At the present time, a number of the engine properties of manganese tricarbonyl cyclopentadienyl (TsTM) have been studied rather thoroughly, and an antiknock compound based on this material has been developed [1-8].

The TsTM-based antiknock compound consists of manganese tricarbonyl cyclopentadienyl \( \text{C}_5\text{H}_5\text{Mn(CO)}_3 \), diethylxanthogen \( \text{C}_6\text{H}_{10}\text{O}_2\text{S}_4 \), and tricresyl phosphate \( \text{(C}_9\text{H}_{18}\text{CH}_3\text{O)}_3\text{PO} \).

However, in connection with research on new means of increasing fuel economy and engine reliability, further study of the combustion process of TsTM-containing fuels is of interest not only from the theoretical, but also from the practical viewpoint.

An equally important task is increasing engine reliability and service life. When engines are operated on leaded gasolines, the accumulation of combustion chamber deposits increases the octane number requirement.

The present article includes data on the combustion process of TsTM-containing fuels at partial loads and a description of the effect of combustion products of TsTM-containing fuels on engine knock.

In the past, it has been considered that antiknock compounds increase the knock resistance of a fuel but do not affect engine operation under nonknocking conditions. However, it was recently found by applying acoustic spectrometry to the combustion process that antiknock agents also have an effect on combustion under normal conditions [4]. Acoustic spectrograms of normal and knocking combustion were compared, and it was found that auto-vibrations are set up in the engine under both sets of conditions, and that the two types of combustion differ only in the amplitude of the vibrations.

The effect of an antiknock compound shows up first of all in the reduction of shock wave intensity. Therefore, it may be predicted that at partial loads, where the normal course of the working process is disrupted severely, it will be easy to detect any practical effect due to antiknock action. It already had been shown by initial comparisons of the actual fuel consumptions required to attain identical loads (Table 1) that the hourly fuel consumption in engine operation on fuel without additive is 1 to 12% greater than in operation on TsTM-containing fuel, the actual difference depending on engine operating conditions.

For a more detailed investigation of the nature of the change in specific fuel consumption at various engine speeds as a function of load when an engine is operated on fuel with TsTM, the load characteristics were determined for two fuels of the same octane number—A-72 gasoline and A-66 gasoline + 0.8 g TsTM per kg fuel. The characteristics were determined with an MEMZ-966 engine by the GOST 491-55 method.

The load characteristics made it possible to determine the absolute values of hourly fuel consumption at various crankshaft rpm's and at various loads, to calculate the specific fuel consumptions, and to determine the fuel economy of the engine in operation on A-72 and on A-66 + TsTM.

Experimental values of \( \text{P}, \text{G}_f, \text{N}_e, \) and \( \text{g}_e \) are listed in Tables 2 and 3, and the relation between \( \text{g}_e \) and \( \text{N}_e \) is shown in Fig. 1 for A-72 and for A-66 + 0.8 g TsTM (per kilogram of fuel).

\*A-66 gasoline is usually a low-octane gasoline (66 minimum, motor method) with TEL content up to 0.8 g/kg. However, as used in this article, the term A-66 appears to refer to the unleaded base fuel, with octane number slightly below 66—Publisher's note.
TABLE 1. Efficiency of Fuel with TsTM at Partial Loads (MEMZ-966 engine)

<table>
<thead>
<tr>
<th>Load</th>
<th>rpm</th>
<th>Operating time, min</th>
<th>Fuel consumption, kg/h</th>
<th>Relative fuel consumption, %</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>A-72†</td>
<td>A-72† + TsTM (1 g/kg)</td>
</tr>
<tr>
<td>0.25 Pen‡</td>
<td>2000</td>
<td>35</td>
<td>1.62</td>
<td>1.55</td>
</tr>
<tr>
<td>0.36 Pen‡</td>
<td>3000</td>
<td>35</td>
<td>3.06</td>
<td>2.93</td>
</tr>
<tr>
<td>0.37 Pen‡</td>
<td>4000</td>
<td>35</td>
<td>4.05</td>
<td>4.01</td>
</tr>
<tr>
<td>0.5 Pen‡</td>
<td>2500</td>
<td>15</td>
<td>3.49</td>
<td>3.11</td>
</tr>
</tbody>
</table>

*Average values from 10 cycles.
† A-72 is an unleaded gasoline, motor-method octane number 72 minimum—Publisher's note.
‡ Symbols Pen and Pen are shown as in the original, with the subscripts transliterated from the Cyrillic. It is believed that these should all have been Pen, representing maximum effective (brake) load at the given rpm under open-throttle conditions—Publisher's note.

A comparison of the load characteristics shows that operation of the engine on fuel with TsTM improves the fuel economy by 4.8-14.3%. The improvement in fuel economy at engine speeds above 3000 rpm is not more than 1-2%.

If it is considered that an automobile engine under city driving conditions operates at 30-50% of full load, the efficiency of fuels with TsTM under throttling conditions is quite evident.

When an engine is operated for long periods on fuel with TsTM, just as with leaded fuels, metal oxides are formed in the combustion chamber; these, along with other combustion products, are deposited on the walls of the combustion chamber and increase the compression ratio of the engine.

However, as demonstrated by inspections, the combustion products from TsTM-doped fuels, as they accumulate in the combustion chamber, not only do not decrease the allowable spark advance angle based on audible knock (as is the case with leaded fuels), but actually increase the allowable spark advance. For studies of the effect of combustion products of TsTM-doped fuels on the tendency of an engine to knock, a commercial A-66 gasoline with 64.5 octane number (motor method) was chosen. This gasoline was doped with TsTM and with R-9* in amounts required to raise the octane number to 72-73 (motor method).

The effects of the antiknocks on engine knocking tendency were compared by means of long-term test-stand evaluations in an MZMA-407 engine.

Since the deposition of combustion products on the engine parts determines the engine operating regime to a considerable extent, the tests were run under alternating high-temperature and low-

* R-9 is an antiknock additive (fluid) containing 54% TEL (min), 33% bromoethane (min), 6.3-7.3% chloronaphthalene, and balance gasoline, antioxidant, and dyes; bromoethane/TEL ratio 0.61 min—Publisher's note.