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AN ANALYSIS OF CONSTRUCTION AND CAPITAL INVESTMENT
AT LIQUID FUELED ROCKET ENGINE TEST FACILITIES
IN THE USSR: PERM' ROCKET ENGINE TEST FACILITY

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AN ANALYSIS OF CONSTRUCTION AND CAPITAL INVESTMENT
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Summary

The total cost of construction of the Perm' Rocket Engine Test Facility is estimated to be 15 million rubles, or US \$25 million.* Total capital investment at this facility, for equipment as well as construction, is estimated to be 25 million rubles, or \$42 million.**

The first static test stand probably became operational in 1963 and appears to have been used for production acceptance testing of storable-liquid fueled rocket engines of moderate thrust (100,000 to 300,000 pounds). The engines tested on this stand from 1963 through 1966 probably were used in the Soviet IRBM and/or ICBM programs. Modifications to the test stand and expansion of the facility, which were completed in late 1966 or early 1967, possibly indicate that the original test series has been completed and that the facility is being readied for use in one or more new programs.

The second static test stand -- a small stand with a possible altitude simulation capability -- is probably designed for testing upper stage engines with up to 100,000 pounds of thrust. The stand was structurally completed during 1966 and probably is now operational.

Both test stands are designed for engine testing or cluster testing but are not capable of handling entire stages. On the basis of its structural strength, the larger test stand is estimated to have a thrust capacity of 7 million to 8 million pounds,*** but it is limited by its water supply to testing engines in the 100,000 to 300,000 pound class.

* Throughout this report, dollar values are given in 1963 US dollars and ruble values are given in new rubles expressed in 1955 prices. The factor for converting new rubles in 1955 prices to 1963 US dollars is 0.6 ruble to US \$1.

** Equipment and installation costs were estimated as a residual from the relationship of construction to other capital costs in various sectors of the Soviet economy.

*** The thrust capacity is the maximum capacity from a gross structural standpoint and does not indicate the size of the engines actually tested. In fact, the large stand at Perm' is one of three "standardized design" test stands which have been used to test a variety of moderate-to-large engines and engine clusters.

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The initial facilities at Perm' were completed in 1962 and the site probably became operational in 1963. The site was expanded during 1964-66 and a second test stand was added. Housing is currently available for about 2,500 persons in family housing and for about 1,250 men in barracks/dormitories. Even after expansion, Perm' is the smallest of the Soviet liquid rocket engine test facilities and also the most heavily secured.

I. DESCRIPTION OF THE FACILITY AND CHRONOLOGY OF CONSTRUCTION

A. Operations Area

The operations area of the Perm' Rocket Engine Test Facility is in rolling, heavily wooded terrain about 12 miles east of Perm', south of the Sylva River (see Figure 1). It is served by a spur from the Perm'-Chusovoy railroad and by a paved road from Perm'. The first section of the operations area and the first static test stand (hereafter referred to as Stand 1) were structurally complete when first observed in May 1962. The access railroad, however, was still under construction at that time and thus the site was judged to be nonoperational. Based on the status of construction in May 1962 and the pace of similar projects carried out elsewhere, it is estimated that construction of the site began in early 1960 and that the site became operational in 1963. Stand 1 at Perm' appears to be identical to Stand 1 at the Kurumoch Rocket Engine Test Facility. The water supply of the Perm' stand, however, limits its present capability to a thrust of only 100,000 to 300,000 pounds.

A major expansion of the operations area began in 1964 and was probably completed in late 1966 or early 1967. During this expansion a small test stand (hereafter referred to as Stand 2) with a possible altitude simulation capability was built, industrial support floorspace was more than doubled, and Stand 1 was modified by the addition of a large-diameter duct. Stand 2, which is estimated to have a thrust capacity of up to 100,000 pounds, probably became operational early in 1967.

B. Construction Support and Housing Areas

The construction support area was probably constructed early in 1960-62 and was used as the base from which the rest of the facility was built. This area was complete and operational when first observed in May 1962.

As at other test facilities, both barracks/dormitory housing for military troops and/or construction workers and family apartment housing

for technical personnel and their families have been constructed. From 1960 through 1965, about 390,000 square feet of family housing and about 100,000 square feet of barracks/dormitories were constructed. In accordance with Soviet norms for use of housing space, these quarters can accommodate about 2,500 persons in family housing (of which about one-third would be technical personnel working at the site) and about 1,250 men in barracks. Perm' has far fewer technical personnel than any other site but about the same number of troops. (Kurumoch has 4,400 in family housing and 1,200 troops, Krasnoyarsk has 3,700 and 800 troops, and Omsk has 5,700 and 1,200 troops.)

The growth of housing, by type, in 1960-66 is shown in Figure 2. Included in the category of family housing are 14 single family and duplex houses (built in 1964) probably for top-level military and civilian personnel. No new housing has been started since 1965, indicating that the currently planned staffing level for the test facility has been attained.

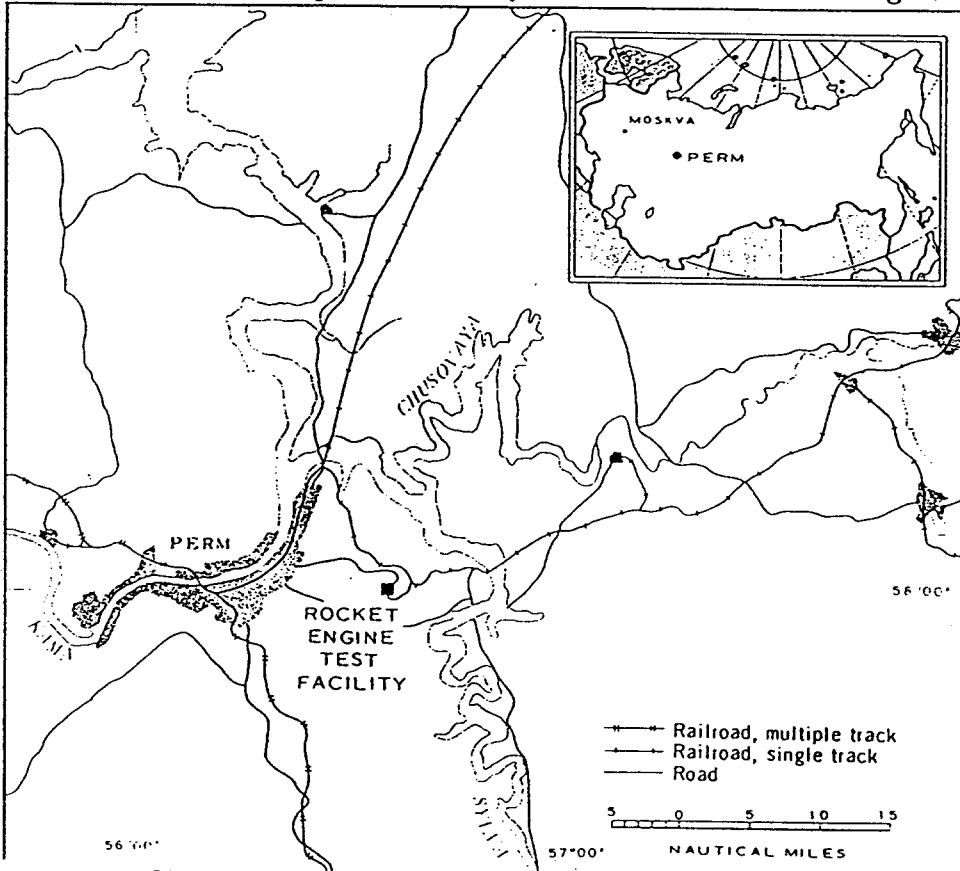
II. FEATURES INDICATING POSSIBLE USES OF THE TEST FACILITY

The operations area of the Perm' facility contains less industrial floorspace than any other Soviet liquid fueled rocket engine test facility. Initially buildings with only 105,000 square feet of floor space were constructed. This area was expanded to 230,000 square feet by new construction during 1964-66 (see Figure 3). By comparison, the engine test facility at Omsk has 360,000 square feet, that at Krasnoyarsk has 315,000 square feet, and that at Kurumoch has 305,000 square feet.

Perm' is the only Soviet liquid rocket engine test facility which was constructed without an air separation plant, and it operated without one until 1965 or 1966.

USSR: Perm' Rocket Engine Test Facility

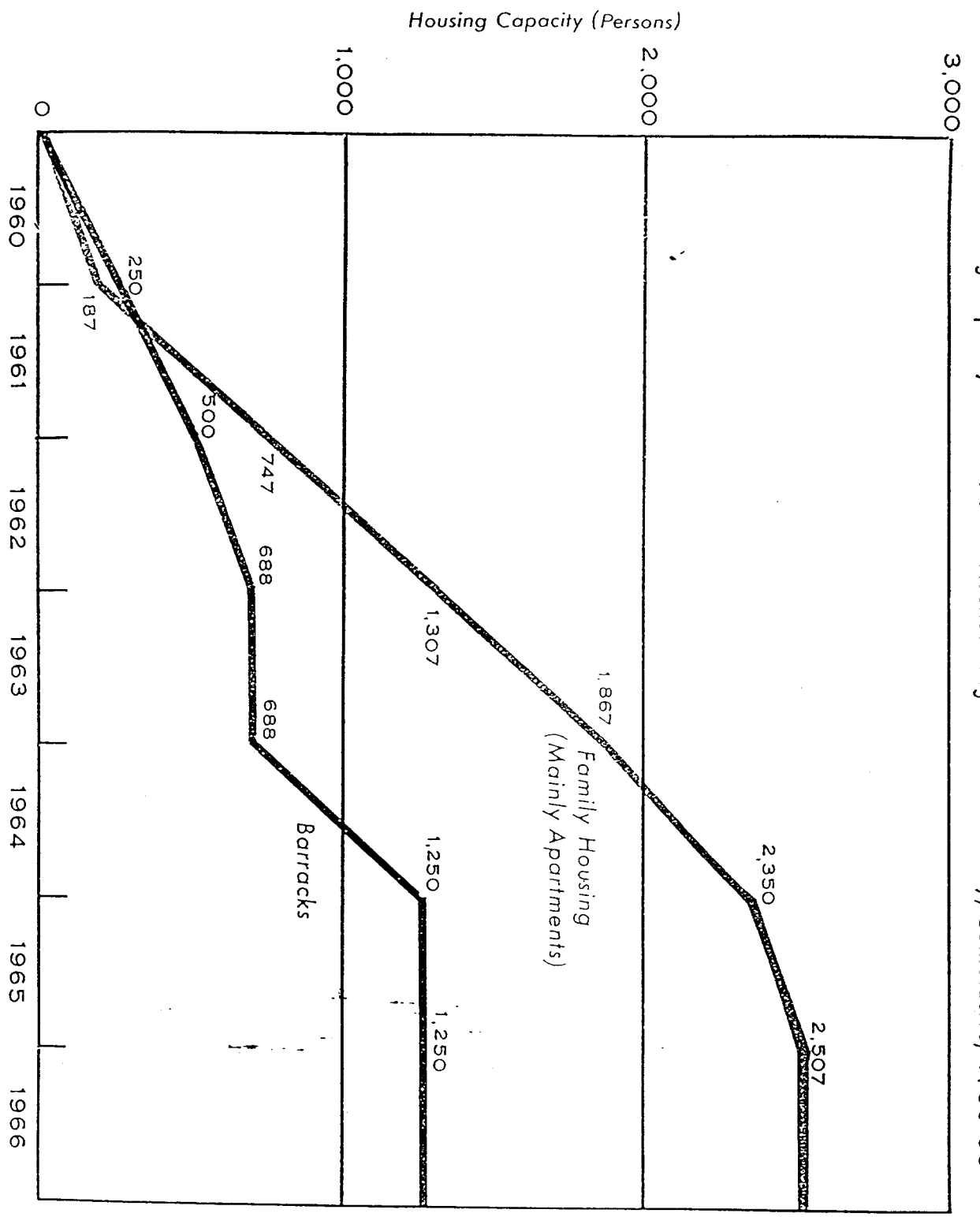
Figure 1



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Housing Capacity at the Perm' Rocket Engine Test Facility, Cumulative, 1960-66

Figure 2



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Finally, Perm' is distinguished by much more stringent security measures than are observed at other Soviet test facilities.

The expansion program, which was completed in 1966, included the construction of a small test stand with a possible altitude simulation capability, a large assembly/checkout building, an air separation plant, and other buildings and structures. In addition, Stand 1 was modified by the addition of a large-diameter duct which connects it to a small building near the air separation plant and to Stand 2. The expansion program probably indicates changes in the testing program and/or the beginning of one or more new testing programs at Perm'.

III. METHODOLOGY

A. General

Costs of construction have been estimated on the basis of costs for replacement of buildings and structures given in official Soviet handbooks. All costs have been adjusted for regional and climatic cost differentials prevailing in Perm' Oblast.

B. Climate and Soil Data

The Perm' Rocket Engine Test Facility is in the most severe climate zone (Climatic Zone I). The regular winter differential is paid for 173 days in Perm' Oblast, compared with 152 days for Moscow. In addition, a regional differential of from 4 to 17 percent of base cost is paid to the construction organization, depending on the type of structure being built, to cover the additional costs of construction resulting from the severely cold climate and remote location.

Soil conditions at the test facility are similar to those prevailing in the city of Perm'. Loadbearing characteristics of the soil for test stands and for heavy industrial construction range from poor to good.

C. Cost of Construction and Capital Investment

1. Cost of Construction

The Perm' Rocket Engine Test Facility consists of one large vertical test stand and a small vertical test stand, an operations area containing industrial support buildings, a modest-size housing area, a construction support area, an access road, and a railroad line. The minimum use of specialized buildings has kept costs relatively low for such a project, and its close proximity to existing trunk road and railroad lines kept the cost of building access lines to a minimum. For example, the cost of these lines at Perm' was only 4 percent of total construction costs, whereas at Omsk they accounted for 22 percent.

Apart from the test stands, the buildings and structures are constructed according to standard Soviet industrial and housing designs, which make it possible to use Soviet reevaluation handbooks to determine costs of construction. The costs given in these handbooks are average estimate costs per unit of construction (cubic meter, linear meter, and the like) for all types of buildings and structures. For each building or structure in the complex, the average estimate cost was determined and then adjusted for regional and climatic cost differentials appropriate to Perm' Oblast.

Test stands are structures of unique design and the cost cannot be estimated directly from handbooks in the same manner as other buildings and structures at the facility. To estimate the cost of construction of the test stands, it was first necessary to divide the activity into its major construction phases -- excavation, concrete work, steel placement, and the like. The volume of work for each component was determined from dimensions obtained

and supplemental consultations with Unit costs obtained from handbooks covering costs for the construction of hydroelectric installations, which were judged to be most similar to test stand construction, were then applied to the volumes of work in the various components.

2. Capital Investment

To determine total capital investment from total cost of construction of the test facility, the costs of construction for the six major sections of the facility were first calculated separately. The cost for each section was then divided by the percentage that construction costs represent in total capital investment for the type of construction in that section. The difference between total capital investment and cost of construction consists mainly of the cost of equipment and its installation. The derivation of total capital investment for the Perm' Rocket Engine Test Facility is shown in Table 1.

D. Distribution of Capital Investment over Time

Costs of construction and of equipment were allocated over time for each section of the test facility.

The status of construction in May 1962 made it possible to estimate the date of initial work as early 1960.

The cost of equipment and its installation was allocated in accordance with the construction schedule, with a lag of six months in all areas except housing (equipment and its installation are minor items in housing). The inclusion of a timelag is necessary because installation of equipment cannot begin until construction is at least partly completed. The distribution of capital investment during 1960-67 is shown in Figure 4 and Table 2.

Table .

Derivation of Total Capital Investment in the Perm' Rocket Engine Test Facility a/
Totals for 1960-67 b/

Item	(1) Construction Work (Thousand New Rubles c/)	(2) Share of Capital Investment d/ (Percent)	(3) Equipment and Installation e/ (Thousand New Rubles c/)	(4) Capital Investment f/ (Thousand New Rubles c/)
Operations area	3,303	45	4,037	7,340
Test Stand 1	3,716	54	3,165	6,881
Test Stand 2	1,034	54	881	1,915
Construction support area	882	45	1,078	1,960
Housing area	3,953	96	165	4,118
Access lines g/	1,859	80	465	2,324
Total h/	<u>15,000</u>		<u>10,000</u>	<u>25,000</u>

a. Because of rounding, components may not add to the totals shown.

b. Values for 1967 cover the completion of buildings and structures and the installation of equipment under way in 1966.

c. In 1955 prices.

d. The shares of construction in total fixed capital investment used in this report follow: 45 percent for industrial construction, based on data for the USSR automotive industry; 54 percent for test stands, based on breakdown of investment on the stands for the F-1 engines at Edwards Air Force Base in California; 80 percent for access lines, based on general experience in estimating Soviet construction costs; and 96 percent for housing, based on Soviet handbooks. The derivation of these percentage shares is described in earlier reports.

e. The difference between columns (1) and (4).

f. Column (1) divided by column (2).

g. Including roads, railroads, water lines, and power lines between the preexisting network and the test site.

h. Data have been rounded to the nearest million new rubles.

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Table 2

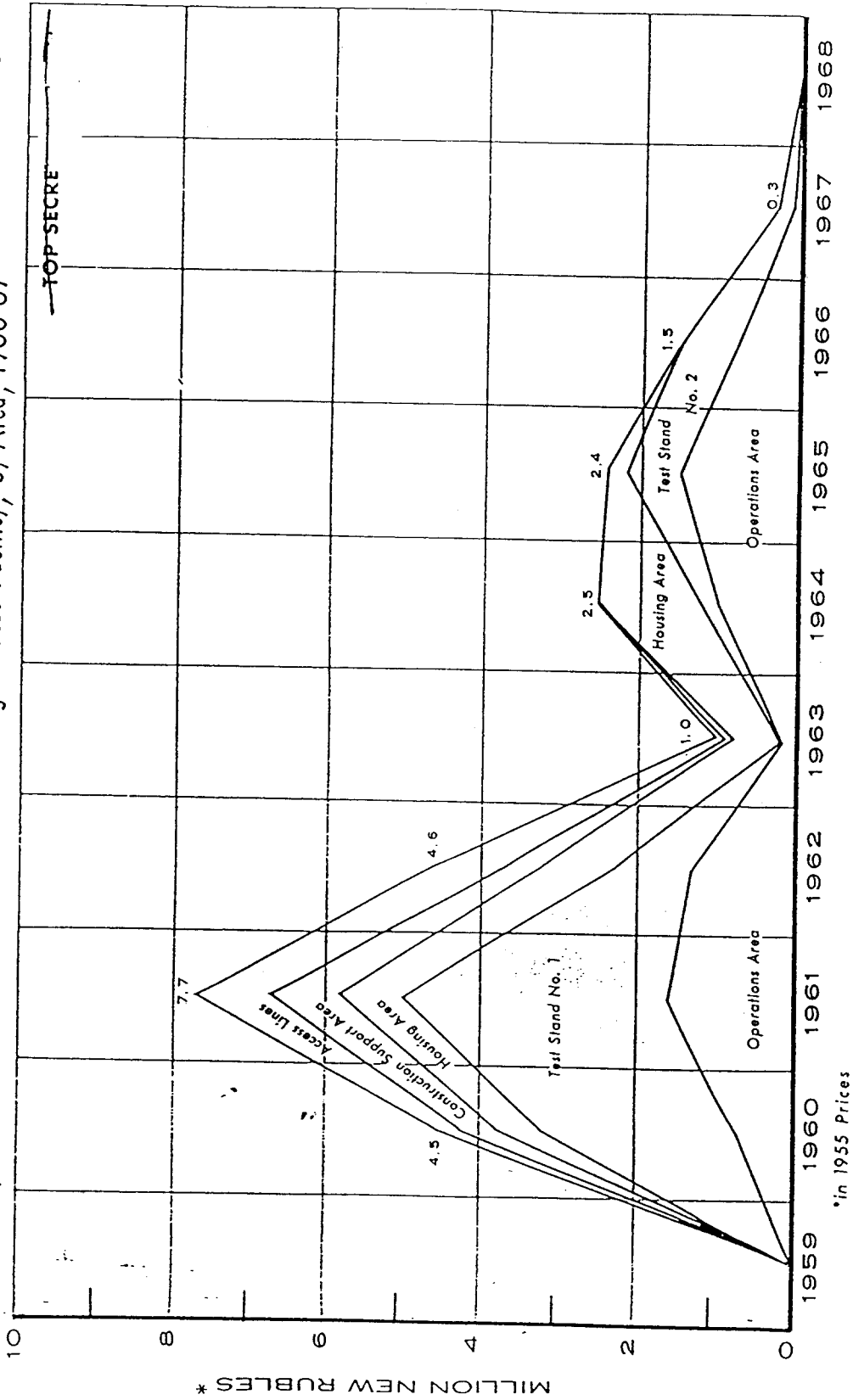
Annual and Cumulative Capital Investment
in the Perm' Rocket Engine Test Facility, by Category
1960-67

Category	Million New Rubles ^{a/}										Total
	1960	1961	1962	1963	1964	1965	1966	1967			
Construction	3.5	4.7	2.0	0.6	2.0	1.4	0.5	0.0			14.7
Equipment and installation	1.0	3.0	2.6	0.4	0.5	1.0	1.0	0.3			9.8
Capital investment	4.5	7.7	4.6	1.0	2.5	2.4	1.5	0.3			24.5
Cumulative capital investment	4.5	12.2	16.8	17.8	20.3	22.7	24.2	24.5			24.5

a. In 1955 prices.

Annual Capital Investment in the Perm' Rocket Engine Test Facility, by Area, 1960-67

Figure 4



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*in 1955 Prices