

GRAND PIANO MANUFACTURING IN ESTONIA: HISTORICAL REVIEW

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Abstract. The history of piano manufacturing in Estonia was reviewed. The purpose of a recent collaborative project between the Tallinn Piano Factory and the Institute of Cybernetics of Estonian Academy of Sciences was to improve the musical quality of the instruments produced by the Factory. The design of almost a new instrument - the Estonia-Minion grand piano under development at the Tallinn Piano Factory was described.

1. INTRODUCTION

The Tallinn Piano Factory is known worldwide. Had the piano makers started from nothing, such a rapid and successful development would hardly have happened. Historically, the famous piano company Estonia developed from small piano workshops, as a result of the experiments and attempts to improve the pianos. The present study gives a brief survey of the development of Estonian piano companies from the late 18th century to 1995.

2. THE LATE EIGHTEENTH CENTURY

The earliest data about piano makers in Estonia go back to 1779. In a Tallinn weekly *Nädalaleht* advertisement, Johann Friedrich Gräbner [1], wrote that he made pianos (clavichords), harpsichords (cembalos), fortepianos (hammer claviers), upright pianos, positives (small and portable organs), harps, and lutes. Such a universal instrument maker came from Bremen at the beginning of March, 1779. Partly because of no competition, he was fast to find his customers. Apart from that, he taught his skills both to local and foreign apprentices. Among them was Christian Ludwig Werner who studied for four years at Gräbner's. On February 9, 1786, he was promulgated a journeyman by Gräbner. The fact that he achieved it working alone was exceptional because in 1784, Johann Gottfried Neidhard, another instrument maker, worked in the lower town. In *Revaliche Wöchentliche Nachrichten* (no.52, 1796) Neidhard denied the rumours as if he had stopped making the pianos and invited everybody to look at his recent made musical instrument.

Most probably Gräbner, the maker of organs and other musical instruments for the knighthood, working on the Tallinn Toompea, was subject to the Toompea laws and therefore could promulgate his apprentice a journeyman without Neidhard's participation in the procedure.

3. THE EARLY NINETEENTH CENTURY

L. Erich was the piano maker in Tallinn from 1815 to 1824. Hans Heinrich Falck his apprentice, later founded his own piano factory and became his main competitor. The dynamic amplitude of the pianos made by Erich was limited, and the pianos had only one pedal. (One of his pianos, the oldest Estonian made piano and the oldest one known to have come down to the present time, is exhibited in the Tallinn Theatre and Music Museum.) Erich's company impoverished and the owner died in 1824.

In 1815, F. Lorenz advertised in *Revaliche Wöchentliche Nachrichten* that he had started making pianos and hoped that his instruments would be as good as the foreign ones.

Hans Heinrich Falck [1] was the most outstanding instrument maker in the first half of the 19th century. Falck opened his piano factory on April 4, 1818. In the first year, he mainly tuned and repaired the pianos. The squires did not want to bring their pianos to town as repairs were expensive. Falck found a way out - he travelled around Estonia and repaired the pianos upon order. His fame spread all over the country, and his company prospered. By the end of his first year, he had employed four journeymen, and in 1822, he already had 12 journeymen and 24 apprentices. His factory made the grand pianos and cottage pianos with wooden frames and iron supports.

In the first half of the 19th century there were other piano makers in Estonia: C.L. Gönson, F. Hasse, Meyer, Mirsalis, Weisner. Unfortunately, there are no more available data about them.

4. THE LATE NINETEENTH CENTURY

Piano making was in full swing in Estonia [1]. In 1853, T.E. Sopha, a piano maker, advertises his pianos in the newspaper. At the same time, Goldorff was active, and since 1868 R. Rathke's factory worked in Tartu. There were sixty five workers in Rathke's factory in 1890. It burnt down in 1892. All in all, sixteen pianos and upright pianos were made at the factory.

In about 1865, J. Moriz founded his company in Tartu, which operated until 1918. Based on that company, O. Heine's Piano Factory started in the same year. At the end of the century, there were two more companies in operation: 1890-1917 – J. Priske's and 1895-1925 – M. Oss's and Saarmann's.

J. Tusty's piano factory, founded in 1896, was in Suur-Karja Street, Tallinn. In 1906, it employed eight or nine workers. K. Saar studied tuning there. In 1916, Tusty left for the U.S.A. and was a foreman at Steinway Co & Sons.

J.R. Pöörmann, a teacher of the Tartu Music School, recalls J. Rässa's factory as follows: "The factory was situated at 86 Tiigi Street. I came there in 1924. Besides me, there were about fifteen workers. Most of the work was done by hand. There was a steam boiler, later replaced by an engine. Rässa worked side-by-side with us. He was a relative of mine. One of the best specialists was Reino who assembled the mechanisms."

Romm, a piano maker (who worked in 1895 - 1917, according to some data until 1898), was a germanized Estonian. He made the pianos mainly for the barons, who all had them made by Romm.

Leppenberg, a piano maker from St. Petersburg, knew Romm and said, "Romm is super, the others do not know anything." Romm's pianos had a really rare sound and were long-lasting. Eevald Aav composed his opera "Vikerlased" on Romm's piano. (The piano is now at the Theatre and Music Museum). Later, Romm's company was taken over by Jurgenson.

5. THE EARLY TWENTIETH CENTURY

Orntlich's piano factory, founded in 1905 or 1906 in Tallinn, was situated where the Hollywood Club is today. They started their business with harmoniums (I-II manuals). Before 1907 they had made one upright piano. With the war starting, work was interrupted but was resumed in 1922. A. Bürger, the future owner of the piano factory and A. Kurmet, the tuner of Tallinn Piano Factory, both were his disciples. In 1935, Orntlich employed Altmets, who had studied with his relative Leppenberg, a piano maker in St. Petersburg. Altmets was responsible for adjusting mechanisms and tuning. Most of the work in Orntlich's factory was done by hand. They only had a circular saw turned by foot.

After the 1917 revolutionary events, over thirty tuners and piano makers from St. Petersburg settled in Tallinn. Piano production developed rapidly, and Estonian instruments were competitive on the world market. Raw materials were mostly supplied from Germany (mechanisms, pear veneer) by Schenker and Co.

Mihkel Salong started making pianos in St. Petersburg in 1905 and worked there until 1917 when he returned to Estonia and founded his company in Kuressaare.

Between 1910 and 1940, H. Jurak (Hermann), a piano maker, worked in Tartu. Due to his long-term experience, he succeeded in making a new good model of the concert upright piano. His upright pianos have an extraordinary gentle, merging and long-lasting tone, producing all possible voice variations as the upright piano has a precisely and lightly functioning mechanism. The tone will last for thirty seconds (seven to ten seconds longer than the previous pianos). This technique is a step forward in piano making. The Hermann instruments, displayed at an exhibition in Tartu, won the highest prize – the big gold medal.

Earlier, the single soundboard was made of spruce boards of the same thickness. Wooden ribs (from nine to twelve per instrument) were glued on the soundboard. Jurak introduced a double soundboard. It was made of spruce boards in two different thicknesses with the soundboard glued together against the grain. Thus, Jurak attempted to increase the sound and improved the quality of voicing. His contemporaries tell us that his experiment was a failure. It was impossible to achieve absolute coalescence in glueing. By chance, one instrument out of a hundred could succeed .

Jurak built his pianos alone without help. His instruments were of perfect finish. The Piano Company Vanemuine developed from his company.

Tõnis Olbrei, a piano maker, his brother Jaan and August Krämänn, a builder, merged their companies and started making pianos, harmoniums, mandolins, guitars and

other musical instruments in 1905. On September 7, 1905, the pianos and harmoniums made by Krämänn Co Olbrei won the first prize at the Estonian farming and handicraft exhibition. During thirteen years, Krämänn Co Olbrei produced about five hundred upright pianos, fifty harmoniums and many other instruments.

Upon Jaan Olbrei's death in 1918, Tõnis inherited the workshop. First, he made the pianos using the name Krämänn - Olbrei. T. Olbrei produced the same instruments like his predecessors and operated until 1944. Already in 1920s he moved to the new premises. Under his name, twenty pianos, fifteen harmoniums and an organ in 1938 were made .

O. Heine's company, based on Moriz's operated from 1918 to 1944. This factory makes even piano mechanisms and keyboards that had been imported exclusively before. O. Heine's piano factory was the sole producer of these parts in Estonia. Thus, every inch of his piano is homemade. Sales were centered on upright pianos since the grand pianos were too expensive in the economic situation.

The piano factory Astron started with three workers and a manager on January 1, 1923. The first upright piano was completed in four months. In 1923, they displayed six upright pianos at the trade and industry exhibition [2]. The upright piano Astron was compared to Bechstein at the concert. By 1924, the factory had already forty workers, and they had won forty gold medals at exhibitions. E. Hiis, the manager of the company, had thirty three years of experience in piano industry in Russia and at Blüthner's. According to Hiis's drawings, parts of a piano were made in Estonia, except

for resonance boards, imported from Bucovina (stored in the open air for six or seven years), beech and oak veneer from Hamburg, strings from Röslau, red copper wire from Samaria, mechanisms from Berlin, and keyboards from Hamburg.

In May 1926, E. Sprenk-Lätte founded his own piano factory in Tartu. The maximum annual output was forty upright pianos. (Small upright pianos of 7 octaves and concert upright pianos of 7 1/4 octaves). Apart from these, two grand pianos were made during the operation of the factory.

Upon E. Sprenk-Lätte's death on March 6, 1932, his brother A. Läte inherited the factory. He attempted to improve the quality of the pianos: the moderator felt was replaced by silk, the lift of an upright piano opened 45° to gain a better sound. Läte had also a small self-made keyboard for experiments.

In his booklet A. Läte writes: "We know that sound is created by air thickening and thinning. Nevertheless my personal opinion is different. I claim that sound is born by breaking atoms. As a result of an increasing force, air atoms break into electrons and ions – now called even protons. The broken atoms join, the force and speed of fusion creates sound, its height and depth".

To open his company, Karl Saar bought equipment from Tusty and Olberg. His company made five pianos a month. Saar used double action. In 1929, he got a patent for constructing an extra slat of wood. It was a long batten across the ribs of the soundboard, and an extra slat was glued and screwed onto the ribs. Thus, Saar attempted to prolong the age of pianos, as time would change the shape of the sound board. The sound would

also carry better. In 1936, at the agricultural exhibition in Tallinn, his upright piano won the highest prize – the gold medal.

Ernst Hiis was by far the most talented and honored Estonian piano maker. In 1903, he founded his own company named E.A. Ihse. Since 1907, in addition to working in his company, he was a turner at Zimmermann's company. In 1912, he spent twenty five days in Germany, practising at the Steinway factory. On July 1, 1915, Hiis sold the equipment of his factory to the R.A. Dietrich brothers, and recommended by pianists Rahmaninov and Silot, started as a leading expert and a constructor at the above company where he worked until 1918.

At the end of 1918, Hiis returned to Estonia. Between 1919 and 1922 he worked at Moor's piano factory in Tartu. In 1923, Hiis went to Paris and visited the Erard's piano factory – the oldest in France, founded in 1775, and also Gaveau's piano factory. From 1923 to 1926, he was the leading expert and manager of the Astron piano factory. In 1927, he opened his own workshop to make upright pianos and baby grands. A specification of the piano made by E. Hiis is as follows: A baby grand – 1.65 or 1.75 m long, 1.5 m wide, 7 1/3 octaves. Double action. Tops of hammers covered by the moisture proof Weickert felt. Black color, mahogany, Caucasian walnut. Mechanisms from Paris or Stuttgart. Strings made by Röslau or Pöhlman. Soundboards of Bucovina spruce. Iron frame withstands 18,000 kg of tension.

For some reason, Hiis has never made pianos under his own name. He went to the Mit's company and worked under the name of J. Beckner. Before the war, Hiis set up a

cooperative *Heli*, chaired by him. Thus, E. Hiis is a landmark in the history of Estonian piano manufacturing. His name ends the period of two hundred years of private piano companies in Estonia and begins a new period – the foundation of the Tallinn Piano Factory.

6. TALLINN GRAND PIANO FACTORY

The Second World War stopped piano manufacturing in Estonia. The factories were destroyed. Only Ernst Hiis continued his grand piano production. His attempts to resume grand piano manufacturing in Estonia were successful. In September 6, 1950, by the order of J. Stalin, based of the People's Furniture Factory, the Tallinn Piano Factory was established, and the new grand piano was named *Estonia*. This day is the founding date of the Tallinn Piano Factory. Osvald Kuub was the first head of the new factory, and Ernst Hiis was the chief engineer.

In April 6, 1951, the first grand piano *Estonia* was presented to the State Board. In 1953, the first medium-sized grand piano was produced. In 1958, the Tallinn Piano Factory was awarded by a silver medal at the World Exhibition in Brussels. Since 1960, the white grand piano *Estonia* adorns the Georgian Hall in the Moscow Kremlin.

The *Estonia* pianos are widely known throughout the world because of their fine timber, perfect sound and high technical characteristics. Concert halls, music parlours and music schools all over the world have the *Estonia* pianos.

The *Estonia* pianos have been exported to seventy countries. Many celebrated pi-

anists, such as Emil Gilels, Van Cliburn, Eugen Kelder, Dmitry Shostakovich, Leonard Hokanson, Artur Lemba, Daniel Pollack, Oskar Peterson, Anna Klas, Bruno Lukk, George de Godzinsky, Kalle Randalu, Peep Lassmann, Dave Brubeck, and Mati Reinman have performed the *Estonia* pianos. They all have expressed their appreciation. In 1961, Daniel Pollack, as the guest of the Tallinn Piano Factory wrote: "I would like to take this opportunity to tell you how pleased I was to play the *Estonia* concert piano. It is indeed a wonderful instrument and has a lovely tone – which is the most important quality for any instrument".

The *Estonia* pianos are handmade, built by the artists of their craft who use long-term experience of Estonian piano-making, passed on from generation to generation.

In the 1970s, the *Estonia* piano was tested by the *Brüel and Kjaer* electronic equipment. After these experiments, the new models of the three-pedal *Estonia – 5* concert piano and the two-pedal *Estonia – 6* concert piano were developed. At the end of 1970s, the new model of the medium-sized *Estonia – 7* piano was produced. An enormous experimental work was done to develop the medium-sized *Estonia – 8 Chippendale* piano (Fig. 1). This is the three-pedal piano with the range of 7 1/4 octaves. Its short characteristics are: casework - mat, white; frame - open type, bronzed cast-iron; steel strings from *Röslau*; pinblock made of *Delight* material; turning pins from *Biene*; key-action from *Schwander*; double repetition with tonekeeper; furls of brass, polished; length – 1892 mm; weight – 330 kg.



Fig. 1. The medium-sized *Estonia – 8 Chippendale* piano.

This piano was awarded the gold medal at the 1987 Leipzig Autumn Fair. Currently, the Tallinn Piano Factory is the only manufacturer of the grand pianos in the former Soviet Union, Baltic States and the Scandinavian countries.

7. CURRENT PROJECTS

In 1990, a collaboration offer came from the Institute of Cybernetics Estonian Academy of Sciences. This offer to the Tallinn Piano Factory concerned constructional problems, contributing to the improvement of the quality of the piano. A two-year contract was concluded. The research team from the Institute of Cybernetics included Naum Veksler, Anatoli Stulov, Arkadi Berezovski, and Monika Perkmann. The topic was specified as the theoretical investigation of the acoustical features of the grand piano.

N. Veksler, who investigated the structure of the string set, studied the measurable set of strings of the *Estonia* grand piano and proposed a new improved set of strings. Thus, new lengths and diameters of the strings were chosen, and the new diameters of the bass strings and their inharmonicity were calculated. A. Berezovski analyzed the influence of the geometry, mass and stiffness of the hammer felt on the quality of sound production. A. Stulov concentrated on the hammer-string interaction. A method of matching of the hammers to the piano was suggested, and the hammer models were developed. The first simple model of the hammer felt is described in [3], and the hysteretic hammer felt model in [4, 5]. The interaction between the hammer and the string is described in [6].

The results of these investigations were presented in the Report on Contract *no* 8140, and in the Research Reports of the Institute of Cybernetics [7, 8].

A new half-year contract between the Institute of Cybernetics and the Tallinn Piano Factory was concluded in 1995. The team consisting of N. Veksler and A. Stulov from the Institute of Cybernetics and M. Kokla and A. Laurik from the Tallinn Piano Factory is developing a mini-sized *Estonia-Minion* piano (163 cm in length).

To accomplish this, much effort was made to design a small-sized soundboard. Several novel types of the soundboard were considered. One of these to be used in the new piano is shown in Fig. 2.

This is the soundboard of the diaphragmic type with variable thickness. The levels of constant thickness, varying by 1 mm, are marked by numbers. At the center of the

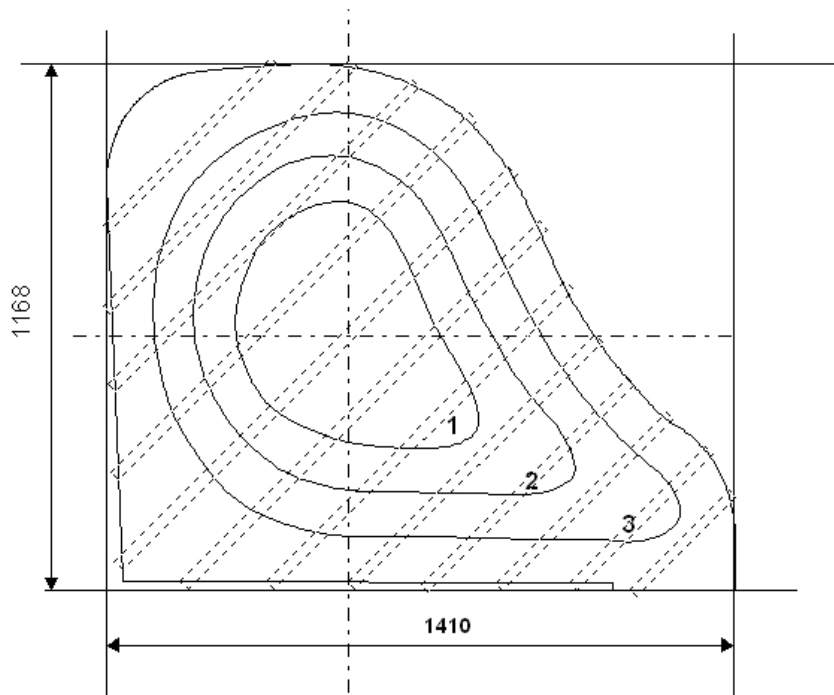


Fig. 2. The soundboard of the mini-sized *Estonia – Minion* piano.

soundboard, thickness equals 9 mm and on the sides 6 mm. Across the soundboard there are twelve ribs (shown by dashed lines), varying in cross-section and profiles. A new iron frame was designed. The numerical calculation shows that this light frame can hold the load due to the string tension up to 200,000 N.

The measurable set of strings to the *Estonia – Minion* piano was calculated by

$$T = (2fL)^2\mu, \quad (1)$$

where

T – string tension; f – note frequency; L – string length; μ – linear mass density of the string.

As the value of frequency for each note is known, by matching the lengths of the strings and their linear mass density, the appropriate tension of the string was obtained.

The mensura calculated to the *Estonia – Minion* piano is shown in the Table.

Mensure of the *Estonia – Minion* piano.

n	$f[Hz]$	$L[mm]$	$l[mm]$	$T[N]$	N	$\mu[g/m]$	$d_1[mm]$	$d_2[mm]$	$d_3[mm]$
1	2	3	4	5	6	7	8	9	10
1	27.5	1239.2	150.2	1019.4	1	219.4	1.500	0.700	1.700
2	29.1	1231.1	149.1	1058.5	1	205.6	1.400	0.650	1.700
3	30.9	1220.8	147.8	1056.8	1	186.0	1.400	0.600	1.600
4	32.7	1210.5	146.5	1106.2	1	176.5	1.350	0.650	1.500
5	34.7	1197.8	144.8	1111.0	1	161.2	1.300	0.550	1.500
6	36.7	1185.2	143.2	1153.9	1	152.3	1.250	0.500	1.500
7	38.9	1171.5	141.5	1171.3	1	141.0	1.250	0.500	1.400
8	41.2	1156.6	139.6	1182.7	1	130.2	1.250	1.800	
9	43.7	1140.6	137.6	1238.8	1	124.9	1.250	1.750	
10	46.3	1125.7	135.7	1243.8	1	114.7	1.250	1.650	
11	49.0	1108.5	133.5	671.5	2	56.9	1.000	1.100	
12	51.9	1098.2	132.2	694.7	2	53.4	1.000	1.050	
13	55.0	1075.4	129.4	700.9	2	50.0	1.000	1.000	
14	58.3	1057.1	127.1	723.8	2	47.6	1.025	0.950	
15	61.7	1040.0	125.0	734.4	2	44.5	1.025	0.900	
16	65.4	1024.0	123.0	744.4	2	41.4	1.025	0.850	
17	69.3	1004.6	120.6	774.1	2	39.9	0.975	0.850	
18	73.4	987.4	118.4	778.9	2	37.0	0.975	0.800	
19	77.8	968.0	116.0	793.6	2	35.0	1.000	0.750	
20	82.4	949.8	113.8	791.8	2	32.3	1.000	0.700	
21	87.3	924.7	110.7	824.4	2	31.6	0.975	0.700	
22	92.5	909.9	108.9	823.4	2	29.0	0.975	0.650	
23	98.0	889.4	106.4	863.3	2	29.0	0.950	0.650	
24	103.8	871.1	104.1	871.1	2	26.6	0.975	0.600	
25	110.0	850.6	101.6	893.3	2	25.5	1.025	0.550	
26	116.5	831.2	99.2	911.7	2	24.2	0.975	0.550	
27	123.5	1031.0	123.0	925.0	2	14.2	0.975	0.300	
28	130.8	1007.4	120.1	905.8	2	13.0	1.000	0.250	
29	138.6	985.3	117.4	939.0	2	12.5	0.975	0.250	
30	146.8	964.1	114.8	626.0	3	7.8	1.125		
31	155.6	939.5	111.8	638.2	3	7.4	1.100		
32	164.8	912.3	108.5	644.8	3	7.1	1.075		

Table (continued)

1	2	3	4	5	6	7	8	9	10
33	174.6	888.4	105.6	655.5	3	6.8	1.050		
34	185.0	855.3	101.6	650.0	3	6.4	1.025		
35	196.0	823.8	97.8	676.8	3	6.4	1.025		
36	207.6	788.9	93.6	662.3	3	6.1	1.000		
37	220.0	747.3	88.6	667.1	3	6.1	1.000		
38	233.1	711.4	84.3	678.6	3	6.1	1.000		
39	246.9	681.4	80.7	664.8	3	5.8	0.975		
40	261.6	651.4	77.1	682.0	3	5.8	0.975		
41	277.2	617.1	73.0	687.0	3	5.8	0.975		
42	293.7	580.3	68.6	681.9	3	5.8	0.975		
43	311.1	550.2	65.0	688.1	3	5.8	0.975		
44	329.6	515.8	60.9	678.8	3	5.8	0.975		
45	349.2	491.5	58.0	691.8	3	5.8	0.975		
46	370.0	466.4	55.0	663.5	3	5.5	0.950		
47	392.0	441.2	52.0	666.4	3	5.5	0.950		
48	415.3	424.5	50.0	692.5	3	5.5	0.950		
49	440.0	399.3	47.0	687.7	3	5.5	0.950		
50	466.2	374.0	44.0	677.2	3	5.5	0.950		
51	493.9	351.1	41.3	669.9	3	5.5	0.950		
52	523.3	333.2	39.2	677.2	3	5.5	0.950		
53	554.4	318.8	37.5	695.9	3	5.5	0.950		
54	587.3	300.1	35.3	692.2	3	5.5	0.950		
55	622.3	286.4	33.5	670.8	3	5.2	0.925		
56	659.3	271.8	31.6	678.1	3	5.2	0.925		
57	698.5	256.9	29.7	680.0	3	5.2	0.925		
58	740.0	245.3	28.2	695.9	3	5.2	0.925		
59	784.0	231.9	26.5	698.1	3	5.2	0.925		
60	830.6	220.9	25.1	673.3	3	5.0	0.900		
61	880.0	208.3	23.5	672.0	3	5.0	0.900		
62	932.3	198.6	21.6	685.7	3	5.0	0.900		
63	987.8	187.4	19.6	685.3	3	5.0	0.900		
64	1046.5	176.0	17.7	678.5	3	5.0	0.900		
65	1108.7	168.7	16.3	661.9	3	4.7	0.875		
66	1174.7	160.1	15.8	669.2	3	4.7	0.875		
67	1244.5	151.3	13.5	670.8	3	4.7	0.875		
68	1318.5	143.0	12.2	672.6	3	4.7	0.875		
69	1396.9	134.8	11.1	670.9	3	4.7	0.875		
70	1480.0	127.5	10.1	673.7	3	4.7	0.875		
71	1568.0	121.4	9.2	685.6	3	4.7	0.875		
72	1661.2	114.1	8.3	679.8	3	4.7	0.875		
73	1760.0	109.3	7.7	700.2	3	4.7	0.875		

Table (continued)

1	2	3	4	5	6	7	8	9	10
74	1864.7	104.5	7.0	677.4	3	4.4	0.850		
75	1975.5	99.3	6.4	686.5	3	4.4	0.850		
76	2093.0	94.8	5.9	661.4	3	4.2	0.825		
77	2217.5	89.6	4.5	663.2	3	4.2	0.825		
78	2349.3	84.5	4.8	662.1	3	4.2	0.825		
79	2489.0	80.3	4.4	671.1	3	4.2	0.825		
80	2637.0	77.1	4.1	694.5	3	4.2	0.825		
81	2793.8	73.0	3.7	698.8	3	4.2	0.825		
82	2960.0	69.0	3.4	700.8	3	4.2	0.825		
83	3136.0	65.9	3.1	674.8	3	3.9	0.800		
84	3322.4	64.0	2.9	671.0	3	3.7	0.775		
85	3520.0	61.0	2.6	684.2	3	3.7	0.775		
86	3729.3	58.0	2.4	694.3	3	3.7	0.775		
87	3951.1	55.0	2.2	700.8	3	3.7	0.775		
88	4186.0	52.0	2.0	703.1	3	3.7	0.775		

Here l is the distance of the hammer from nearest string end, N is the number of strings in choir, d_1 , d_2 , and d_3 are the diameters of the kernel, the first winding, and the second winding wires, respectively. These diameters were obtained from the linear mass density of the string, taking into account that the kernel wire is made of steel, and the winding wires are always made of copper. Strings lengths and the place of the striking point were calculated in accordance with the new dimensions of the piano to obtain the suitable string tension.

The tension of the string calculated is shown in Fig. 3. Figure 3A shows tension distribution per each string of the piano, and Fig. 3B illustrates the same tension distribution per choir, or the same per note. All the calculation were made so as to obtain the unbroken form of tension distribution per choir, as well.

Such kind of the string tension gives a more uniform spectra of string vibrations for the notes with the different number of strings per choir. In this case, the total tension applied to the frame is equal to 161,900 N.

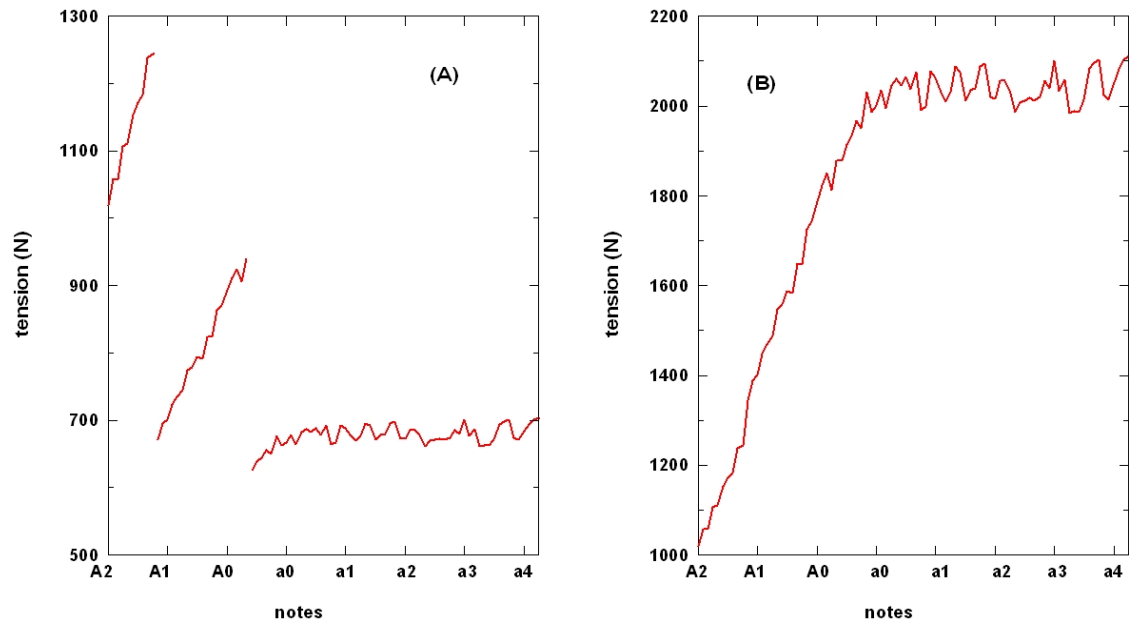


Fig. 3. The tension distribution for the mini-sized *Estonia – Minion* piano: A - tension per string; B - tension per choir.

The first samples of the new *Estonia – Minion* piano were completed by the end of 1995, and they are the wonderful instruments, indeed.

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