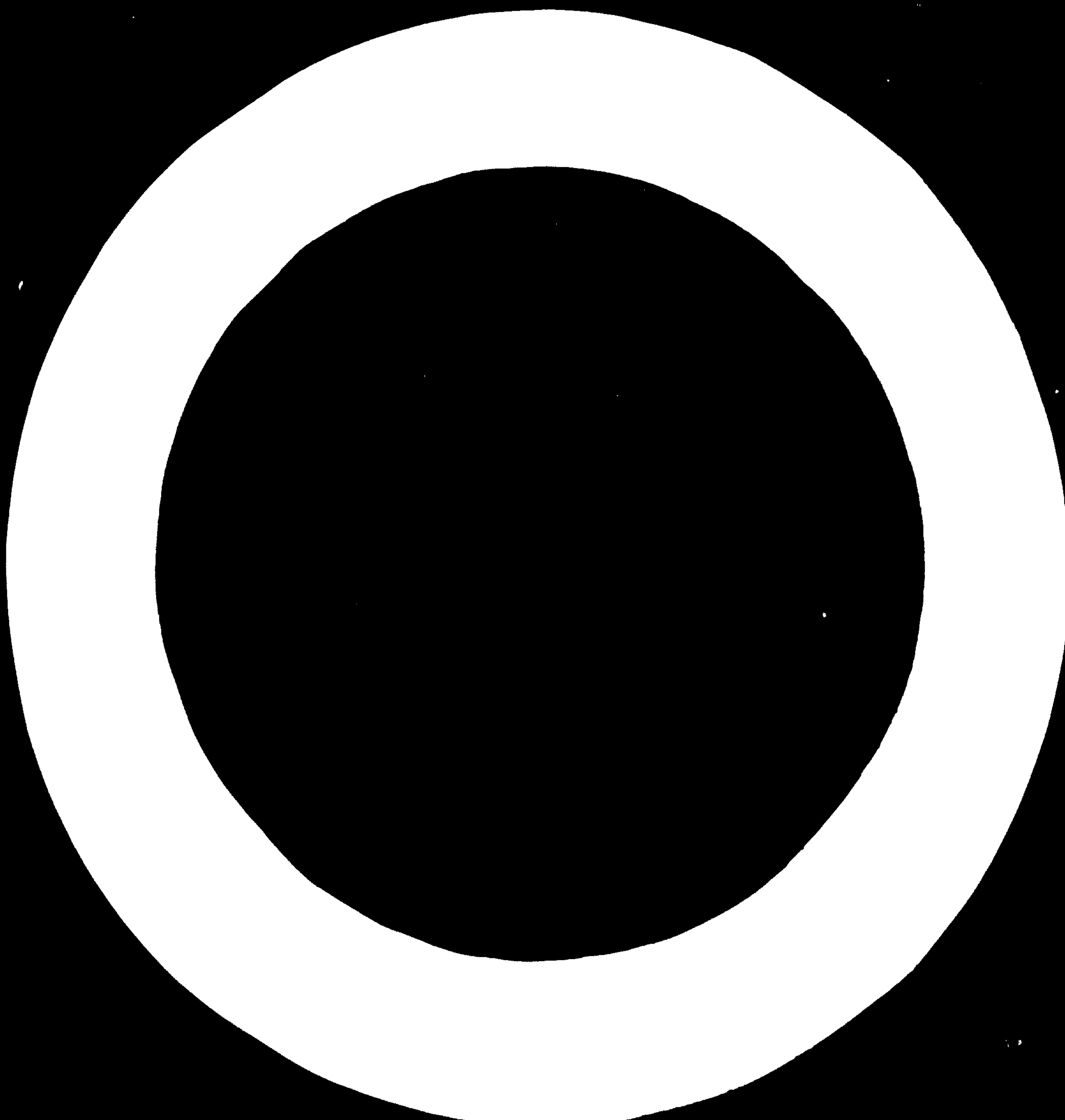


Рис. 1
Fig. 1.



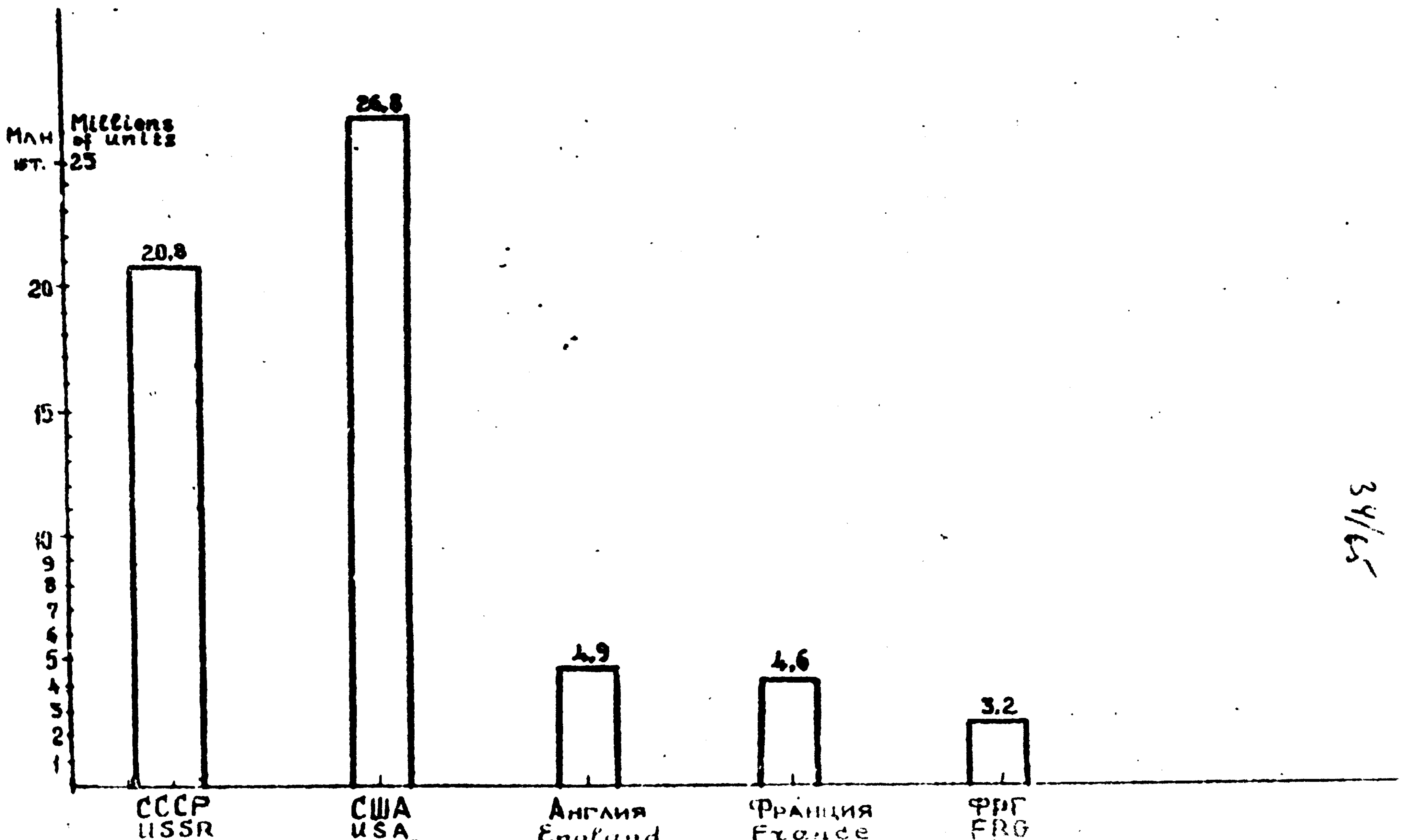


Рис. 2.
Fig. 2

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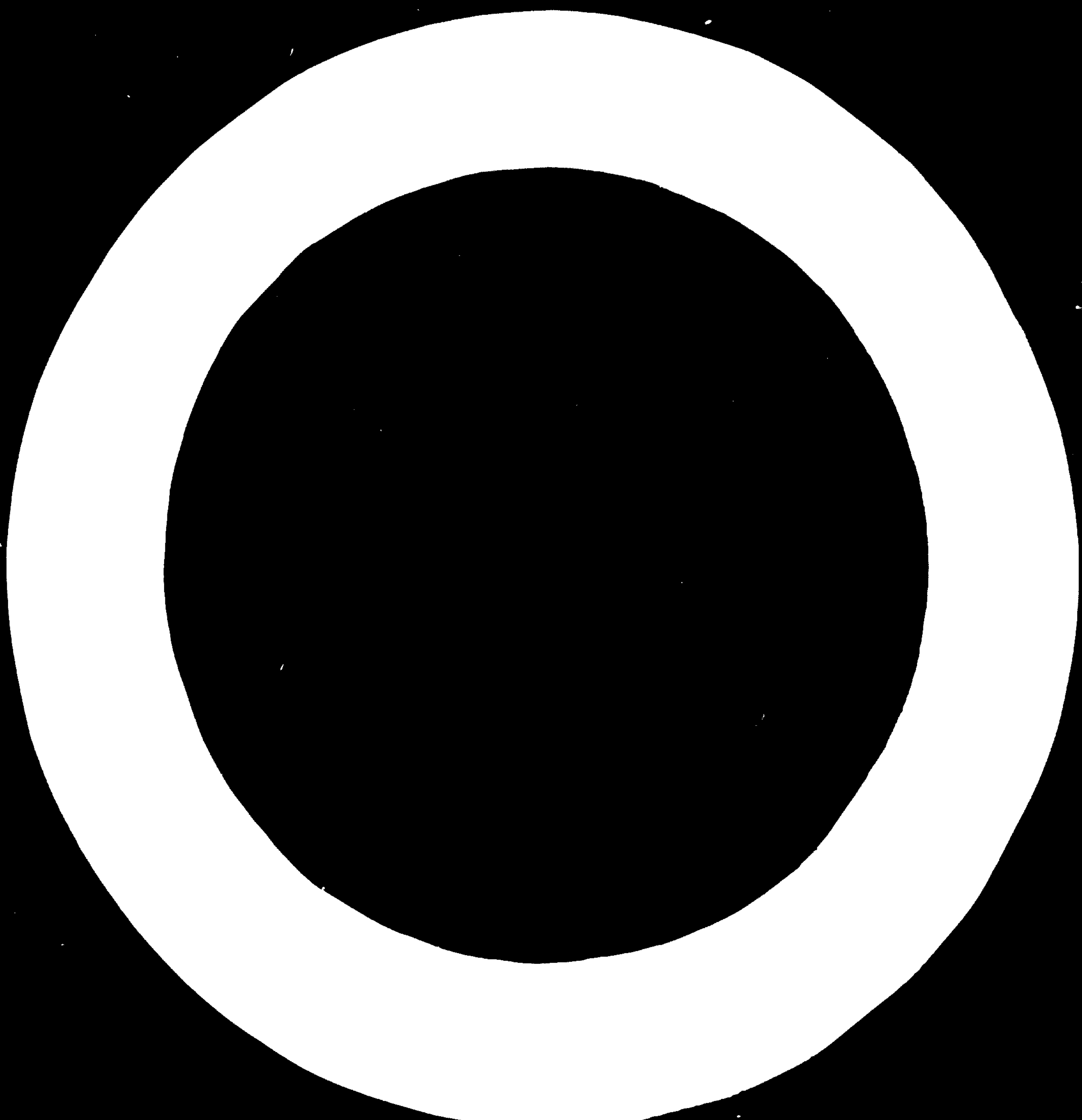

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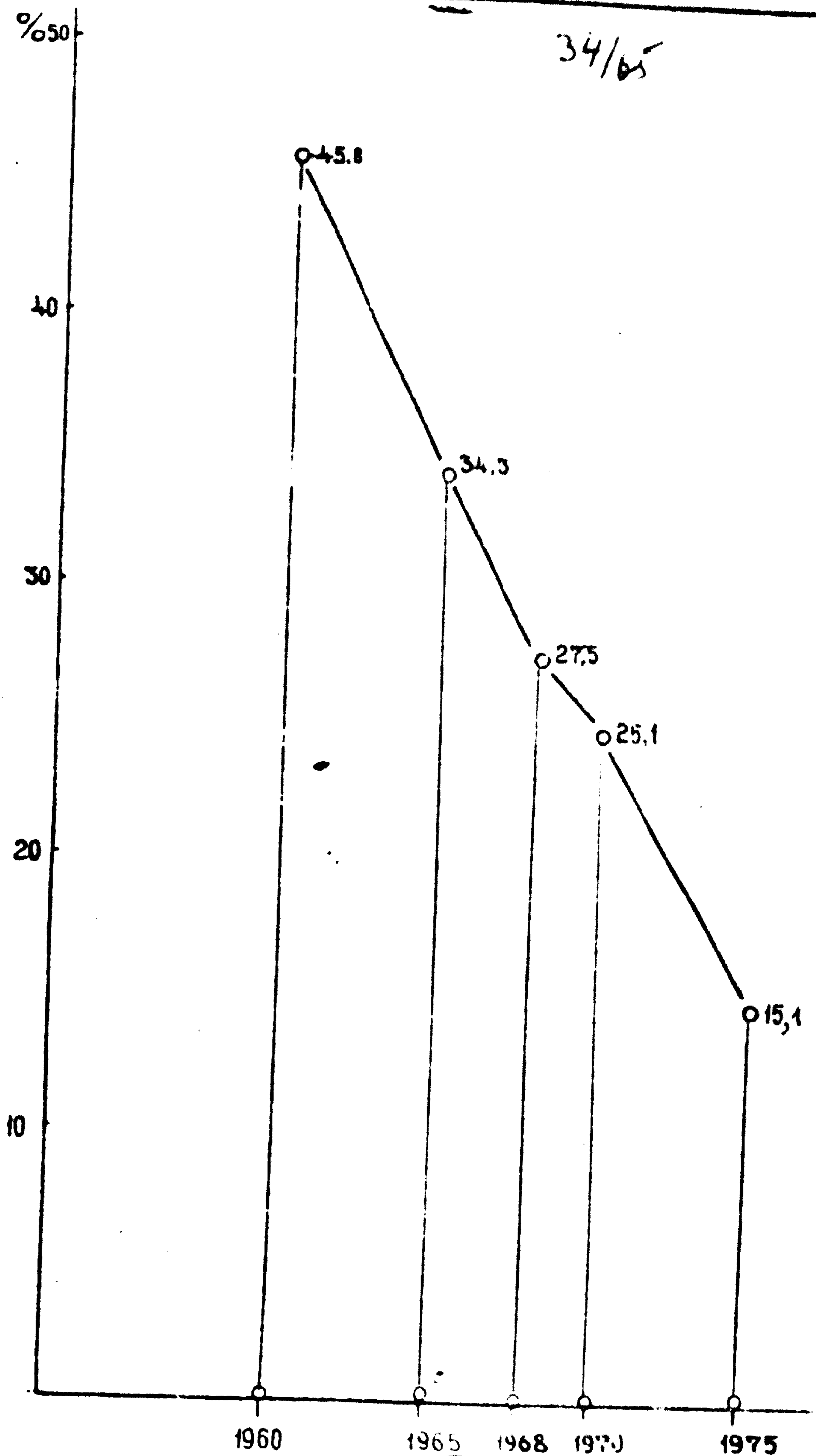

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