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I. I. Slavin the forgotten Russian acoustician who defined in 1956 the noise levels limits for workplaces the first in world practice

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Abstract

Ilya Ilyich Slavin was an important Russian acoustician in 1949-1959 decade; he defended his Thesis in 1940 and during the war he worked as a senior researcher at the Acoustics Laboratory of the Physics Institute named after P.I. Lebedev Academy of Sciences of the USSR. In 1948 he returned to Acoustics Laboratory of the Leningrad Institute of Labor Protection of the All-Union Central Council of Trade Unions (LIOT), where he developed his career and became an outstanding specialist in the field of noise control. This article presents Slavin's most influential work, he is the one which developed and scientifically substantiated the noise limits for workplaces, and he outlined the first noise level references curves in different frequency intervals that in February 1956 the USSR have legally introduced them. Slavin presented at XII International Congress of Occupational Health (Helsinki, 1957), that normative and later in 1959, his work became worldwide known.

Keywords: Occupational noise, standards, noise limits, audibility, history of science.

И. И. Славин - забытый российский акустик, который в 1956 году определил первые предельные уровни шума для рабочих мест

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Аннотация

Илья Ильич Славин был важным русским акустиком в 1949-1959 гг.; защитил диссертацию в 1940 году, а во время войны работал старшим научным сотрудником в лаборатории акустики Физического института им. П.И. Академия наук Лебедева СССР. В 1948 году он вернулся в Акустическую лабораторию Ленинградского института охраны труда Всесоюзного центрального совета профсоюзов (ЛИОТ), где развивал свою карьеру и стал выдающимся специалистом в области борьбы с шумом. В этой статье представлена наиболее влиятельная работа Славина, он разработал и научно обосновал пределы шума для рабочих мест, и он наметил первые эталонные кривые уровня шума в разных частотных интервалах, которые в феврале 1956 года СССР официально ввел их. Славин представил на XII Международном конгрессе гигиены труда (Хельсинки, 1957), что нормативно, а позднее, в 1959 году, его работы стали всемирно известными.

Ключевые слова: Профессиональный шум, стандарты, пределы шума, слышимость, история науки.

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Introduction

The *History of Science* is an important branch to every scientific discipline, because it is a tool to study and understand the development of empirical, theoretical, and practical knowledge about them. The *History of Science* is most common to find in social studies field, but it is a big support for the engineering field, where the research was conducting for philosophers at the beginning and lately, the *History of Science*, is becoming a specialization inside each engineering area individually.

Talking about the Acoustics field, there are plenty of works concerning the *History* of Science research, and an important event took place in the last International Congress on Acoustics in Aachen ICA2019: A special Session on 'Modern history of acoustics' has been introduced (promoted by Max Planck Institute for the History of Science), being this event the starting point between this two disciplines.

This article has been written using the few documents and references that are free in Internet and which are available from Argentina (it is well-known that web search engines not always display all the information): five of them are into Russian, one into German, and the rest are into English.

This article is a contribution to the *History of Science* where the works of I. I. Slavin are commented: He was a Russian researcher into acoustics field who defined scientifically the noise level limits at workplaces, the first in world practice.

Slavin presented a *noise limits curves* at ISO/TC43 Group, in order to develop an international standard, and also the former German Democratic Republic (and the other ex-Communist countries), implanted that noise references for its occupational legislation.

Slavin was responsible and Chairman of some Acoustical Congress which took place in Russia, and he participated at XII International Congress of Occupational Health (Helsinki, 1957) where he presented '*Tentative Standards and Regulations for Restricting Noise in Industry*,' and lately it was published posthumously in 1959 in ASA Noise Control magazine.

1. Early days of Slavin's life

At the moment of writing this article, the only reference about Slavin's life is the Obituary published a few months after his death, in Journal of Acoustics of Russian Acoustical Society (Акустический Журнал):

Ilya Ilyich Slavin was born in 1912. In 1935 he graduated from the Faculty of Physics and Mechanics Leningrad Polytechnic Institute, where he later taught and scientific work. In 1940, Slavin defended his thesis, after which he headed the Laboratory for the Suppression of Industrial Noise of the Leningrad Institute of Labor Protection of the All-Union Central Council of Trade Unions (LIOT). [1]

The following picture of Slavin is in that Obituary and it is not dated.



Fig. 1. Ilya Ilyich Slavin (1912-1959)

2. The acoustic work of Slavin during the World War II

There are briefly references about the Slavin participation when he was working, during the World War II, at *Acoustic Laboratory* in the Atomic Nuclear Laboratory of the Lebedev Physical Institute.

Scientists of the Acoustic Laboratory and the Atomic Nuclear Laboratory of the Lebedev Physical Institute, evacuated to Kazan in July 1941, from the first days of the evacuation began to look for applications of their knowledge in solving acoustic problems that could be useful to the front. [2]

Vladimir Iosifovich put forward the idea of improving acoustic means for detecting noise sources by replacing the operator with an electronic device - a two-channel objective detector - direction finder, based on the method of matching signals from several sensors, widely used in elementary particle physics. [3]

Talking about specifically on Slavin work:

I. I. Slavin worked as a senior researcher at the Acoustics Laboratory of the Physics Institute [1]

At the beginning of 1942, Sukharevsky was sent to Moscow to establish contacts with military organizations in the field of defense applications of acoustics, he was sent to the command of the air defense forces with the order to assist in the improvement of horn sound absorbers for detecting the noise of aircraft and pointing anti-aircraft guns on them, and above all with the task of protecting the horns from aerodynamic interference, which made sound catchers in windy conditions almost inoperative. When in 1942 full-scale studies of sound catchers conducted in the western region of Moscow's air defense (the engineers of the acoustic laboratory were I.P. Zhukov and I.I. Slavin). [3]

In the spring of 1942, a group led by Sukharevsky, the Acoustic Laboratory staffs, Zhukov and I.I. Slavin, were carried out in the Western part of the Moscow air defense ring in the vicinity of Art. Kubinka, they worked on the study and improvement of sound pickup aircraft noise. In particular, the noise immunity of the receiving horns of sound absorbers to wind noise was studied, which led to a significant decrease in the detection range of targets. [2]

3. Slavin's publications, books, Papers, patents

There is one isolated data about Slavin work during 1946-1947, that he '... attempts were made to apply materials with large losses for damping vibrations of metal structures' [4], this publication of 1967 is a summary of 50 years' Soviet acoustics; according to himself he contribute to develop, to design and improve some noise level meter devices [5].

3.1. Books and Papers published by Slavin

The following list lists the titles of his Technical papers and books that were written by Slavin (of those available on the Internet).

a) Izv. AN USSR, Vol. XIII, 1949, p.6.

b) Silencers for mine pneumatic engines. M., Ugletekhizdag, 1952.

c) Objective noise measurements with a loudness scale. Tr. Comis. Acoustics, Academy of Sciences of the USSR, 1953.

d) Industrial noise and its control (Производственный шум и борьба с ним) 1955.

e) Norms and liked to limit noise in the workplace (project) LIOT, 1955; Temporary sanitary rules for limiting noise in the workplace (draft). Sat Tr. Scientific LIOT.

f) Standards and rules for organizing noise in industry. Leningrad, 1955.

g) The main tasks and ways of dealing with industrial noise. LIOT, 1955.

h) Noise abatement on ships. Navy. LIOT, 1955.

i) Temporary sanitary norms and rules for the limitation of noise in the workplace, 1956.

j) Scientific conference on the fight against noise and the effects of noise on the body. Акустический Журнал, 1957.

3.2. Paper about Philosophy of Technology

The Slavin's scientific work is immeasurable, he wrote an interesting paper titled 'A summary of works on the study of noise and on the fight against noise in the USSR for the period before 1957' (Краткий очерк работ по исследованию шумов и по борьбе с шумами в СССР за период до 1957 г.) [5], posthumously published in Journal of Acoustics of Russian Acoustical Society (Акустический Журнал), Slavin have wrote a brief review of Soviet work on the study of noise in the fight against them, he describes the evolution of the acoustics science in the USSR: The earlier research done by Russian physicians, the development of the first noise level meters, the use of sound absorbing materials, and so many historical issues; the conclusion of this paper is:

In conclusion, it should be noted that even our brief outline of Soviet work on the study of noise and finding methods to combat them shows that Soviet acoustics have done a lot and continue to expand work in this important area, where the results of studies of technical improvements are directly aimed at improving working conditions and rest of millions of citizens of our country. [5]

3.3. Industrial patent

There is a few data available in Internet about industrial patents, for Slavin case there is only one reference: 'The way to improve the acoustic properties of the room' [6].



Fig. 2. The Slavin patented device for sound absorption (Edited from [6])

The device is a 'sound absorber panel,' here is a brief description of the patent:

Known methods for improving the acoustic properties of rooms using sound-absorbing material, such as bags of cotton, enclosed in boxes with perforated walls. The present invention relates to the same method of improving the acoustic properties of a room and aims to reduce the consumption of sound-absorbing material, aimed at reducing reverberation and attenuating the volume of the echo. In the described invention, this is achieved by using a concave surface, for example, of wood, fixing the sound, with the location in the place of concentration of sound energy of sound-absorbing material. [6]

According to the sketch and its explanation (see Fig. 2), the Slavin's acoustic device has to be installed 'between the unit emitting noise and the workers servicing this unit, such screens measuring 1.4 X 2 m reduced the intense hissing noise of air-jet devices from 116 dB (in front of the screen) to 102 dB (behind the screen)' [5].

4. Slavin and his proposal of having legal noise limits at workplaces

In the Slavin's paper mentioned above [5], he explains the study that they had done at LIOT and the previous one about the physiology of the inner ear and the human response to different noise levels. Slavin mentions the following:

A great influence on the development of noise control activities could be provided by scientifically sound legislation to limit industrial noise. Work in this direction was conducted by the LIOT laboratory. Based on an analysis of experimental data on the effect of noise on hearing and the general condition of people, as well as special studies conducted by the Laboratory, Slavin developed in 1954 a production noise standardization system, which was introduced in 1956 by the USSR Ministry of Health in as mandatory in the Soviet Union. [5]

It is important to highlight the year: 1956; this means that the ex-USSR was the first country in the world to legalize the maximum noise limits at industrial noisy places and non-noisy location workplaces. The original Slavin's Paper into Russian is not available on Internet yet, so the author has to use the CIA translation into English [7], and one article published in *Noise Control* magazine by Acoustical Society of America (ASA) in 1959 [8].

The amazing contribution that Slavin have done is the fact to define three frequencies intervals (see Fig. 3) to stablish the industrial noise levels limits:

All I wale to Industry for Made

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Table I Permi	ssible Levels I	n industry for various Noises	
Description of Noises	Permissible Sound Pressure Level, db re 0.0002 microbar	Description of Noises	Permissible Sound Pressure Level, db re 0.0002 microbar
1—Low-frequency noises (produced by non-percussive units of slow operating speed, noises penetrating through sound-proofing barriers, such as walls ceilings, casings), whose highest levels in the spectrum are situated below a frequency of 300 cps, above which levels become lower (by no less than 5 db per octave)	90–100	3—High-frequency noises (ringing, hissing and whistling sounds characteristic of percussive units, air and gas streams and units operating at high speeds whose highest levels in the spectrum are situated above a frequency of 800 cps	; ; ; ; ; ; ; ; ; ; ; ; ; ; ; ; ; ; ;
2-Median-frequency noises (noises produced by most non-percussive machines mills and plant units), whose highest levels in the spectrum are situated be low a frequency of 800 cps, above which levels become lower (by no less than 5 db per octave)	- - - - - - - - - - - - - - - - - - -		

Fig. 3. Permissible noise levels defined by Slavin in 1954 (Edited from [8])



Fig. 4. Permissible noise levels curves defined by Slavin in 1954 (Edited from [8])

This astonishing scientific proposal would have been revolutionary for the time it was proposed, and the most impressive thing is that Slavin have defined sound limits on low-frequencies range, it means he had account the auditory response in frequencies below 300 Hz (see Fig. 3), and not just 'one single number;' the table above was translated to a drawing as noise reference curves (see Fig. 4).

The curves in Fig. 4 are difficult to understand and they had to been simplified, as one can see the followings charts in Fig. 5.



Fig. 5. (a) Curves into a familiar form [8] (b) Slavin noise limits (Edited from [9])

Chart in Fig. 5-b is known as 'Slavin-curve,' it was used in German literature [10] and it was mentioned in several US publications (it is impossible to mention all of them).

Reading the whole document [7] gives us the idea on how advanced was the studies about the noise impact on worker at industries in the USSR during the first half of 1950 decade (and studies about testing intelligibility of speech under noisy conditions); there are dozens of actual Russian publications that mention them.

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۸.	Tentative	Standards	for P	ermissible	Noise	Levels	in :	Industry		1
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TESTING INTELLIGIBILITY OF SPEECH UNDER HOISY CONDITIONS

Under given conditions of noise, an announcer (or an individual with good elocution) reads numbers of several (four or five) digits in a voice of normal loudness. Four or five listeners record these numbers at a distance of 1.5 meters from the announcer. If, of the 50 numbers read, over 40 are recorded correctly, intelligibility is taken to be satisfactory, and the noise is considered not to exceed permissible standards.

Fig. 6. Translation by CIA of Slavin paper (Edited from [7])

Slavin explicates how to use a sound level meter (SLM) in 'Methods of noise measurements' [7], it is important to quote that the acousticians at LIOT have used Standardized frequencies weighting networks in 1950 decade (an explanation about those old curves have been published by the author in this Journal [13]). Unfortunately to this day, pictures of SLM manufactured by LIOT and used in the ex-USSR during 1950 decade are not available on Internet yet.

Talking about how to make the analysis using the noise limits curve, Slavin recommends making the analysis of the noise measurement results as follows: Record the sound level on each frequency octave band, and draw the spectrum in a chart, then by using a transparent sheet that has drawn the noise limit curve, superimpose it and observe at what frequency the limit has been exceeded, or not.

The author of this article knows nothing of the investigations carried out at LIOT - like the rest acousticians of the 'western world' - or in other research centers of the ex-USSR during the 'Cold War Era', the Slavin paper 'Brief description of the works on the study of noise and on the fight against noise in the USSR for the period before 1957' [5] is an excellent starting point to know their work, and among them there is one that aroused the author curiosity: In 1940 they have 'proposed a device for the hygienic assessment of the harmfulness of noise. The device had a frequency response in the form of an "equal annoyance" curve by Laird and Coye,' [5] this is an incredible scientific achievement, because the Laird&Coye studies weren't widely known (even in 2020), but at LIOT they have a specific device which used their curves (an explanation of Laird&Coye study is in [13]).

Last but not least, it is worth mentioning how advanced was Slavin's research about human hearing perception, according to him the results that they had got at LIOT are almost the same of US ones, and he suggested 'In the future, based on the same idea of increasing the unit of the scale, Slavin was proposed to take sound volume at a level of 40 phons as a unit, which turned out to be very convenient' [5]; we have to keep in mind that 40 phon loudness curve is close to 85 dBA value.

5. Slavin participation and mentions at International Congress

5.1. XII International Congress of Occupational Health ICOH1957

Slavin have participated at XII International Congress of Occupational Health (ICOH) which took place in Helsinki, 30th June-5th July 1957, where he presented 'Tentative Standards and Regulations for Restricting Noise in Industry,' [9] originally written into German; the paper is a summary of his 1955 work 'Standards and rules for organizing noise in industry,' the one used as background to USSR legal noise level for the occupational law.



Fig. 7. Images extracted from [9] Slavin paper presented at 12th ICOH, 1957

This Congress was really important because the Slavin's noise levels limits were internationally known; according to him 'Noises allowed by Soviet norms are close in their values to those reported at the Congress in the order of discussion by scientists from the USA ([Charles R.] Williams) and Japan ([Shiji] Katsuki)' [9].

5.2. Third International Congress on Acoustics ICA1959

Slavin died in January 1959, but his work was presented posthumously at Third International Congress on Acoustics, ICA1959 which took place in Stuttgart, by D. Brodhun an acoustician from the ex-GDR, he presented a deep analysis of Slavin curve and the evaluation of his noise criteria [11].

The Slavin paper is not in ICA Proceedings, but in the well-known 'Wireless World' magazine of October 1959 issue, they pointed out that 'In Russia, according to a paper by I. I. Slavin and J. M. Iljaschtschuk three classes of noise spectra are recognized (low, middle and high frequency) each with a permissible upper limit of intensity.' [12], this comment gives the idea that Slavin work was Oral presented (perhaps) by Jurij Iljaschtschuk who worked at LIOT, he developed a sound analyzer among other devices [5].

6. The international impact of Slavin's proposal on the legal noise limit

Slavin's work on engineer noise control and noise legal limits are mentioned in several international publications, this gives us an idea of the scientific magnitude of his work into acoustics, noise control engineering, and auditory prophylaxis, limiting high noise levels at workplaces.

6.1. Slavin recommendation in US publications

Charles R. Williams was chairman of *American Industrial Hygiene Association* and met Slavin at ICOH; he published in *Noise Control* ASA magazine the Slavin Paper in 1959[7], and it has been referenced in several USA medical and technical publications since then.

It is interesting the fact that Slavin is mentioned more in US technical publications than ex-Communist countries, a brief list of the American institutions are:

- a) NASA, 'Hygienic characteristics of industrial noise' [14], [15]
- **b)** US Navy, 'Control of noise and sonic vibration in ships' [16]
- c) US Department of Commerce 'Soviet noise-control research' [17]
- d) EPA, 'A basis for limiting noise exposure for hearing conservation' [18]
- e) Central Intelligence Agency, CIA digital repository [19][20][21][22]

The well-known American acoustician Karl D. Kryter, who worked at Bolt-Berank-Neumann and NASA into several hearing conservations programs, he highlighted that 'Slavin states his contours are meant to be a practical balance between hearing conservation and necessary industrial noise conditions' [23].

6.2. The ISO/TC-43 Group and the Slavin recommendation about noise limits

According to Slavin, the Russians representatives at ISO presented his work about noise limits in workplaces; probably they did it in 1958 to discuss it in ISO/TC-43 board:

Currently, the International Committee for Standardization (ISO/TC-43), with the participation of representatives of the USSR (A.V. Rimsky-Korsakov, I.G. Rusakov, V.V. Furduev), is preparing for standardization of the volume scale. It should be pointed out that this standardization is associated with great difficulties and may turn out to be premature so far, due to the possible introduction of new curves of equal loudness for noise. There is also no doubt that for assessing the physiological effect of noise, noise characteristics such as the degree of its unpleasantness, harmfulness and the like are also of great importance. These characteristics are not yet quantifiable. [5]

Unfortunately, there is no other information available on Internet yet, surely his criteria was discussed in ISO/TC-43 board meetings work, but his noise curve criteria was never finalized as a technical proposal.

Slavin comments in another paper that, in September 1955, I. G. Rusakov from Moscow Central Research Institute of Physical-Technical and Radar Measurements presented at ISO/TC-43 'an international recommendations for the study and measurement of airborne noise in order to standardize values and measurement methods' [24].

6.3. Publication about hearing conservation

Among several scientific publications on hearing conservation which mention the Slavin's work, according to the author, there are two that stand out from the rest, because both publications rescue Slavin's work at the end of 1960 decade:

- a) Walter Reichardt, 'Loudness level Loudness noise' [10]
- b) Rummerfield, & Rummerfield, 'Noise Induced Hearing Loss' [25]

Conclusions

The author found the Slavin noise limits curve as serendipity when he was seeking information for one of his investigations, about the history of the inception of '85 dBA' as unique value for noise limit, but the Slavin proposition is previous to those criteria and it does not fit into the same study branch.

This article is a tribute to the memory of I. I. Slavin, rescuing his work in acoustics science to the 21st century, because he has done an important contribution into the field of human hearing conservation, and because his scientific research ended as legislation being the first of this kind in the world, later it was used as reference for other countries. The Acoustics has a few representatives' scientists; perhaps Ilya Ilyich Slavin could be among those who have made contributions to this discipline, specifically in the area of occupational noise, hearing conservation or similar.

The author wants to acknowledge and thank Iuliia Rassoshenko (Noise Theory and Practice Journal) who encourage him to write about I. I. Slavin.

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