The paper presents phonetico-experimental data concerning dynamic tenso palatography technique which makes it possible to correlate the dynamic articulatory processes as the last link of the syllables, words, syntagmas in speech production with their physical characteristics. Analyzed were tensooscillograph records of Russian syllables with the vowel "a" and with initial stop front lingual consonants differing in their hard, palatalized, voiced, voiceless and sonant features.

The study and a statistical analysis of the data received yielded in:
1. The syllable is produced as an articulatory integrity. 2. The syllable includes an aggregate factor manifesting itself in a lesser/greater homogeneity of the components due to muscular tension. 3. Syllables differ according to the mode their articulatory tension develops.

The Kiev State University Experimental Phonetics Laboratory (KSUEPHL) experimental phonetics study of over some recent decades has aimed at a detailed describing the speech production articulatory aspect which was due to both practical tasks (to understand articulatory standardization, to correct pronunciation) and an important objective dealing with syllable- and word-structure.

A syllable, a minimal structural unit of a spoken speech stretch, has an aggregate factor enabling to find its wholeness and continuity as an original chain structuring lexical and syntactical language events.

The study of syllables and words dynamic manifestations makes it possible to treat them resulting from the final chain speech production - one of the speech activity processes. An articulatory process thus turns out to be immediately related to the language (phonological) speech study: the syllable/word articulation presupposes the producing of language units functioning as spoken text components elsewhere. The academician L.V. Shcherba theory suggests that the syllable production and division is dependent on the muscle tension impulses which are responsible for a consonant power changeability within a syllable.

This hypothesis experimental test made us to design a technique enabling us to record articulatory tension and its progress within a syllable, a word and word sequence.

The papers and books on phonetics have not yet had experimental evidence concerning the tension growth within a syllable, though the syllable peak (a vowel in most languages) is believed to be made with the most tension possible. There were some ideas presented as to the consonants articulation heterogeneity which is due to the tension.

Yet there are no data available on vowels heterogeneity based on the feature in point. The consonants tension is assumed to result from their being voiceless/voiced; from the syllable being stressed/unstressed; from their position in a syllable or a word (opening/closing).

Strong-ended consonants, voiceless and consonants in stressed syllables opening a word are believed to be more tense. The KSUEPHL has designed a technique for the tongue pressure on the palate (palatum durum) to be investigated. The power exercised by the tongue muscle is known as a mechanical one. Thus with consonants this power can be defined as the pressure upon some rigid surface. A technique combining tensometric processing with palatography and oscillography has been created to answer a number of points: how articulatory tension changes in lingual consonants within articulated syllables and words; the way the muscle tension manifests itself within a syllable; what the syllable peak is (whether it is a definite and the most tense point, the attainment of which is immediately followed by a relaxation, or whether it is a segment more or less elongated); the way the motor impulse of muscle tension is being produced, whether there is the inaccessibility of the impulse and what it is
manifested in.

The technique is called tensopalatography.

The technique in point (see first described - 7) makes it possible to correlate the physical characteristics of speech (of syllables, words and names as groups) to simultaneously registered articulatory organs movements. The oscillograph record not only acoustic signals but the tongue pressure impulses upon the roof of the mouth as well, when which analysis can appreciate the articulatory tension, the articulatory duration and compare these features with signals acoustic durations.

The sensory (sensing) elements in the pressure electric measuring element were minute (2 mm base) wire tensometers.

The measuring elements taring enabled us to value the tongue pressure impulses. The recording apparatus was a rotating mirror oscillograph. The oscillograph record simultaneously showed pressure signals from two measuring elements and the speech acoustic picture. (Comp.2,12 and 5).

To choose indicator position on the palate plate there has been made a standardization of consonants and vowels articulatory contacts according to the Russian speech sounds palatography evidence taken from the EKSNPHL phonetical archives. The contacts in question were grouped into three types. Each of the three speakers, the participants of the experiment, had three separate palates specially made. Each of the palates with two (front and side) detectors attached to it served as an integrate detector. (see fig.1) through the two channels of which the oscillograph record had signals registered. The registered tongue pressure signals looked like impulses having the front, the peak and the cut-off of their own. The impulses did not superimpose with acoustic signals boundaries.

The impulse form and such of its parameters as amplitude and peak duration burdened with one or several peaks, constantly varied due to the syllable components structure. Different impulse forms were analyzed; this resulted in determining six impulse types: 1) a rectangular one having the peak length with relatively low amplitude; 2) a triangular one having a minimal peak duration, an increasing front and a descending cut off; 3) a bell-formed one also having a minimal peak yet having soft prominent front lines and cut off; 4) impulses with a complicated compound form having but one peak; 5) complex impulses with two peaks; 6) blending impulses having adjoining peaks. (See fig.2).

Further tongue pressure impulses analysis and measuring made us have the parameters as followed: a front duration, a peak duration, an articulatory integrated duration. The front duration and the pressure increase velocity were correlated with the greater the velocity and consequently, the higher pressure at the syllable beginning.

The cut off duration determined the pressure decreasing time, tension heterogeneity/homogeneity at the juncture of a consonant and a vowel. The angle between the zero-th and the beginning front lines as well as the front duration indicated the pressure progress speed; the angle growth corresponds to the pressure increase speed growth.

The impulse peak duration was interpreted in terms of: a) a peak line uniformity/form; b) the duration of the level part of the peak; c) the existence of front and cut-off, a) in the beginning part of a peak duration.

The uneven peak line growth indicates the uneven pressure manifestation with its maximum observed within a relatively stable segment.

The technique serves for describing and measuring the boundaries correlation between the syllables and word articulatory and acoustic duration. The tensopalatographic record of syllables with initial stop consonants displays the development of their first components - consonants; their syllables being registered in zero-shape. It makes it interesting to describe coincidences of the final segment in the pressure impulse and the start of the acoustic signal for the syllables differing in modal indications: the voiced beginning syllables, voiceless beginning syllables and sonant beginning syllables.

The basic indicator employed was an acoustic signal. All the impulses pressure observed after the acoustic signal switched on were assumed to be retarding or slow and had minus index during the evaluating procedure. Plus index was attached to the parameters being ahead of the signal attack. Thus, the technique makes a foundation to investigate the problem of interdependence articulatory and acoustic features. / 6

The syllable analysis based on impulses shape yielded the description to follow. The initial components of all syllables displayed on the oscillograph record took the shape of the first class impulses. Hard consonants syllables preferred the 1, 4 shape (rectangular impulse with a gradual front and cutting off). Syllables with initial palatalized stop consonants preferred the 1, 2 shape (rectangular with a steppe front and cut-off).

Initial voiceless hard syllables differed from those with initial voiced and nasal consonants by belonging to the 1, 4 class, while voiced and nasal consonants - to the 1, 2 class which indi-

Figure 1. a) The artificial palate with the front and side pressure detectors; 1 - front detector, 2 - side detector. b) Tensopalatograph record of the syllables /t/ [t], /n/ [n], /t̪/ [t̪], /n̪/ [n̪], /d̪/ [d̪], /d̪/ [d̪].

Figure 2. Types of the impulses.

Figure 3. Impulses of the investigated syllables.
cates the lack of identity in the growth and decline of tension in the syllables. The palatalized stops syllables of those consonants which differed from hard consonants syllables by their vocal nuclei, respectively, those with voicing, manifested the same amplitude and a relatively unchanging manifestation of peak duration. The homogeneity in the difference of voiceless and voiced syllables of both consonant groups (hard and palatalized) shows that voiced and nasal syllables differ from voiceless as having a special, smoother tension growth at the consonant-vowel transition. The tension grows in voiceless syllables with initial hard and palatalized consonants of is of overall nature — an abrupt transition at the consonant-vowel boundary. The analysis of all syllables with hard and palatalized consonants with respect to their impulses shape enabled us to distinguish long syllables impulses with the same amplitude and a relatively unchanging manifestation of peak duration. Here belong the initial voiceless syllables and those with hard and palatalized consonants. The second group contains the syllables with the initial voiced and nasal consonants having the impulse shape whose tension is found less stable concerning their peak duration manifestation and respectively, a short period of time. The first syllables have more consonant-voiced long syllables, i.e. of a consonant-voiced nature. The second group is of mixed character, i.e. of a consonant-voiced or a mixed nature. The tension change (the overfall during consonant vowel juncture) is more pronounced with the voiceless syllables and less pronounced with the voiced syllables. The second group of syllables is characterized as a natural manifestation for voiceless and palatalized, recorded with identical amplitude and from the same articulatory duration of signal. The most autonomous (see A and B) are the initial voiceless components; the voice and the sonant syllable enable us to express the most contrastive, relative homogeneity of the parameters (see above). The greater manifestation of relations between the initial voiceless and the nasal for het—

The table of syllable tension. Impulses and ratios

<table>
<thead>
<tr>
<th>Syllables</th>
<th>Front (F)</th>
<th>Cut-off (c)</th>
<th>Amplitude (A)</th>
<th>Parameters</th>
</tr>
</thead>
<tbody>
<tr>
<td>Front</td>
<td>36 59 61</td>
<td>64 91 118</td>
<td>3.5 43 42</td>
<td>Front/Cut-off (Dac.)</td>
</tr>
<tr>
<td>Cut-off</td>
<td>34 50 52</td>
<td>58 65 65</td>
<td>1.5 43 41</td>
<td>Amplitude (A)</td>
</tr>
<tr>
<td>Articulatory duration of signal (3 art.)</td>
<td>354 325 350 326 339</td>
<td></td>
<td></td>
<td>354 430 410 452 448</td>
</tr>
</tbody>
</table>

Note: The table gives statistical data obtained from tensive-syllables with constant amplification on the same artificial palate of one speaker.

REFERENCE

2. Бородин И. Ф. Фонетика русского языка в свете экспериментальных данных. Л.: Языки рус. нар., 1971, с. 226-256.