The first remote recording of gramophone records in continental Europe (Zagreb, 1927) for HISTELCON 15

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Abstract – In 1926, in an alliance between the Zagreb pencil factory Penkala and the English company Edison Bell, a gramophone and gramophone record factory, was founded in Zagreb, under the name Edison Bell Penkala. In 1927 experts from that factory undertook the first remote recording of a gramophone record in continental Europe, using a telephone line. This was the third recording in the world, after the recordings in the New York Metropolitan opera house and in London's Covent Garden. This article describes the technical recording methods used, from the microphone in Zagreb Cathedral, to the gramophone record cutting machine in a studio about 1250 m away. The recording arrangement was developed by Paul Voigt, an electrical engineer from Edison Bell Company who spent the second half of 1927 in Zagreb. It also describes the development of the necessary scientific base in Croatia from 1875 to the Second World War for such an enterprise.

I. Introduction

At the time when I was collecting information and writing the article, I read a book entitled *The Secrets of the Hittite Empire* written by Vojtèch Zamarovský [1]. The Hittite state was founded in about 1800 BC; and fell in about 1190 BC, it stretched from the shores of the Mediterranean Sea around Cyprus, almost to the coast of the Black Sea (the capital of the Hittite state Hattusa was about 1000 km as the crow flies from Tel Aviv). With the fall of the Hittite state, the Hittite script and language were forgotten, in brief that is, the entire Hittite culture and history. On the basis of artefacts discovered (clay tablets with hieroglyphics, archaeological digs of its cities), and knowledge of the culture and history of neighbouring nations, in the first half of the 20th century the Hittite language was reconstructed and the Hittite culture and history established chronologically.

Analogously, the reconstruction of the technical execution of remote recording of a gramophone record over a telephone line in Zagreb in 1927 is based on written documentation (there are no longer any people alive who undertook that recording or who took part in it) and on knowledge of the cultural, economic and scientific environment of Zagreb, Croatia and England. It truly is a matter of scientific archaeology.

The method used for reconstruction of the technical execution of remote recording is the method of modelling. From a number of known facts related to the event, we selected only a few, the rest were left aside. It was not possible to take unknown facts into account. So the model created of the technical execution of the recording only describes the actual event in some respects. However, this is not a weakness, because even if we knew many times more facts, we would still have to select only some of them according to the aim of understanding the event. History is possible, even if many facts remain hidden.

II. Newspaper documentation of the recording

In the Zagreb dailies *Jutarnji list* (*Morning newspaper*) and *Novosti* (*News*) of 3 December 1927, an advertisement was published by the Zagreb gramophone and record factory Edison Bell Penkala, inviting the public to a public recording of Christmas carols, which would take place in the Zagreb Cathedral on Sunday 4 December 1927, at four p.m., Fig. 1. The advertisement

stated that a choir of Zagreb clergy, with the participation of the public, would be conducted by the opera master N(ikola) Faller.

I expected that a review of the recording of the Christmas carols would be published in the magazine *Sveta Cecilija* (*Saint Cecilia*), in the Music Supplement, giving an overview of the musical events of the previous year, in the January/February 1928 edition [3], especially because the organist Franjo Dugan sen. was a member of the editorial board of the magazine and editor of the musical supplement. I examined the years 1927 and 1928, but found nothing.

Figure 1: Announcement by the company Edison Bell Penkala in *Jutarnji list* of 4 December 1927, of the public recording of Christmas carols in Zagreb Cathedral, conducted by Nikola Faller, the director of the Opera of the Croatian National Theatre (HNK) in Zagreb

III. The First Publication of Publicly Recorded Christmas Carols

In *Jutarnji list* of 29 January 1928, in the unsigned article entitled: "From the World of Gramophones", it says:

"...Since the gramophone has been common place in our homes for a long time now, many of us were interested in the origins of its wonderful records (Carus records). All we knew was that they were made in a factory in another country. And indeed when we placed records on the device, on every single one of them, we found the inscription: Berlin, London, New York etc. No one even imagined that such records could ever be produced in our country. However, time soon proved us wrong and showed not only that this was possible, but that it was already being done on a large scale.

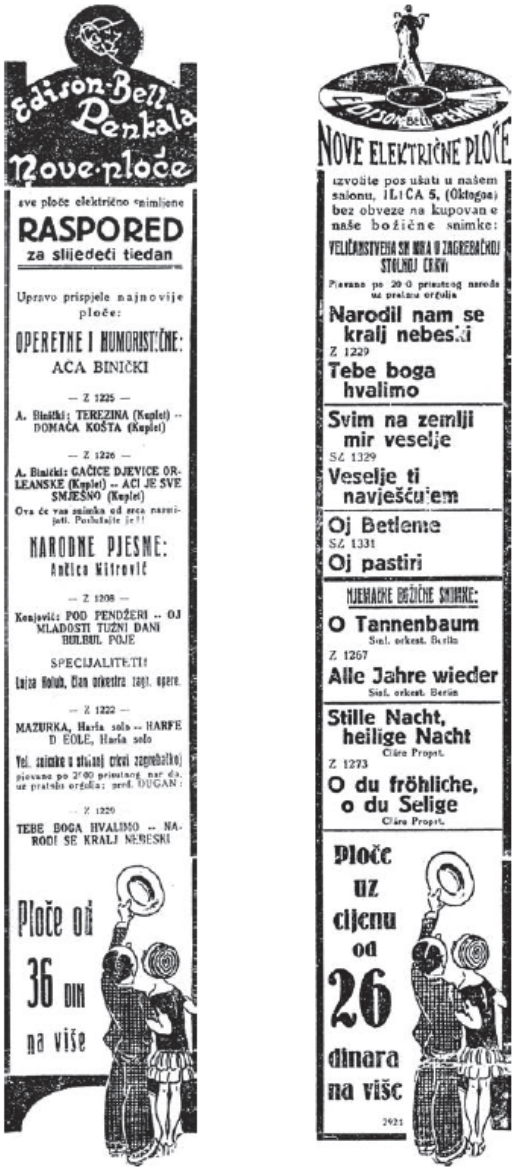

Figure 2: The notices by the company Edison-Bell Penkala in *Jutarnji list* of 19 February 1928 and 8 December 1929 about the newly released gramophone records "Narodi se Kralj nebeski" and "Tebe Boga hvalimo" (*Te Deum*)

We became very interested in this phenomenon, so one of our editors visited the Zagreb gramophone record factory, Edison Bell Penkala, and became convinced that first rate records are being produced here by electronic means, and they may compete with any foreign record. We point out that we listened in detail to a recording of the organ and church choir (Tebe Boga hvalimo, *Te Deum*) of our cathedral and we were amazed at the precision of the performance. …"

In *Jutarnji list* of 19 February 1928, and of 8 December 1929, the company Edison-Bell Penkala announced that it was possible to purchase gramophone records for the price of 26 dinars or 36 dinars or more (for the sake of comparison a beginner teacher's salary in a high school was about 800 dinars), Fig. 2. From the advertisement we can read that the records were "electronically recorded", that in the cathedral "about 2000 people present sang to the accompaniment of the organ", and that the organ was played by Franjo Dugan sen.

In the catalogues for 1928 and 1929, the company Edison-Bell Penkala advertised the sale of the records under the title: "Magnificent remote recording – the only remote recording in existence to date" and went on to say that "... the choral society *Vijenac* sang, comprised of seminary students from the Archbishopric of Zagreb" (today's title: Music and Choral Society *Vijenac*, address: (Archbishopric Theological Seminary, Kaptol 29, 10000 Zagreb), Fig. 3 and 4. It is interesting that in the catalogue, along-side the text in Latin script, the text is also given in Cyrillic. This was the period of the forced unification of the Croatian and Serbian languages.

Perhaps ten records have been preserved in private collections to the present day, e.g. one is owned by the sound technician, Vito Gospodnetić (owner of the company Samofix of Zagreb), and the engineer Veljko Lipovšćak (for many years an employee and director in the company Jugoton), Fig. 5. The records were 25 cm in diameter (10 inches) and made from natural shellac resin.

The company Edison Bell Penkala (EDP) produced and sold gramophone records 25 cm and 30 cm in size, with the labels Edison Bell Penkala Records and Edison Bell Electron. After 1929, for the sake of economy, they only used the Edison Bell Electron label. That is to say, the name Penkala was protected, and they had to pay to use the name. It went bankrupt in 1937, but existed formally until 1945. [2]


CRKVENI ZBOROVI
ЦРКОВНИ ЗБОРОВИ
Pjev. društvo »Vijenac«: bogoslovi nadb. sjem. Zagreb
Пјев. друштво »ВИЈЕНАЦ«: богослови надб. сјем. Загреб
cm Broj
25 Z 1230 Narodil nam se kralj nebeski (Božićna). Radujte se narodi (Božićna).
Народил нам се краљ небески (Божићна) Раујте се народи. Божићна).
!! VELIČANSTVENA SNIMKA IZ DALJINE !!
!! ВЕЛИЧАНСТВЕНА СНИМКА ИЗ ДАЉИНЕ !!
Jedina dosad opstojeća ovakove vrste
Једина досад обстојећа оваконе врсте
Pjevano po 2000 prisutnog naroda uz pratnju orgulja (Prof. DUGAN)
Певано по 2000 присутног народа уз пратњу оргуља (Проф. ДУГАН)
cm Broj
25 Z 1229 Narodil nam se kralj nebeski. Народил нам се краљ небески, Tebe Boga hvalimo. Тебе Бога хвалимо.
Ruski crkovni zbor pravoslavne crkve, Zagreb
Руски црковни збор православне цркве, Загреб
25 Z 1161 Hvalite ime Gospodina· Slava va višnji Bogu. Хвалите име Господина, Слава ва вишњи Богу.

Fig. 3: A page from the catalogue of the company Edison Bell Penkala from 1928


CRKVENI ZBOROVI
ЦРКОВНИ ЗБОРОВИ
Pjev. društvo »Vijenac«: bogoslovi nadb. sjem. Zagreb
Пјев. друштво »ВИЈЕНАЦ«: богослови надб. сјем. Загреб
cm Broj
25 Z 1230 Narodil nam se kralj nebeski (Božićna). Radujte se narodi (Božićna).
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!! VELIČANSTVENA SNIMKA IZ DALJINE !!
!! ВЕЛИЧАНСТВЕНА СНИМКА ИЗ ДАЉИНЕ !!
Jedina dosad opstojeća ovakove vrste
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Певано по 2000 присутног народа уз пратњу оргуља (Проф. ДУГАН)
cm Broj
25 Z 1229 Narodil nam se kralj nebeski. Народил нам се краљ небески, Tebe Boga hvalimo. Тебе Бога хвалимо.
Ruski crkovni zbor pravoslavne crkve, Zagreb
Руски црковни збор православне цркве, Загреб
25 Z 1161 Hvalite ime Gospodina· Slava va višnji Bogu. Хвалите име Господина, Слава ва вишњи Богу.

Figure 4: A page from the catalogue of the company Edison Bell Penkala from 1929

Figure 5: Labels from the gramophone records "Narodi se kralj nebeski" and "Tebe Boga hvalimo".

IV. The Fundation of the Company Edison Bell Penkala

In 1926, the Edison Bell Penkala d. d., gramophone and gramophone record factory was founded in Zagreb, which was actually a subsidiary of the English company Edison Bell International Ltd. of London. Why Zagreb? Zagreb was a suitable place for expanding the gramophone record market in south-east Europe, the Balkans and the Near East. Moreover, it has to be added, copyright had not yet been regulated in the Kingdom of Yugoslavia.

The agreement to found the joint stock company Edison Bell Penkala was signed by representatives of the Zagreb Pen Factory Penkala-Moster d.d. and a representtative of Edison Bell International Ltd., Abraham Benhard Goodman, in Zagreb on 12 June 1926. The founding assembly was held on 15 October 1926, and the equity capital of the company was set at 150,000 dinars.

The company was registered in the companies' register under number 139, with the date 17 February 1927, court decision no. 12923, with the company name in Croatian: Edison Bell Penkala d.d., with its seat in Zagreb, Fig. 6, 7 and 8, and in ten other languages due to the possibility of working abroad:

English	Edison Bell Penkala Ltd.
French	Edison Bell Penkala S. A.
Romanian	Edison Bell Penkala s. o.
Greek	Edison Bell Penkala o. a.
Hebrew	Edison Bell Penkalal'er m.
German	Edison Bell Penkala A. G.
Hungarian	Edison Bell Penkala r. t.
Bulgarian	Edison Bell Penkala a. d.
Turkish	Edison Bell Penkala chairie
Arabic	Edison Bell Penkala s. a.

Figure 6: The Penkala-Moster d. d. factory (completed in 1911) in Baroševa cesta – today's Branimirova ulica 43 (Baros street, Branimir street 43), where the headquarters of the company Edison Bell Penkala were located. This photograph is probably from the period of the Kingdom (*Kraljevstvo*) of Serbs, Croats and Slovenes (1918–1921) or the Kingdom (*Kraljevina)* of Serbs, Croats and Slovenes (1921–1929), because on the carriage there is an inscription in Cyrillic script: CHC. In front of the factory, wood for fuel being loaded from a railway wagon onto the horse-drawn cart.

Figure 7: The building of the former Penkala-Moster d.d. factory today. After the Second World War it was the site of the *Nada Dimić* Textile Factory. In 1993 this state company was transformed into the joint stock company Endi International, and in 2000 bankruptcy proceedings began against it. Today the building is ruined and deserted. (photo: Z. Benčić)

It is interesting how these two companies began to cooperate. Before the First World War, the engineer Slavoljub Penkala worked on sound reproduction. He worked to improve the function of gramophone pick-up. The company Edison Bell, as a manufacturer of mechanical gramophones, became interested in his work. The cooperation between the two companies at that time led to the foundation of the gramophone and gramophone record company in Zagreb.

Figure 8: The collapsed central part of the courtyard building (about 50 m long but less than 5 m wide) of the former *Penkala-Moster d.d.* factory. In that building was the production of gramophones and gramophones records). The building of the red façade, on which this collapsed building leans, faces onto Branimirova ulica (see Fig. 6 and 7). This happened on 1 October 2007, whilst a pit was being dug for an underground car park in the *Krešimir* commercial centre. (photo: Z. Benčić)

V. The telephone line from Kaptol (the Cathedral) to Nikoliceva ulica (the studio)

It has been established from original documents that the recording took place in Zagreb Cathedral on Kaptol, Fig. 9, but the record was cut in the studio which was part of the Music Hall in Nikolićeva ulica 7a, Fig. 10. The locations of the Zagreb Cathedral and Music Hall are shown in Fig. 11.

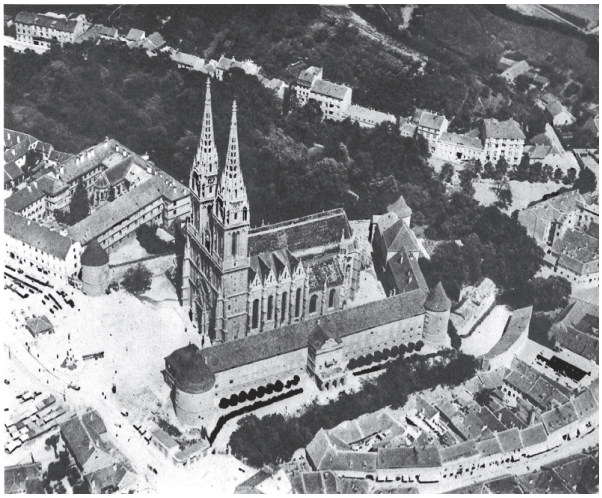


Figure 9: Aerial image of Zagreb Cathedral from 1928 [10]

In the Zagreb telephone directory from 1922 [11] the telephone number is listed of the Archbishop's palace (Kaptol 31), which is right beside the Cathedral: tel. 1–55 (on page 73), whilst there is no telephone number for the Music-Hall (Nikolićeva 7a). Naturally there was no telephone in the Cathedral itself. In the telephone directory for 1928 [12], Fig. 12, the telephone number of the Archbishop's palace is listed: tel. 4155 (on page 64) and the telephone number of the Music-Hall: tel. 2829 (on page. 49). It may be assumed that in December 1927, when the remote recording was undertaken, the Music

Figure 10: The Music Hall building today (unfortunately we could not find a photograph from the 1920's). The Zagreb Youth Theatre is now located in this building (photo: Z. Benčić)

Hall already have a telephone number. Therefore, it was necessary to run an aerial open-wire line from the microphone in the choir of the Cathedral to the Archbishop's palace (marked no. 8 on Fig. 11), which is no more than 100 m away.

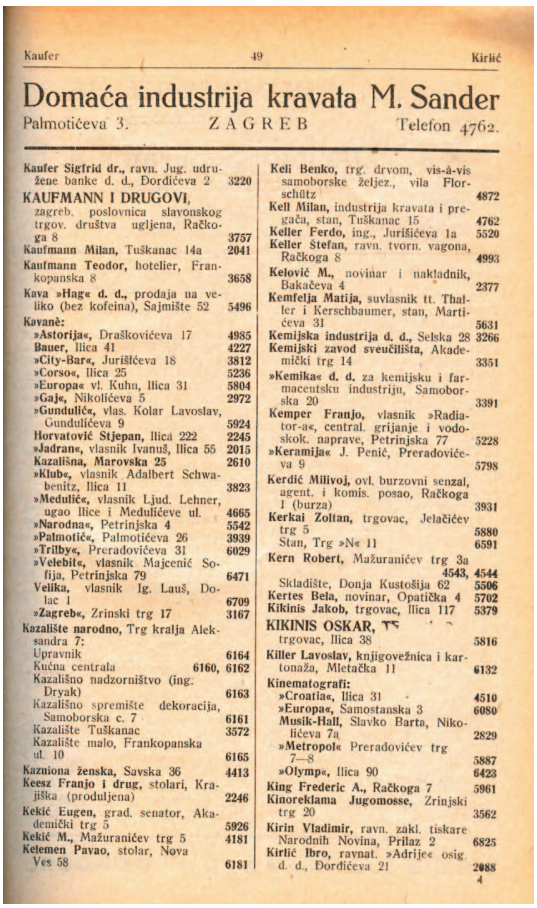
The telephone exchange was in Jurišićeva 13 (Jurišić street). In 1904 the Zagreb telephone exchange was moved to a new building in Jurišićeva 13 [13, 14], Fig. 13, and in 1928 the first automatic telephone exchange began work in Zagreb in Palmotićeva (Palmotić street, already marked on the plan of Zagreb from 1926). However, it should be noticed that it is the same building, which has its main entrance in Jurišićeva and a side entrance from Palmotićeva.

VI. The visit by the experts Edison Bell to Zagreb

In *Jutarnji list* of 24 July 1927 [15] information was published about the recording of gramophone records in Zagreb, which amongst other things, included the following:

Figure 11: A detail from the plan of the City of Zagreb in 1926: the part of the city through which they telephone line ran: from the Cathedral (7) on Kaptol, to the Music Hall (123) in Nikolićeva ulica 7a. In 1931 the population of Zagreb was about 260,000.

Figure 12a: Zagreb telephone directory from 1928



Kaufer 49 Kirlić

Domaća industrija kravata M. Sander

Palmotićeva 3. ZAGREB Telefon 4762.

Kaufer Sigfrid dr., ravn. Jug. udružene banke d. d., Đorđićeva 2 3220

KAUFMANN I DRUGOVI, zagreb. poslovnica slavonskog trgov. društva ugljena, Račkoga 8 3757

Kaufmann Milan, Tuškanac 14a 2041

Kaufmann Teodor, hotelier, Frankopanska 8 3658

Kava »Hag« d. d., prodaja na veliko (bez kofeina), Sajmište 52 5496

Kavane:
»Astorija«, Draškovićeva 17 4985
Bauer, Ilica 41 4227
»City-Bar«, Jurišićeva 18 3812
»Corso«, Ilica 25 5236
»Europa« vl. Kuhn, Ilica 31 5804
»Gaj«, Nikolićeva 5 2972
»Gundulić«, vlas. Kolar Lavoslav, Gundulićeva 9 5924
Horvatović Stjepan, Ilica 222 2245
»Jadran«, vlasnik Ivanuš, Ilica 55 2015
Kazališna, Marovska 25 2610
»Klub«, vlasnik Adalbert Schwabenitz, Ilica 11 3823
»Medulić«, vlasnik Ljud. Lehner, ugao Ilice i Medulićeve ul. 4665
»Narodna«, Petrinjska 4 5542
»Palmotić«, Palmotićeva 26 3939
»Trilby«, Preradovićeva 31 6029
»Velebit«, vlasnik Majcenić Sofija, Petrinjska 79 6471
Velika, vlasnik Ig. Lauš, Dolac 1 6709
»Zagreb«, Zrinski trg 17 3167

Kazalište narodno, Trg kralja Aleksandra 7:
Upravnik 6164
Kućna centrala 6160, 6162

Kazališno nadzorništvo (ing. Dryak) 6163
Kazališno spremište dekoracija, Samoborska c. 7 6161
Kazalište Tuškanac 3572
Kazalište malo, Frankopanska ul. 10 6165

Kazniona ženska, Savska 36 4413
Keesz Franjo i drug, stolari, Krajiška (produljena) 2246
Kekić Eugen, grad. senator, Akademički trg 5 5926
Kekić M., Mažuranićev trg 5 4181
Kelemen Pavao, stolar, Nova Ves 58 6181
Keli Benko, trg. drvom, vis-à-vis samoborske željez., vila Florschütz 4872
Keli Milan, industrija kravata i pregača, stan, Tuškanac 15 4762
Keller Ferdo, ing., Jurišićeva 1a 5520
Keller Štefan, ravn. tvorn. vagona, Račkoga 8 4993
Kelović M., novinar i nakladnik, Bakačeva 4 2377
Kemfelja Matija, suvlasnik tt. Thaller i Kerschbaumer, stan, Martićeva 31 5631
Kemijska industrija d. d., Selska 28 3266
Kemijski zavod sveučilišta, Akademički trg 14 3351
»Kemika« d. d. za kemijsku i farmaceutsku industriju, Samoborska 20 3391
Kemper Franjo, vlasnik »Radiator-a«, central. grijanje i vodoskok. naprave, Petrinjska 77 5228
»Keramija« J. Penić, Preradovićeva 9 5798
Kerdić Milivoj, ovl. burzovni senzal, agent. i komis. posao, Račkoga 1 (burza) 3931
Kerkai Zoltan, trgovac, Jelačićev trg 5 5880
Stan, Trg »N« 11 6591
Kern Robert, Mažuranićev trg 3a 4543, 4544
Skladište, Donja Kustošija 62 5506
Kertes Bela, novinar, Opatička 4 5702
Kikinis Jakob, trgovac, Ilica 117 5379
KIKINIS OSKAR, tt. trgovac, Ilica 38 5816
Killer Lavoslav, knjigovežnica i kartonaža, Mletačka 11 6132

Kinematografi:
»Croatia«, Ilica 31 4510
»Europa«, Samostanska 3 6080
Musik-Hall, Slavko Barta, Nikolićeva 7a 2829
»Metropol« Preradovićev trg 7—8 5887
»Olymp«, Ilica 90 6423
King Frederic A., Račkoga 7 5961
Kinoreklama Jugomosse, Zrinjski trg 20 3562
Kirin Vladimir, ravn. zakl. tiskare Narodnih Novina, Prilaz 2 6825
Kirlić Ibro, ravnat. »Adrije« osig. d. d., Đorđićeva 21 2088
4

Figure 12b: The telephone number of the Music Hall (tel. 2829)

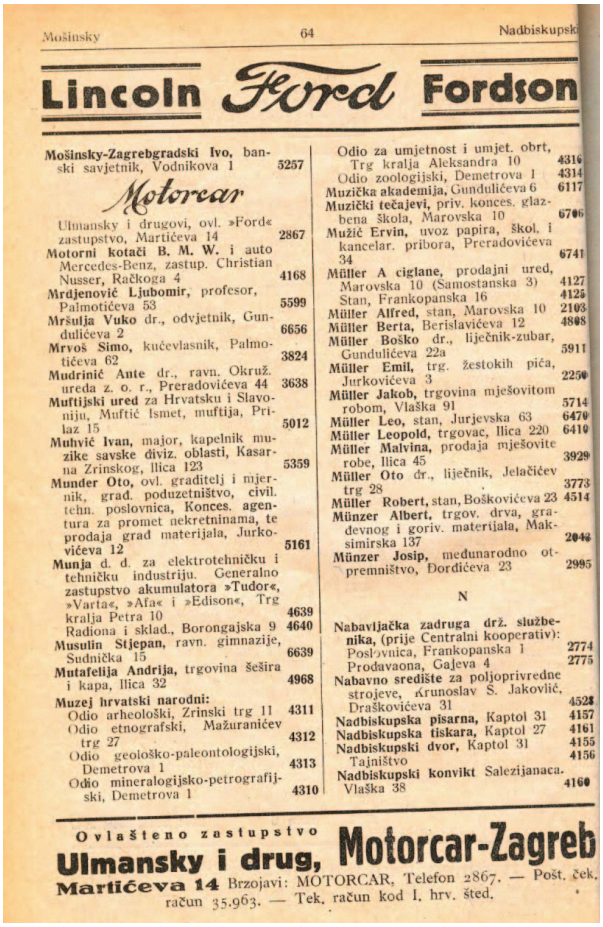


Figure 12c: The telephone number of the Archbishop's palace Nadbiskupski dvor: tel. 4155

Fig. 13: The building in Jurišićeva 13 into which the telephone exchange was moved in 1904 from Gajeva 4

"...here also in Zagreb an enormous new laboratory is being opened by Edison-Bell (Penkala) in which a large number of records will be recorded of our national music, and the quantity will increase. Since recordings are made electronically, they will be without doubt first rate, and will make a major contribution to promoting Croatianfolk and artistic songs overseas, because these records are already in great demand from abroad.

It is wonderful to go into that room, where everything is buzzing with work, the singers in front of the microphones, the choir masters and composers at the desk or piano, the choir trying hard to keep to the beat, which is given here only by a look or an electric light bulb. Everything must be performed precisely, because even the smallest error is audible on a gramophone record. The whole project is being run under the artistic management of Prof. Albini, choir master Faller, Sachs, Smodek, and operettas and light music are the responsibility of Mr. Tijardović. Various things are recorded: opera, operettas, songs accompanied by a tamburitza orchestra, and gypsy choirs etc. This enterprise can certainly bring us Croats nothing but pleasure, because we are ahead of larger nations than us in this regard."

In Fig. 14 the person with the earphones is probably Paul Voigt. Fig. 15 could further confirm this identification. Fig. 16 shows the studio in which the company Edison Bell Penkala undertook recordings up until 1933. The importance to Edison Bell of the cooperation with the Penkala company is shown by the visit by its general

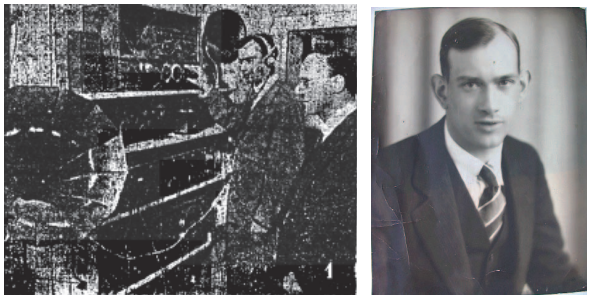


Figure 14:: The electronic recording laboratory, with mobile machinery in Zagreb (Nikolićeva ul. 7a). The machines are manned by experts from London [15]. The person with the earphones is probably the engineer Paul Voigt. This portrait was taken no later than in 1923.

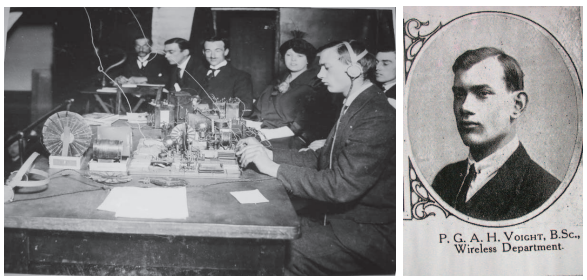


Figure 15: The young Paul Voigt (with earphones) demonstrates a reflex (dual high and low frequency) amplifier circuit for the Wireless and Experimental Association of Peckham in 1922. [16]. Notice that on the portrait the surname is spelled Voight [17], but in the same document Voigt points out that his surname is spelled without the "h".

director to Zagreb, Fig. 17., noted in *Jutarnji list* of 24 July 1927 [15]. It is interesting to note that the first radio broadcast of a football match by Radio Zagreb took place one week earlier, on 17 July 1927, by connecting a microphone at the pitch by wire to a telephone line. The connection was set up by technicians Kopsi and Mundi.

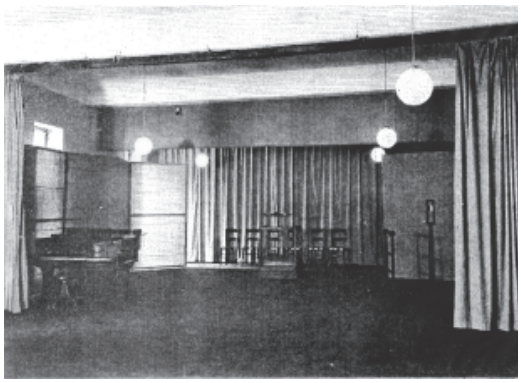


Figure 16: The Edison Bell Penkala studio for recording gramophone records in 1933. This studio was taken over by Radio Zagreb, and EBP moved to a studio in the factory in Branimirova ul. 43

Figure 17: The composer Ivo Tijardović with the opera singer Božidar Vičar and the theatrical choir recording his "Floramy and "Kraljica lopte". Sitting to the right is the general director of Edison Bell from London. Photograph by the well-known Zagreb studio, Foto Tonka.

The technical editor of Gramophone magazine of that time, Percy Wilson in [19] cites the words of Paul Voigt, explaining what he did in Zagreb:

> "Very soon, anything that was not electrically recorded was practically unsaleable. A live agent in Zagreb, Yugoslavia wanted Edison Bell to record out there. It had to be electric, so I spent the first part of 1927 setting up duplicate equipment in London and training people to keep it running, and also made portable equipment for the Zagreb expedition. The only person capable of setting up from scratch was myself, so I spent most of the second half of 1927 in Zagreb, where I recorded over 600 titles."

In an extensive letter of 12 January 1973, on twenty typewritten pages, addressed to P. P. Tomson [17], Voigt confirmed that records were being recorded in Zagreb:

> " ... The three years above included in 1927 (i.e. 1928 and 1929, author's note) a period of six months which I spent in Zagreb, Yugoslavia, recording local music there".

In [19] Paul Voigt points out that in 1926 he developed cutting apparatus known as *Malabar* and that he tried out remote cutting of records:

> "By Armistice Day, I was involved in our first 'OB' (from the BBC term for 'outside broadcast'), i.e. music originating other than in one of their studios). In this case the subject matter included the cinema (in Lewisham) full of veterans singing the chorus of *Land of Hope and Glory,* solo by one of our regular artists, etc., etc. The cinema was only a few miles away by road, but the distance via the telephone exchanges was about eight miles. I used no line transformers, even though my microphone amplifiers were not push-pull, nor my main amplifiers. My output transformer in those days, feeding a 1 Ohm cutter coil (aluminium), was fairly good, but I had no line transformer designs and in any case wanted to keep out transformers as far as possible. I therefore constructed resistance coupled, single ended to push-pull, in which an extra stage was used solely for phase reversal (no gain), and at receiving end the same again in reverse."

VII. The Technical Implementation of Recording

There is no direct (written) information regarding the technical methods used for remote recording of gramophone records. Voigt says himself in his memoirs [19] that he was the only one who could find his way round his sketches. There is nothing we can do but get a sense of the technical methods used on the basis of Voigt's autobiographical information and conclusions drawn on the basis of the situation as it was at that time regarding telephone and audio technology.

A. Micraphones and microphone amplifiers

The recording spectrum of the gramophone record shows that frequencies up to 5 kHz were transferred by microphone, telephone lines, and cutting machine, Fig. 18. Since the frequency limits of a carbon microphone are from 3 kHz to 5 kHz, and of aerial open-wire lines about 150 kHz [14, p. 96], it was possible to use a carbon microphone, Fig. 19. However, in [16] Vogt states, "I tried carbon mikes, but the amplitude distortion made me scrap the idea" and in a letter to P. P. Tomson [17], he says that in Zagreb he used, "my 'slack diaphragm condenser mikes' "

We presume that it was not necessary to use an amplifier between the microphone and the telephone line, because the telephone line was short, only 1.25 km long.

However, Fig. 20 shows the principle of connecting the condenser microphone to a triode microphone pre-amplifier. In order to reduce the noise, the housing and the membrane of the condenser microphone, CM, are grounded. The grid electrode, through the resistor R_1 = =60 MΩ has a positive bias of 80 V to 100 V. The AC voltage generated at the resistor R_1 is supplied through the condenser C_1 = 1000 pF and the bleeder resistor

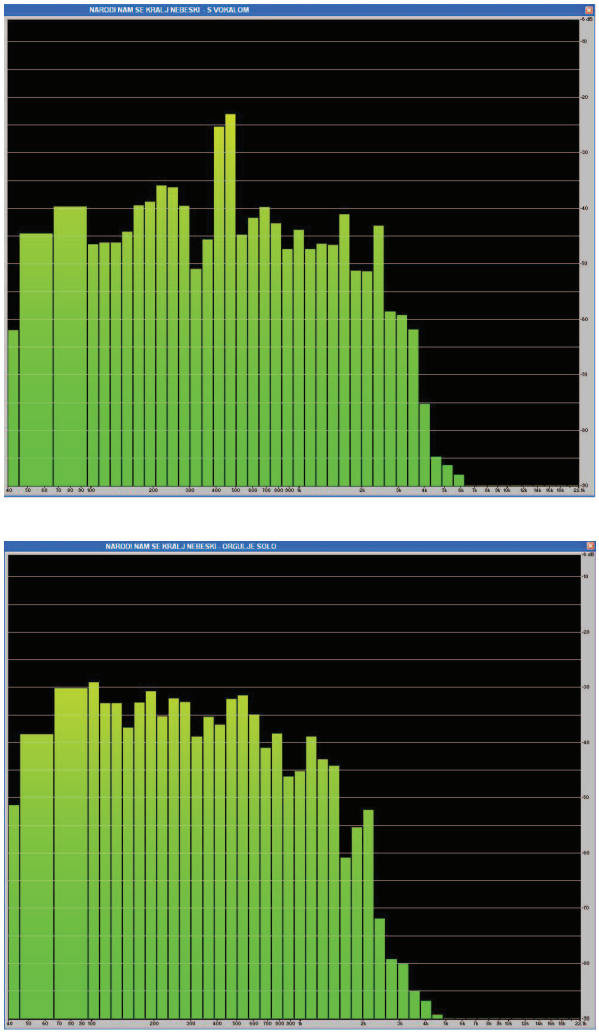


Figure 18: The spectrum of the analogue recording of the Christmas carol "Narodi nam se Kralj nebeski" recorded on 4 December 1927: a) with vocals b) the organ alone. The sampling frequency was 44.1 kHz. The shellac record reproduced by means of an ELP (extended long play) laser gramophone, with the shift of the ray to the part of the groove which was never in contact with the needle, so that in the spectrum the deformations are not shown which are the result of reproduction by mechanical gramophones

R_2 = MΩ in the triode V (e.g. RE 084 – in production since 1928) grid circuit. High values of R_1 and R_2 are necessary for sufficient resistance their parallel connection, in relation to the capacitive resistance of the microphone system (capacity about 100 pF) at low frequencies. With a relatively small anode resistor R_3 = 10 kΩ (good for transmitting high frequencies) enhanced AC voltage is supplied (audio signal) through the condenser C_2 to the low frequency transformer NT (transmission ratio 5:1 to 6:1). The condenser C_2 prevents the passage of DC anode current (about 2 mA) through the input (primary) winding transformer NT. The capacity C_2 was chosen so that at low frequencies (e.g. 50 Hz) serial resonance occurs of inductance of the primary winding transformer causing an increase in low frequencies. The bypass condenser C_3 prevents a galvanic reaction. S is the signal relay.

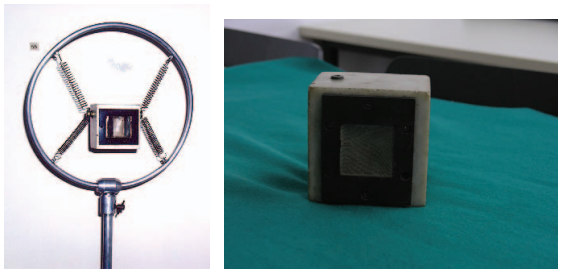


Figure 19: Carbon microphones: a) From Radio Zagreb in 1926, b) from the collection of the Department of Electroacoustics, Faculty of Electrical Engineering and Computing – Zagreb

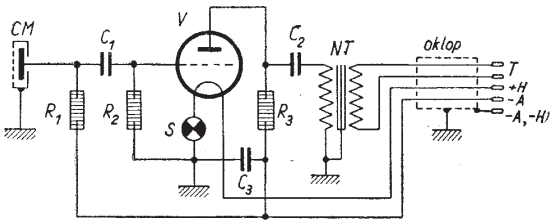


Figure 20: The principle of condenser microphone connection to a low-frequency amplifier

B. Device for cutting and the accompanying amplifier

For recording gramophone records in Zagreb, Voigt designed and constructed a cutting system. He wrote the following about it [16]:

> "I had not been with Hough (J. E Hough, Ltd., Edison Bell Works) for long before I realized that if the artists and musicians played and sang as they did for the B.B.C., into a mike whose output was amplified and fed into some kind of electric cutter, then a better master should result than we could get from using an assortment of large trumpets. Hough encouraged me. And before the end of 1926 I had designed a moving coil cutter system which meant that records did not have the hysteresis distortion natural to moving iron devices. Hough put the system into commercial use and, with minor improvements, it remained in use until Edison Bell Ltd., (the later name of the company) died in the slump in April 1933".

In [18] Voigt added some more details:

> "When I was first recording, I had considered the question of response curve, and decided that 'constant amplitude' would be desirable to 'drown' the scratch of the records of those days. The mechanism of the mechanical gramophone however demanded 'constant velocity'. This would have emphasized the scratch.
>
> The Western Electric system was supposed to be constant velocity, but they had overlooked the obstacle effect of the microphone, which gave them a treble boost above constant velocity. My microphone had 3 dB less sensitivity in the treble than in the bass, so the overall response of both my system and the Western system were in fact between constant amplitude and constant velocity. At Zagreb, I was in charge of the apparatus and determined where the artists should be placed. There I found that even with ideal placing the constant amplitude wave-front

tended to be too steep for low record wear, and the sound on the 'thin' side. I therefore decided on the compromise, and arrange my cutter system to have the response mid-way between constant amplitude and constant velocity. In modern language, that is a slope of 3 dB per octave, and this with the 3 dB mike change (due to the change from isothermal to adiabatic action of the air cushion) gave me an overall response almost identical to that standardized for microgroove these days. My curve was also close to what our competitors were in fact using, this because, in addition to the 6 dB treble boost due to obstacle effect, their mike also had a further boost due the cavity resonance. This subject was discussed in an I.E.E. paper by West. Our two curves thus criss-crossed one another, with theirs having more about 250 cycles (which helped the 'low' end), while I think I scored with less distortions, with the moving coil cutter, the hysteresis distortion common to most moving iron systems was eliminated.

After that, my development was concerned with details only. The 28 lb electro-magnet for example was redesigned, giving me 17 lb magnet with higher flux density. The cutting system was modified to eliminate 'advance ball' method for controlling the depth of cut. I was also able to get closer to my target response curve."

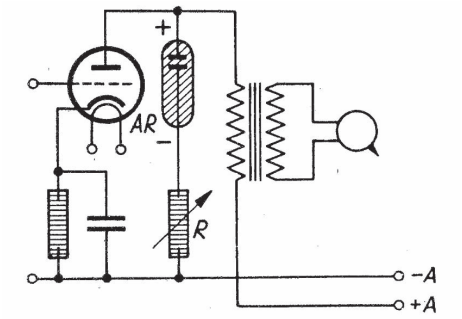


Figure 21: The principle of connecting the apparatus for cutting a gramophone record to a telephone line

Fig. 21 shows the principle of connecting the cutting device to a telephone line. The cutting head is connected to the output stage valve amplifier by means of an adjusted transformer. The power at the cutting head is controlled (to protect from excessive amplitude, which would cause the grooves on the gramophone record to overlap) by means of a glow tube, AR. A variable resistor, R, is used to adjust the glow tube.

VIII. Conclusion

It has been proven without a doubt that on 4 December 1927 the remote recording was undertaken in Zagreb (Croatia) of gramophone records by means of regular telephone lines. Two Christmas carols were recorded, sung by the Choral Society *Vijenac* (the choir of Archbishopric theological seminary students in Zagreb) and the congregation present, conducted by the director of the opera of the Croatian National Theatre in Zagreb, Nikola Faller, and a professor from the Music Academy, Franjo Dugan sen. playing the organ. The transmission was from the choir of Zagreb Cathedral to the studio in Music Hall, 1.25 km away. The organizer of the recording was the company Edison Bell Penkala of Zagreb. The importance given by the company Edison Bell to its cooperation with Edison Bell Penkala can be seen from the fact that in July 1927 the general director of Edison Bell visited Zagreb. The recording system (microphone, tube amplifiers, cutting apparatus) was developed and tested in London by Paul Voigt, an engineer with Edison Bell, who brought it to Zagreb in July 1927. The record was cut under his technical direction. The gramophone records were already on sale in February 1928.

Acknowledgement

The authors are grateful to sound technician Vito Gospodnetić for frequency analysis of gramophone records.

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APPENDIX 1

ACOUSTICS IN CROATIA FROM 1875 TO THE SECOND WORLD WAR

The study of acoustic waves in Croatia began with the arrival of Vinko Dvořák at the Faculty of Philosophy of the Franz Joseph I Royal University of Zagreb in 1875. Vinko Dvořák had attained his PhD in philosophy two years earlier, with physics marked as his speciality, at the University of Prague under the mentorship of Ernst Mach (1838–1916).

In Croatia there was a many as three prominent pupils of the famous Ernst Mach. This is particularly in connection with the continuation of his research into mechanical waves, especially sound waves. They were: Vinko Dvořák, Andrija Mohorovičić and Peter Salcher. We can add to them Dvořák's pupil in Zagreb, Dušan Pejnović.

Vinko Dvořák (1848–1922) explained the gathering of powder in a Kundt's pipe with circulation of air caused by oscillatory movement, and the circulation of the air is such that the air moves in the middle of the pipe from the knots towards and along plates, then returns the opposite way. The famous physicist John Wiliam Strutt, better known as Lord Rayleigh, in his book *The Theory of Sound* (the book is even now highly valued and used in graduate studies, in spite of the fact that its first edition goes as far back as 1877, with further/repeated editions up to 1945), called this discovery Dvořák's phenomenon. Rayleigh, eight years after Dvořák's explanation, gave a theoretical background to it, so today this phenomenon is called Dvořák-Rayleigh's circulations in physics, i.e. circulations of the air in a Kundt's pipe. Dvořák also became famous for his acoustic radiometers. An acoustic radiometer is an apparatus tuned to measure the pressure of sound radiation with which the sound wave effects a surface. When such a radiometer is placed on the spot where the vibration of the particles is strong, it begins to spin around the vertical axis, Fig. 22 [21]. In the case of stationary sound waves the radiometer will spin fastest in the stomach of the vibration. The square plate has 25 holes, intended to enforce rotation by means of their regular surface distribution.

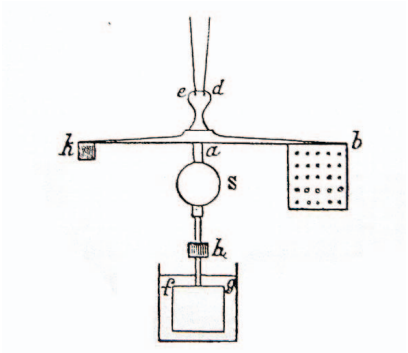

Figure 22: Dvořák's acoustic radiometer

Andrija Mohorovičić (1857–1936) was Mach's student during his studies in Prague. It must be mentioned that the Croatian scientist Andrija Mohorovičić arrived at a discovery regarding earthquakes (infrasound) with which he earned world fame. Analyses of the seismograms of the Kupa Valley earthquake of 8 October 1909 enabled him to prove the existence of the crust-mantle boundary, which later became known as the Mohorovičić discontinuity. He founded the Zagreb seismological station at the beginning of the 20th century and equipped it with the best instruments of the time, thus placing it on a level with the best observatories in the world. [22]

Peter Salcher (1875–1928) was a profesor of physics at the Maritime Academy in Rijeka. With the help of Mach´s written instructions, in the course of 1886 they successfully took some 80 shots during the movement of

a faster-than-sound projectile, using a transparent non-homogenic medium and also of certain manifestations connected to the shock wave. All these high-speed phenomena were shot applying the special schlieren technique. [23]

Dušan Pejnović (1883–1958) in his article *Contribution to the optics of ultrasound waves* from 1942 [25] wrote the same about Dvořák's heritage. In this article Pejnović uses Dvořák's schlieren technique, in order to see ultrasound waves without the presence of foreign particles in the liquid at the sites of knots. However, those particles were an obstacle to the sound field, so a return to the optical method took place. The optical method, with stationary ultrasound waves, resulted in dark areas at spots of knots of pressure (at those places the quotient of light refraction changes least). At places where the quotient of light refraction changes most, light schlieren could be seen, and that were the places of stomachs of the pressure. That article has 20 pages and includes 7 photographs. The liquids used for taking pictures of stationary waves of ultrasound were ksilol, Vaseline oil, ethylene ether, and very clear photographs of ultrasound nets are shown.

APPENDIX 2

BIOGRAPHIES OF THE IMPORTANT PEOPLE MENTIONED

Figure 23: Franjo Dugan sen. (1874–1948)

Franjo Dugan sen., Croatian composer, organist and theoretician, member of the Yugoslav Academy of Science and Art (JAZU) (Krapinica near Zlatar, Croatia, 11 September 1874 – Zagreb, 12 December 1948). He studied physics and mathematics in Zagreb, and the organ privately with V. Kolander, and in 1908 he graduated in composition from the Music High School in Berlin (R. Kahn, M. Bruch, H. Becker). Initially a grammar school teacher, from 1912 until his death he was the permanent organist at Zagreb Cathedral, and from 1920 to 1941 a professor at the Zagreb Music Academy. An organ virtuoso, Dugan also gave his best as a composer for that instrument. He also wrote some fundamental musical theory handbooks (on the theory of music forms and instruments), and his many years of work as a music critic and editor were also of great importance. [7]

Figure 24: Vincenc Dvořák (1848–1922)

Vincenc Vinko Dvořák (Dušejovo near the town Jihlava, Bohemia, January 21, 1848 – Zagreb, Croatia, May 6, 1922), the Czech-Croatian physicist. He started his studies in 1866 at the Faculty of Philosophy Karl – Ferdinand University in Prague and attained his position as Ernst Mach's assistant the same year, who was his teacher during his studies. The Emperor Franz Joseph I appointed Vinko Dvořák as full professor of the Faculty of Philosophy of the Frantz Josef I Royal University of Zagreb on 26 September 1875. He established the Chair for Physics in the sense of a modern university course/study, not only from the teaching point of view, but with the intention of performing demonstration experiments and practical exercises. He was buried in the Zagreb graveyard Mirogoj, where his wife was buried earlier. However, some thirty years later their remains were transferred elsewhere, and once again during the 1970's. Today his remains are in a shared grave amongst hundreds of the poorest citizens. It is extremely sad that not a single name is inscribed on that grave.

Figure 25: Nikola Faller (1862–1938)

Nikola Faller, Croatian conductor and composer (Ivanec, Croatia, 22 April 1862 – Zagreb, 28 February 1938). Initially he studied music in Varaždin and Zagreb, then from 1884 to 1887 he completed his studies in Vienna (A. Bruckner), Paris (J. Massenet, L. Delibes) and London. He worked mainly in Zagreb as a piano teacher, conducting at the Croatian National Theatre Opera, as choir master and music teacher, but also in Split (1889–91) and Osijek (1910–12). From 1924 to 1938 he was the president of the Croatian Choral Association. His work as director of the CNT Opera in Zagreb was particularly noteworthy due to his encouragement of national musical and theoretical works, introduction of the ballet, organizing the documentation and expanding its repertoire (the first productions in Croatia of the works of R. Wagner, G. Bizet, P. I. Tchaikovsky, P. Mascagni, R. Leoncavall and others). He staged more than 250 different works, conducted more than 1900 times, and composed more than 40 compositions, including chamber pieces, choral songs and church music. [8]

Figure 26: Slavoljub Eduard Penkala (1871–1922)

Slavoljub Eduard Penkala (Liptovský Mikuláš, Slovakia, 20 April 1871 – Zagreb, Croatia, 5 February 1922), the Croatian chemical engineer and inventor of Polish origins. He was a contemporary of the American and Croatian inventor, Nikola Tesla (1856-–1943), the American inventor, Thomas Alva Edison (1847-–1931) and George Westinghouse (1846–1914). He graduated in chemistry from the Royal High School in Dresden in 1898, and then worked in the chemistry industry in Košice. In 1900 he moved to Zagreb. He produced about 80 inventions and innovations in the field of mechanics, chemistry, physics and aviation, the most important were: the hot water bottle (1903, the predecessor to the thermos flask), a rotating toothbrush (1905), the automatic mechanical pencil (known as the "penkala", 1906), the solid ink fountain pen (1907), a button battery (the principle), insecticide, blue washing detergent (replacement for bleach which damaged clothes), liquid for impregnation of railway lines, the manometer, rail-car brakes, ebonite suitable for production of mechanical pencils and gramophone records, longer lasting gramophone needles, rotating turbines (1908) and a two-seater plane (1909 – six years after the Wright brothers). [9]

Figure 27: Paul G. A. H. Voigt (1901–1981)

Paul Gustavus Adolphus Helmuth Voigt (Forest Hill, London, England, December 9, 1901 – Brighton, Ontario, Canada, February 9, 1981), English/Canadian electronics engineer. He received his education at Dulwich College and in 1922 graduated with a BSc from University College, London. He had an early interest in the application of valve amplifiers, and after graduating he was employed by J. E. Hough, Edison Bell Works, to develop a line of radio-receiving equipment. However, he became interested in the mechanical (and later electrical) side of recording and from 1925 developed principles and equipment. In particular he developed capacitor microphones (slack diaphragm condenser microphone), not only for in-house work but also commercially, until the midway 1930s. The Edison Bell Company did not survive the Depression and closed in 1933. Voigt founded his own company, Voigt Patents Ltd, based in Sydenham, London, concerning on loudspeakers for cinemas and developing horn loudspeakers for domestic use. In 1936 he merged his company with Lowther Manufacturing Company Ltd. which then became Lowther-Voigt Radio. During the Second World War he continued to develop loudspeaker units and gramophone pick-up, and in 1950 he emigrated to Toronto, Canada, but his company closed. Voigt taught electronics, and from 1960 to 1969 he was employed by the Radio Regulations Laboratory in Ottawa. After retirement he worked with theoretical cosmology and fundamental interactions. [20]