STUDIA UBB MUSICA, LXI, 1, 2016 (p. 107 – 141)
(RECOMMENDED CITATION)

PROFESSIONAL RECORDING OF SPEECH SOUND IN LOW-BUDGET FILMMAKING[1]

AARON FAZAKAS[2]

SUMMARY. The size of a film's budget undeniably defines a significant part of the decisions involved in the planning and making of an audiovisual work. Thus, the film's story, its genre, the size of the crew, the selection of the artistic team etc. must all be adjusted (often involving numerous artistic compromises) to the project's financial possibilities. And yet a competitive film must have excellent sound and visual quality irrespective of its budget. Thus, it is NOT possible to economize on the quality of the basic technical equipment. As long as a film producer does not succeed in squaring the circle, he/she cannot expect of the production's sound crew to make an impeccable film sound recording with modest and cheaply rented audio equipment. In case of a low-budget film: – the location audio operator (who mixes and booms) or the two-person sound crew (sound engineer + boom operator) must pay special attention to preparing for shooting. The choice and use of the audio equipment used on the film set must be made based on the careful reading of the script, the study of the chosen locations (focusing on the acoustic conditions), and on the thorough knowledge of the director's and cinematographer's concept; – good quality sound recording on the filming locations can (and will) greatly reduce post-production costs. The present study aims to offer adequate theoretical knowledge and easy to apply practical ideas/solutions with respect to professional voice recording in case of low-budget film productions.

Keywords: low-budget film, digital sound recording, professional speech recording.

Introduction

Nowadays, with the widespread use of digital technology one can already in his/her childhood come into contact with numerous devices (e.g. smartphone, digital camera etc.) that due to their ease of use and availability

[1] The present paper was written with support of the Hungarian Academy of Sciencies's Domus senior researcher grant.

[2] *Assistant Professor, PhD., at the Sapientia University of Cluj-Napoca, Faculty of Sciences and Arts, Department of Cinematography, Photography and Media, RO-400112, Cluj-Napoca, str. Matei Corvin nr. 4.*
Homepage: *www.aaronfazakas.com*, E-mail: contact@aaronfazakas.com

offer the possibility to accomplish smaller-scale audiovisual projects. Due to the numerous film festivals that encourage the production of short and/or very short (max. 3 minute-long) films (e.g. the *Très Court* International Film Festival[3]) more and more people are drawn (beside short home videos that aim to record family memories) to transposing their artitstic ideas into audiovisual language.

Beyond the aspects of content however, a competitive film must have excellent sound and visual quality.

A significant part of DSLR cameras and/or mobile phones have video recording function, but what good is a high definition (HD) or maximum resolution (Full HD) picture quality if the built-in microphones and sound recording options do not provide adequate sound quality?

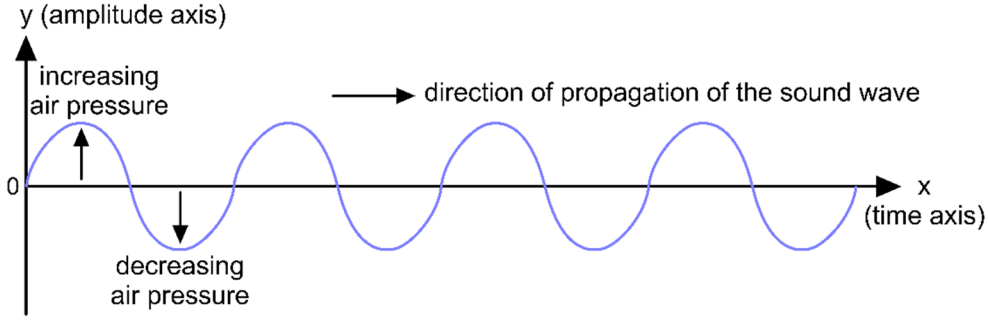
In such cases *single system recording* (sound recording with a external microphone that can be mounted on the camera) can offer partial solution, and professional solution is granted by *double system recording* (sound recording with an equipment totally independent of the camera).

Speech sound

Similarly to other sound phenomena, speech sound in its physical sense is a mechanical vibration that propagates in the form of sound waves. Its occurrence requires a vibrating body (sound source), source of energy, and an elastic medium for its propagation.

When speech occurres, the exhaled airflow provides the source of energy, which forces the sound source (in this case the human vocal cords) to propagate mechanical vibrations, which are then carried by air (as the elastic medium) to our auditory organs. These vibrations are then quickly transmitted to our brain through neural pathways where they are perceived as speech.

Fig. 1



[3] *http://www.trescourt.com*

As a consequence of air pressure disturbance caused by the sound source air molecules are displaced from their resting state (point 0) and force surrounding particles to travel, too. Thus, they ensure the wave-like motion of the mechanical vibration (sound phenomenon).

In our everyday life sound waves are generally transmitted through air to our sensory organs. In this medium, in case of normal humidity and at a temperature of +15°C the speed of sound is $\mathbf{c}^4_{sound}$=340 m/s (in solid mediums and in liquids the speed of sound waves is much higher).

Altough this speed is much slower than the speed of light ($\mathbf{c}_{light}$=299.792,458 km/s), it is still enough to enjoy talkies (visual and acoustic information projected at the same time from a single media) in a perfect sound-image harmony.

Digital sound recording

While in case of analogue recording sound waves are recorded in a continuous manner both in time and in their amplitude (Fig. 2), the digital sound recording technique samples the continuous analogue signal at given time intervals (sampling, see Fig.3), and after quantization defines the amplitude value of the recorded samples (Fig.4) in binary digits (using 0 and 1). This recording can then be stored as a digital audio file in an uncompressed audio format (*wav*) or rarely when justified in a compressed audio format (e.g. *flac*, *mp3*).

Fig. 2 - 4

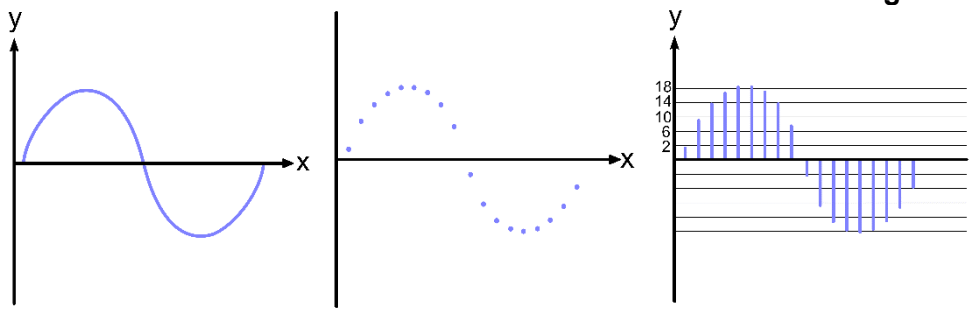


Fig. 2 **Fig. 3** **Fig. 4**

The more frequent sampling (sampling frequency) is and the greater the number of differentiable amplitude values (quantized length), the better the quality of the recording is. However, with this the size of the sound recording increases drastically.

[4] The speed of sound is symbolized with **c** (the initial letter of the Latin *celeritas* = speed) and is measured in meter/second.

"The samples obtained by sampling are the momentary values of the analogue signal. Since the sampled signal's amplitude may take any value, the magnitude of the impulses can show an infinite variety. Representing such patterns in numbers can be difficult, because this could only be done with numbers of infinite length (see Fig. 5). Thus, in order to represent these patterns they must be rounded to a finite number of digits.

This rounding process is called quantization (Fig. 6), and as a consequence, the samples' continuous amplitude becomes discreet[5] (Fig. 7-8), due to the fact that close values become equal after quantization)[6]".

Fig. 5 - 8

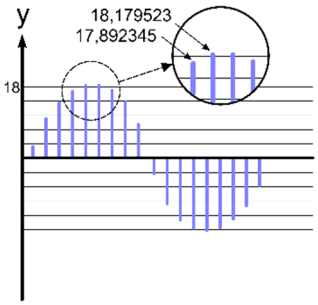


Fig. 5

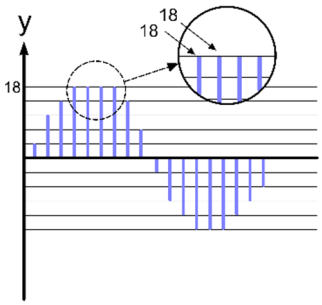


Fig. 6

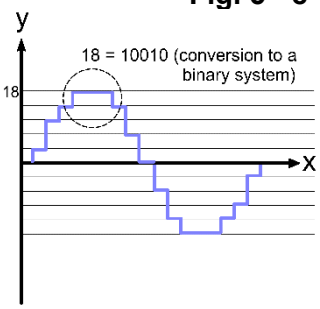


Fig. 7

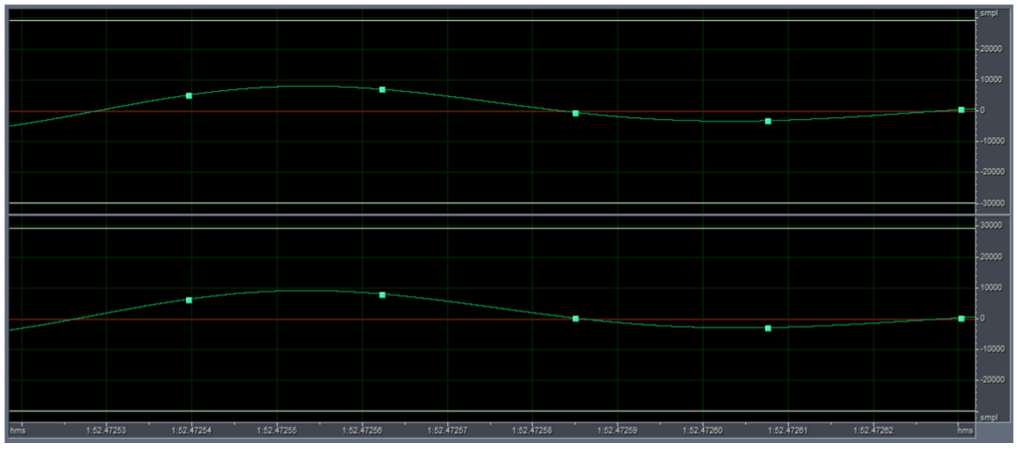


Fig. 8

"Telecommunications theoretical studies showed already in the thirties that in order to represent continuous-time signals of finite bandwidth, it is enough to sample the analogue signal at given time intervals. The sampling

[5] Belonging to a given point, and not continuous.

[6] Péter Jákó, *Digitális hangtechnika [Digital Audio Technology],* ISBN 9630944006, Kossuth Publishing House, Budapest, 2002, p.31-32.

theorem states that the sampling rate must be greater than twice the highest frequency component in the sampled signal.

In practice, for example, for a signal of 15 kHz bandwidth a sampling rate greater than 30 kHz is required, or vice-versa: with a 48 kHz bandwidth we can sample an analogue signal with a bandwidth slightly smaller than 24 kHz. It is important to note that in case of compliance with the sampling theorem sampling does not introduce any distortion to the signal, since due to finite bandwidth, audio signals can change only in one specific way between to moments in time. Thus, if the signal can change only in one specific way, then it is enough to measure the amplitude of the signal at two time intervals, needless to store the intermediate time events.[7]"

Since it offers lossless recording of the audio signal, the most common and recommended (also by the Hungarian Audio Engineering Society) film sound format is **Broadcast WAVE file, 48 kHz, 16 or 24 bit**s.

Fig. 9 - 10

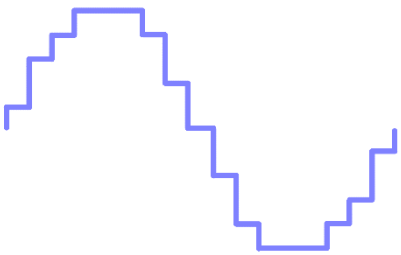


Fig. 9
In case of 48kHz sampling rate, samples are taken 48,000 times in 1 second from the analogue signal, and with 16-Bit quantization a maximum of 216 = 65,536 different (predetermined) amplitude values can be recorded, which can then be stored in an uncompressed wave (*.wav*) sound format.

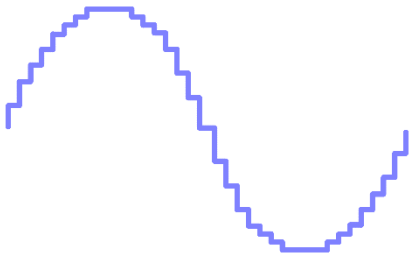


Fig. 10
However, in case of 24-Bit quantization 224=16.777.216 different amplitude values can be recorded, which means an exactly 256-times greater precission in comparison with 16-Bit quantization.

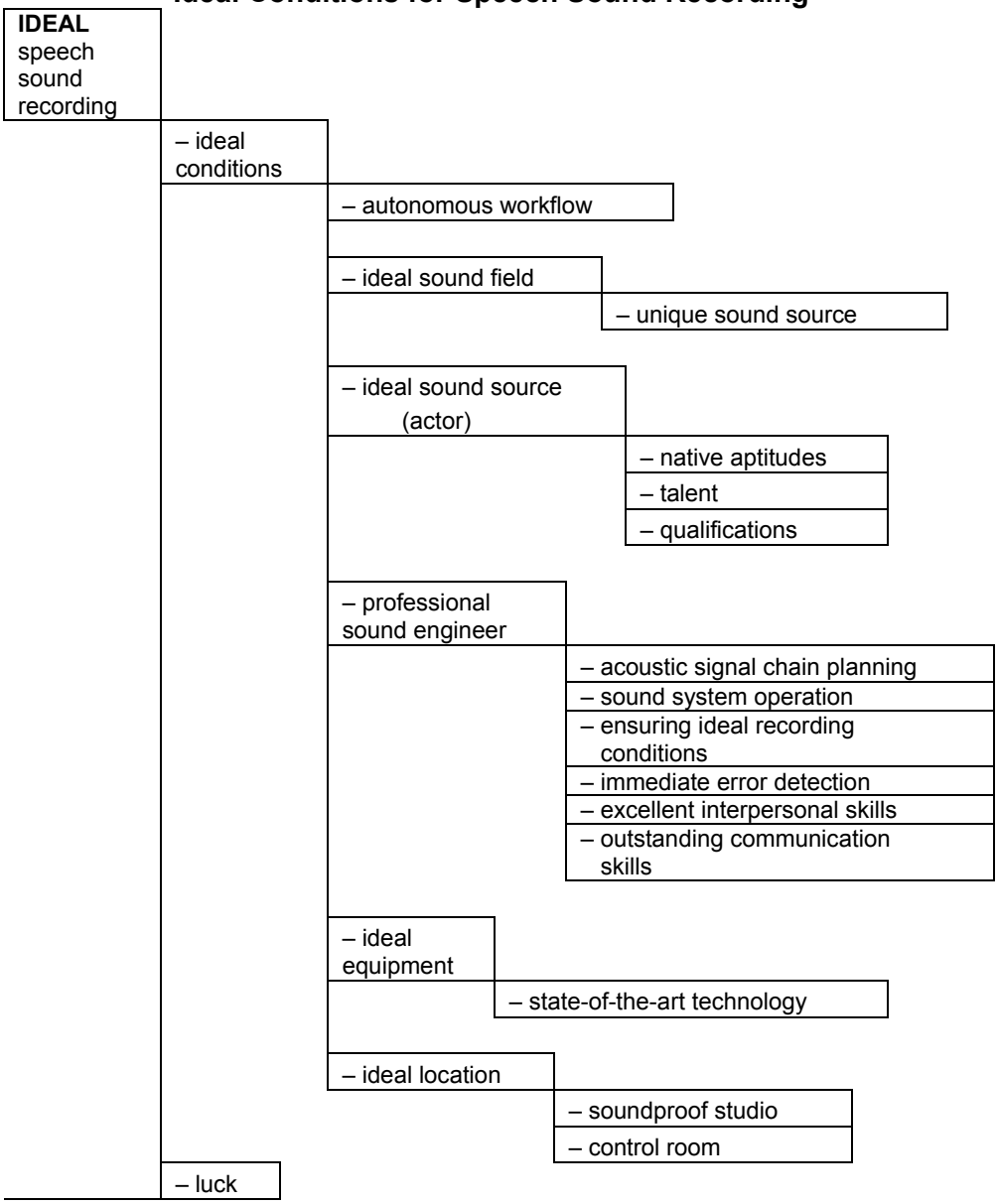
Thus, it is highly recommended to use 24-Bit quantization in all cases.

The great advantage of digital technology lies NOT so much in the improvement of the quality of the recording, but in the possibility of perfect reproducibility and quality preservation. While in the case of analogue technology,

[7] Idem, p. 26-27.

any kind of sound recording inevitably entailed quality deterioration (not having two copies of the same quality), all cloning in the digital era results in sound quality identical with the master copy.

Ideal Conditions for Speech Sound Recording



The conditions enlisted in the table above as a whole, create ideal conditions for (speech) sound recording.

However, on an outdoor filming location of a low-budget film none of these conditions is ensured. Thus, high quality speech sound (mostly dialogues) recording can often pose a serious challenge also to a location audio operator/sound crew with great professional skills and experience.

The objectives of professional sound recording (on in- and outdoor locations)

Contrary to a soundproof studio, which is considered to be an ideal filming location, all outdoor locations have their own characteristic ambient sound. Ambient sound is made up of the sound effects that occur spontaneously around the actor.

An existential space represented only visually would have an unnatural, dead and empty effect. Thus, the artistic representation of the film's visual perspectives can be rendered authentic only with carefully added ambient sounds (birds chirping, city noise of different intensity, background noise in a bar etc.), at the same time ensuring the continuity of the scenes cut up by visual montage. In a given space the camera can jump to and fro because the audible ambient sounds are able to maintain a sense of continuity and unity in the viewer.

In our everyday lives only moments that capture stillness do not have an acoustic equivalent, thus the primary role of foleys in talkies is to emphasize movement. The foleys that are audible in the film's sound (e.g. footsteps, bouncing balls, the sound of a door closing etc.) render sound phenomena that ensue everyday life and motion, and function on the principle of being in total synchronicity with the picture.

Nevertheless, during the recording of location sound, for the sound recordist the most important will be the speaking actor's voice from among the different sound phenomena present on the location (= primary sound), since it has the key role in the unfolding and/or understanding of the film's plot.

All other sounds audible in the sound field simultaneously with the primary sound (speech sound), may be interpreted as noise for a shorter or longer time period in case they disturb in any way the understanding of the primary sound.

Thus, it is important to make a clear distinction between noise and foleys. „Noise entails disturbing someone psychologically: disturbing one's attention with sound", said Ferenc Lohr in his book entitled *A filmhang esztétikája*[8].

[8] Lohr Ferenc, *A filmhang esztétikája [The Aesthetics of Film Sound]*, Magyar Filmtudományi Intézet és Filmarchívum Publishing House, Budapest, 1966, p.73.

Consequently, the objectives of the location audio operator/sound crew responsible for location sound recording can be summed up as follows:

– recording of distortion- and noise free dialogues with strong dynamics;

– the dynamic limitation or total elimination if possible of the sound phenomena (ambient sounds and foleys) that occur simultaneously with the recorded speech sound;

– in order to maintain the illusion of the events unfolding in the film the sound recording equipment shall at all times remain unseen (neither the microphone nor the boompole is allowed to cast a shadow over the pictures as unwanted "extras"!).

"Beyond sound recording, the following are also among the tasks of the sound recordist:

– elaborating the location sound report,

– monitoring the correct use of the clapperboard,

– recording the scene's sounds and making the ambience sound recordings,

– monitoring the correctness and editability of the recorded dialogues,

– taking into account and asserting the artistic considerations agreed on with the director,

– eliminating the disturbing noise sources jointly with with the crew's other concerned members,

– informing the director and the production manager about the possible mistakes in sound recording etc.

Beyond these the continuous communication between the different departments, the appreciation of the sound recordings, technical discussions with the editing studio etc. are also needed during shooting.

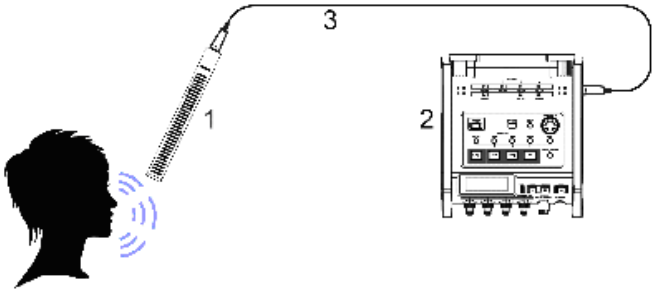
Failing to complete these tasks, the production can be kept under control neither professionally nor from the aspect of its budget"[9].

The structure of the acoustic signal chain

In order to create an autonomous sound recording process at least the following equipment is needed: a microphone (1), a digital sound recorder (2) and a cable that connects the two (3). The chain (see Fig. 11) made up of these three (excellent quality) components will ensure the perception, transformation, transmission, pre-mixing and recording of the acoustic signal occurring in the sound field.

[9] Balázs Gábor és Zányi Tamás, *A filmhang készítés technológiája, I. rész [The Technology of Film Sound Production, part I.],* 2007.

Fig. 11



In addition, one must be familiar with the role and professional use of the numerous accessories (*shock mount, boompole, blimp, deadcat* etc.) developed to overcome the specific technical and/or aesthetic difficulties that can occur during outdoor and indoor sound recording during shooting.

1. The microphone

It is the microphone that registers and transduces the acoustic signal emitted by the sound source and transmitted by air (vibration) into electric signal.

A microphone is an analogue device, thus it always perceives and releases (after converting it into electric signal) the sound waves occurring in the sound field in a continuous manner both in time and in amplitude.

Numerous serious specialist books[10] deal with the classification of the different types of microphones based on their functions. Thus, we only propose to briefly present those features that are vitally important in choosing correctly the most suitable microphone type for making location sound recordings.

1.1. Dynamic and condenser microphones

Irrespective of the functioning principle, it is the membrane installed in all microphones that plays a key role in making the acoustic-electric signal transduction. However, its mass, elasticity and material can vary depending on the microphone type and quality.

The best dynamic microphones are characterised by simple structure, reliability, durability and good sound quality. They can be very well used for the sound reinforcement of human voice (singing and speech)[11] and instrumental music[12] at different live events.

---

[10] Ray A. Rayburn, *Eargle's the Microphone Book: From Mono to Stereo to Surround - A Guide to Microphone Design and Application*, ISBN: 978-0-240-82075-0, Focal Press, 2012.
G. Boré - S. Peus, *Microphones - Methods of Operation and Type Examples*, Berlin, 1999.

[11] E.g. the *Shure SM58* vocal microphone

[12] E.g. the *Shure SM57* instrument microphone

The mass of a condenser microphone's membrane "is only 1 mg, which is approximately 50 times lighter than that of a dynamic microphone. And this is the main cause of tonal differences. Condenser microphones more subtly transmit sound structures. Their upper frequency limit is between 20kHz-60kHz depending on the model"[13].

Electricity is needed to operate a condenser microphone. There are two ways to ensure the needed 48V voltage:

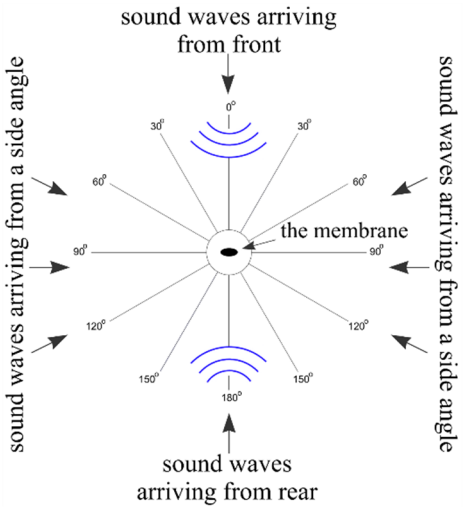
- by transmitting it from the digital recorder to the microphone through the microphone's cable;
- AA batteries can be introduced in certain types of microphones that can ensure the voltage needed for operation.

From the point of view of sound quality condense microphones supersede dynamic microphones, however, they need electricity and are much more vulnerable to environmental impact (changes in temperature, humidity etc.) and shock, and consequently, they perform best in studio technology.

1.2. Microphone pick-up patterns

From among the different sound sources on the filming location our primary objective is the good quality recording of dialogues. For this it is important to be able to separate (to the greatest extent possible) the primary sound that is in the centre of our focus from all other sounds and noises present in the sound field and coming from secondary sound sources.

Fig. 12

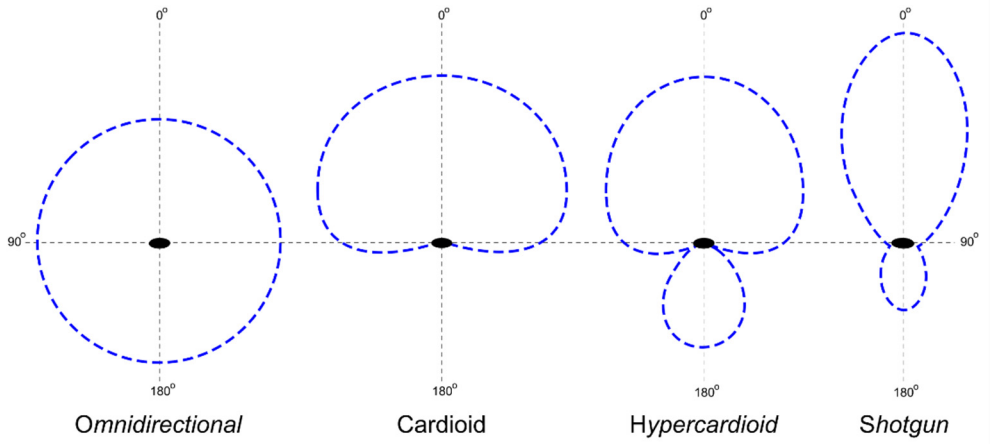


It is possible to exactly determine the direction and intensity of a sound wave that reaches the membrane of a microphone placed in a given space. The size of the lateral angle correlates with the exactly front pickup (=0°), while the exactly rear pickup corresponds to 180°.

[13] P. Arasin, *A Sennheiser hangakadémia vezeték nélküli rendszerek kézikönyve [The Sennheiser Sound Academy Wireless Handbook]*, ISBN 987-963-08-6495-4, 2013, p.12.

The membrane of an omnidirectional microphone (Fig.13) is equally sensitive to sound waves arriving from all directions.

Fig. 13



However, it is possible to reduce the membrane's lateral and back pickup. The polar patterns of a given microphone regulate exactly these parameters.

Accordingly, a cardioid unidirectional microphone has no rear pickup, and is sensitive only to sounds arriving from a side angle of max. 90° (namely from the region falling between our two widely streched arms).

A hyper-cardioid microphone has a smaller lobe of side sensitivity, however, at 180° it has a bi-directional pickup pattern.

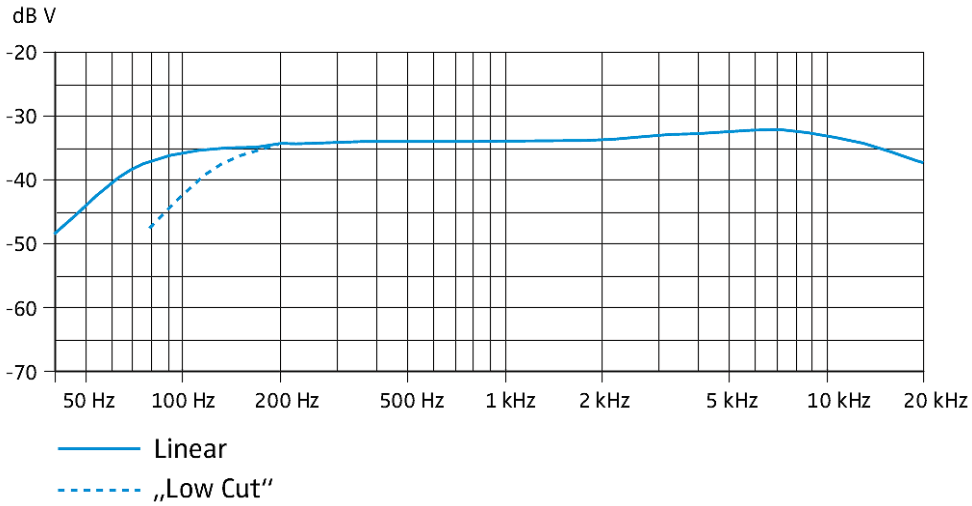
Due to its high directionality (Fig.13), realistic sounding, durability and good resistance to weather conditions (can be exposed to temperatures varying between -10° C and +70° C) the shotgun condenser microphone is the most suitable type of microphone for in- and outdoor dialogue sound recording.

With a shotgun microphone it is possible to target our sound source even from a greater distance (several meters) due to its characteristic that an interference tube cancels the sound waves arriving from the sides.

Fig. 14

The Sennheiser MKH 416 P48 shotgun microphone.

Fig. 15



The excellent frequency transmission of the Sennheiser MKH416 shotgun microphone can be seen here. During speech recording unwanted lower frequency noises (e.g. wind noise) can be eliminated by activating the Low Cut option.

„Speech is made up of compound sounds. The domain of fundamental frequency is approximately between 80 Hz and 1 kHz[14] . With harmonics human speech can reach even 8 kHz, however, the components above 4 kHz being very weak. The information is carried by the 800 and 3500 Hz bandwidth. Components that fall below 800 Hz or are above 3500 Hz primarily contribute to the natural sounding of speech, but play a lesser role in information transfer”[15].

1.3. Shotgun microphone types

As a rule, the technical devices recording the visual and acoustic content during shooting must remain invisible. Although viewers know perfectly well that what they see during projection (in the majority of cases) is fiction resulting from a creative process, still the plot’s credibility would suffer if at any moment one could detect a microphone, a boompole, a camera or a cameraman, or even their shadow.

[14] 1000 Hz = 1 kHz
[15] *http://www.kislexikon.hu/beszed.html#ixzz40dD2ipnX*

Such mistakes are simply cut during visual montage. Still it has happened not only once that in the official version of big budget films frames where sound or image technical devices were visible were simply not cut out.

Consequently, dialogue recording during shooting must be accomplished from a safe distance. However, the safe distance of the microphone from the sound source that is to be recorded changes constantly depending on the shots chosen (for each scene) by the director and the cinematographer.

While in a soundproof studio the microphone is usually placed at a distance of 12-18 cm from the sound source in order to accomplish a perfect recording, on outdoor locations boom operators often have to succeed in making (good quality) speech recording from a distance of even several meters.

Thus, besides the issue of side sensitivity (how much is sensed by the microphone from a given space) the different types of shotgun microphones (short, mid-range and long) have to offer solutions also for recording from a certain distance, which not only influences the intensity of the emitted vibration, but also the quality of the sound phenomenon that is to be recorded.

"When you are closer to the minimum range the dialogue should sound warm, have more bottom end, and sound like the person is close to you. When you boom closer to the mic's maximum range, the dialogue should be thinner, have more mid frequencies, and sound like someone is a few feet away.

You can maintain cohesive sound perspective with the picture by booming closer to the microphone's minimum range for tight shots, and closer to its maximum range for medium to wide shots"[16].

Consequently, it is recommended to know the minimum-maximum range and the lobe of side sensitivity (L) of all three types of shotgun microphones (see Fig. 16).

Short shotgun microphones[17] have a range of 15-60 cm, and their lobe of side sensitivity is 70º (in this case the picked up ambient noise being the greatest).

The range of a mid-range shotgun microphone[18] increases (50-120 cm), and its lobe of side sensitivity decreases to 50º.

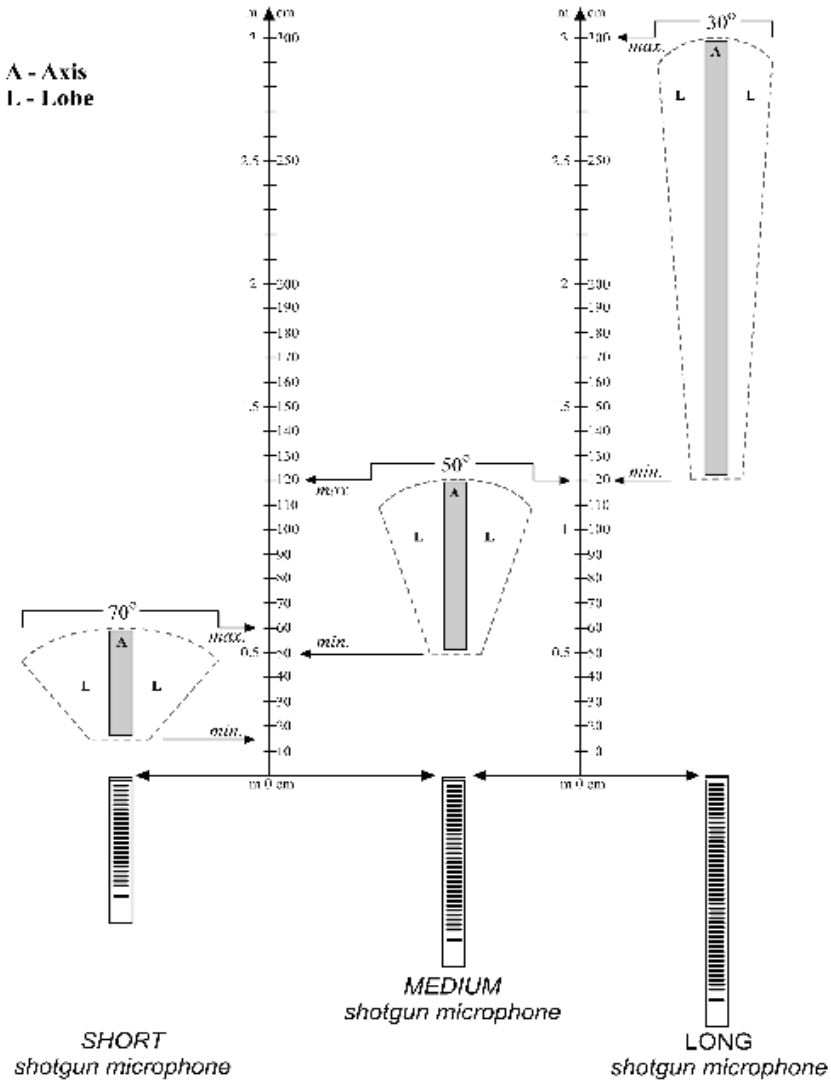
[16] D. Miles, *Location Audio Simplified – Capturing your Audio ... and Your Audience*, ISBN: 978-1-138-01877-8, Focal Press, New Work, 2015, p.96.

[17] E.g. *Sennheiser MKH 416 P48*, *Sennheiser MKH 50*, *DPA 4017B*, *Sennheiser ME66*, *Audio-Technica AT897*, *Shure VP89S*, *Rode NTG2* etc.

[18] E.g. Sennheiser MKH 60, Neumann KMR81i, Sennheiser ME66, Shure VP89M, Rode NTG3 etc.

Evidently, a long shotgun microphone has the biggest range (120–300 cm), but its lobe of side sensitivity is only 30°. This makes it very difficult to be used from a long distance due to the fact that everything emitted by the sound source must be followed very closely, otherwise the the characteristics of speech suffer sensible distortions. Consequently, the use of long shotgun microphones is recommended only for the dialogue recording of very static scenes.

Fig. 16



„Here are a few situations that can change the range of any shotgun microphone:

– When recording outdoors, the microphone's maximum range can increase significantly depending on the amount of ambience. In a quiet outdoor location like an open field, where there are very few reflections (echo, reverb), a short hyper-cardioid mic can sound quite tight when booming as far away as three feet.

– When recording indoors, it's critical to stay within the mic's maximum range. How „live" a room is (a live room has a lot of sound reflections) can easily cut the maximum range of any mic in half. Be very aware of reverb and echo on your recordings – for most dialogue recording they are no good.

– Never jam the mic's range when trying to get more volume from a quiet talker. By jamming the mic's range (that is, booming closer than the mic's minimum range), the voice can enter the cancellation ports as well as the pick-up pattern of the mic. This can cause all kinds of weird phasing. I've heard some pretty funky sound when the boom operator jams the mic's minimum range"[19] .

1.4. The correct position of a shotgun microphone

Fig. 17 – 18

During recording one must literraly aim at the selected sound source with the shotgun microphone. However, in order to continuously maintain the good quality of the recording, one must know exactly how a particular aiming direction influences the quality of the final recording.

Within the microphones range its axis (**A**) must be clearly delimited from its lobe (**L**).

Sound waves picked up from the direction of the axis have a more natural and stronger sound signal quality than those arriving from the lobe. In turn the sensitivity of the axis (marked with grey) is much narrower (see Fig. 17) than the side sensitivity of the lobe.

If we aim the shotgun microphone directly at the around the mouth region of the speaker whose speech we want to record (Fig. 17) that is called **on-axis recording**.

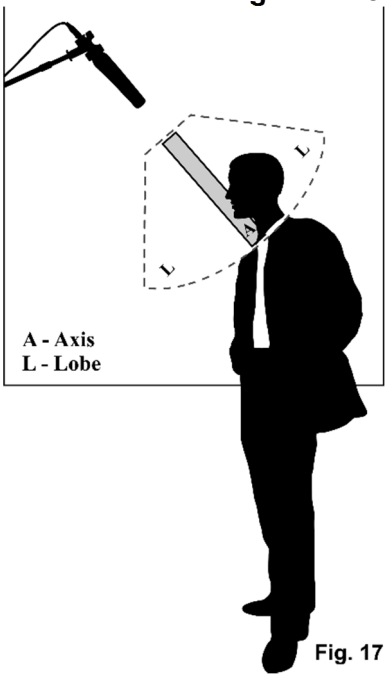


Fig. 17

[19] Idem, p. 97.

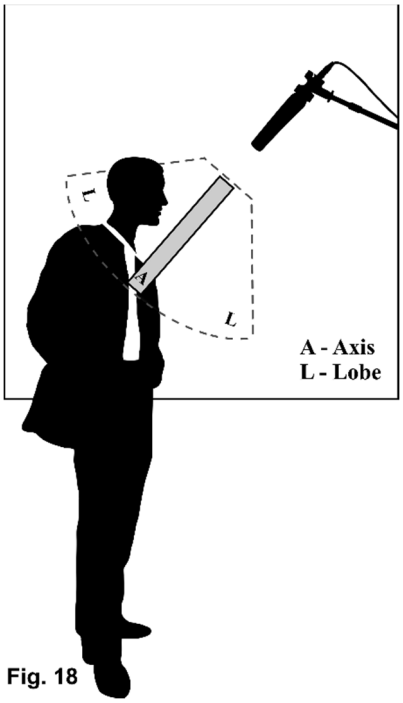


Fig. 18

If we aim the shotgun microphone at the speakers sternum (Fig. 18), then we use the **lobe recording** technique.

Both techniques have their advantages and disadvantages.

The on-axis aiming technique will result in a better quality recording, however, it makes it almost impossible for the boom operator to accurately follow the actor's each move in real time and hold the microphone within the narrow range of its axis. Thus, this technique should be used only during the dialogue recording of very static scenes or those that are very well known to the boom operator.

The bigger pickup angle of the lobe increases sensibly the sound source's freedom of motion without registering any change in the microphone's sensitivity, thus covering well the possible errors occurring during boom operation, so in most cases the lobe side aiming is the recommended technique (on the principle of not that excellent but constant sound quality).

According to Dean Miles location audio operator, this technique "provides increased richness to the lower frequencies of the talent's voice. These low frequencies resonate off their chest, resulting in a warmer, richer sound. By slightly moving the axis off the talent's chest you can change the sound perspective from warm and close (perfect for a close-up), to thinner and further away (perfect for a medium shot)"[20].

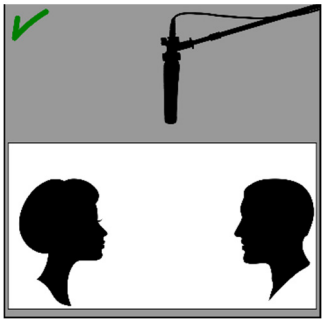
Since the characteristics and quality of the recordable speech are sensibly different in the case of the two techniques, it is advised to avoid mixing the two.

1.5. Recording a dialogue with two interlocutors

When recording the sound of a scene with two characters besides paying attention to the right aiming technique, one must follow also the (often) rapid changeovers, which considerably increases the difficulty level of the task (in comparison to the recording of a single sound source, as presented above).

[20] Ibidem, p.101

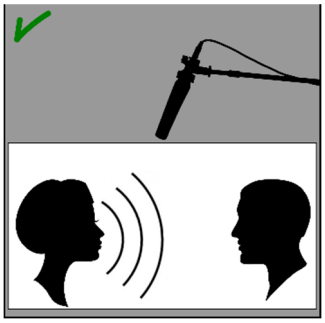
Fig. 19



1.5.1. Initial microphone placement
(before starting shooting)

Before starting the recording of a dialogue with two interlocutors the shotgun microphone must be placed between the two speakers relatively to the middle.

Fig. 20



1.5.2. Microphone placement during recording

The boom operator must watch closely and anticipate the events unfolding on the location. S/he must know exactly all the details of the recordable scene including its course in time. Furthermore, s/he must know when each of the two characters take their turn to speak in order to be able to aim the microphone at the speaker a few seconds beforehand.

1.5.1.3. Microphone placement errors

The following are considered to be microphone placement errors (that are immediately audible on the recording):

Fig. 21 – 23

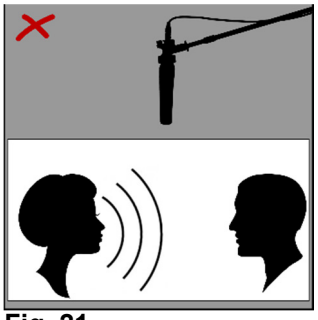


Fig. 21
– in the moment the shooting starts the boom operator is still holding the microphone in the initial placement position;

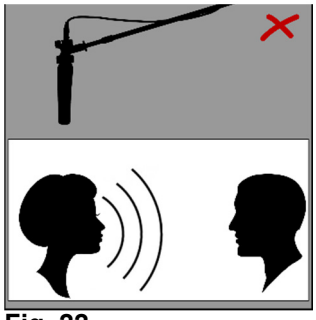


Fig. 22
– the boom operator does not follow closely and immediately the speaking actor's movement and consequently the microphone is off-axis;

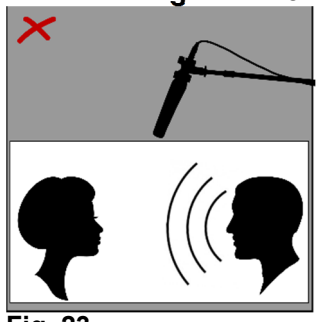


Fig. 23
– the boom operator does not move the microphone fast enough to the other character when they take their turn, and thus, their first words are recorded off-axis.

These mistakes can be successfully eliminated (in the majority of cases) if the boom operator:

– knows the script;

– is present at the reherasals that precede the shooting;

– has a good sense of rhythm;

– shows continuous vigilance and determination throughout the entire shooting.

1.6. The sound recording of films with unknown dramaturgy or scenes with more than two characters

In case of sound recording of a documentary film it is not possible to prepare beforehand, since there is no rehearsing on the filming location. The characters who play themselves do not follow closely the script, but rather they act their own lives (with minimal directorial interference). Moreover, it is not possible to record the scenes twice, due to the fact that a certain human reaction cannot be genuinely reenacted by an amateur character. Consequently, more than one boom operator is needed in such situations.

In the case of such acoustically uncertain or overloaded scenes the safe solution is to operate more than one shotgun microphone (which evidently means more than one boom operator), and/or have invisible lavalier microphones for each character.

1.7. The placement of the shotgun microphone outside the film frame

Before the shooting of every scene, after the cinematographic preparations (lighting, plane setting etc.), the boom operator should also find the ideal microphone position for the scene.

There are two principles to be followed:

– to be as close as possible to the recordable sound source;

– to keep the sight of the microphone, as well as the shadow cast by it outside of the shot at all times.

To adjust and constantly maintain the microphone at the correct height, the following steps are necessary:

Fig. 24 - 27

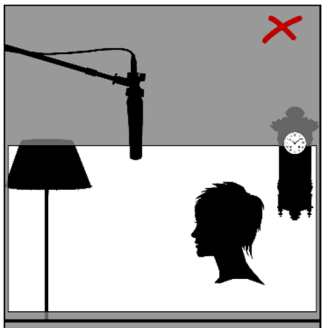


Fig. 24
- the microphone is slowly lowered along the vertical axis until the cameraman signals that it "appears in the shot";

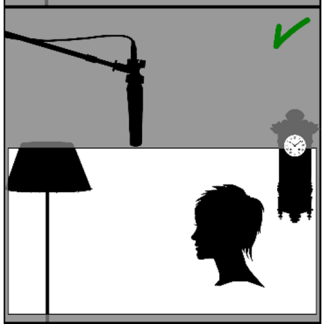


Fig. 25
- following this, the microphone is slowly lifted along the vertical axis until confirmed by colleagues that it does not disturb the visual sphere of the film anymore;

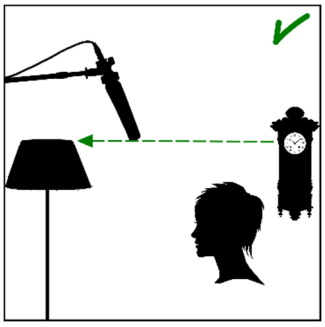


Fig. 26
– after finding the right microphone height for the plane of the scene, one should also be able to continually maintain this vertical position. To achieve this, it is recommended for the boom operator to find a stable object in their surroundings for support.

Fig. 27
For instance, if we set the microphone in figure 26 to a height where its lower end is positioned at the height of the lamp shade in the given space (in this case, a room), then its unwanted sight will not be a problem during shooting (Fig. 27), where such an appearance would make the audiovisual material unusable.

To avoid the microphone's shadow appearing in the image plane, it is recommended to identify the strongest light source on the outdoor or indoor location (which, in the case of outdoor spaces, is usually the sun), and the direction of its light.

The boom operator should relate this to the axis of the cameraman, and stand on the opposite side.

1.8. Holding the boompole correctly

The shotgun microphone is used attached to a rod called the boompole to increase its (horizontal and perpendicular) "reach". In this way we are able to invisibly approach the actor who is about to speak at a certain distance from us.

Expertly aiming at a constantly moving sound source and following it with a shotgun microphone on a boompole of several meters requires serious expertise, precise motor skills and practical experience.

At the same time, the boom operator trying to record the original film sound should also be in a good physical shape, since s/he is required to hold the boompole with outstretched arms above the speaking actors, fighting the force of gravity.

And what is perhaps the most difficult, the boom operator should move (quite frequently) in order to avoid muscle cramps without making the microphone at the end of the pole sway.

In the following figures we will present the boompole holding positions that proved most effective in filming. The posture of the boom operator should be as comfortable as possible, the muscles kept relaxed and flexible and any tension of immobility that appears in the form of pain should be dissolved immediately (with a small movement).

Fig. 28 - 30

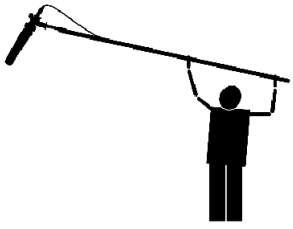


Fig. 28

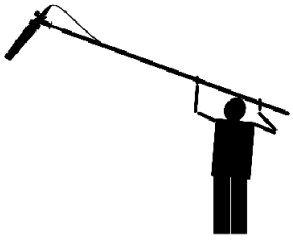


Fig. 29

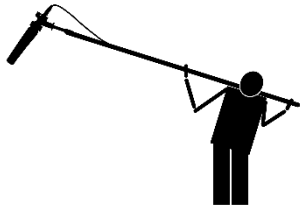


Fig. 30

Fig. 28 shows the basic position of holding the boompole with outstretched arms. By stretching the hands forwards or back, it is possible to follow an actor's minor (within a range of 1-1.5 m^2) movement. Due to the difficulty of this posture, it is only recommended for recording short and dynamic scenes.

If the sound crew is made up of two people and the sound engineer is monitoring the recording through earphones, the boom operator may, in case of fatigue, rest the pole on their own head for a few seconds (Fig. 29) without causing the initial height of the microphone to drop.

Although it is easier and more painless to hold the boompole supported on the shoulders, this kind of operation comes with a certain loss of height (Fig 30). It is adequate to follow the more extensive (within several square metres) motion of an actor only to a certain degree (due to the lack of precision in aiming).

The position shown in figure 31 (and Fig. 46) is ideal for recording mid-height, static speech sound with a longer time span (such as in the case of a sitting interviewee). Hand no. **1** (left or right) is positioned on the body, so the body will take on the weight of the hand-held equipment, similarly to a lever mechanism. The boompole should be held between the thumb and index finger, while hand no. **2** lightly props the end of the pole. We can ensure the alternate relief of each hand through taking the following simple steps:

– the boompole is grabbed firmly with the fingers of hand no. **1**., in this way hand no. **2** can temporarily let go of the pole;

– the elbow of hand no. **2** is placed on the end of the pole, reclining the whole surface of the arm on it and lastly, grabbing it with the fingers as well;

– in this moment, hand no. **1** can be completely taken off the pole and be rested for 20-30 seconds, even be shaken lightly;

– when the signs of painful tension begin to appear in the shoulder of hand no. **2**, hand no. **1** should be replaced to its original position (held to the body), with the fingers tightened around the pole, so that hand no. **2** can temporarily release the pole again;

– after the end of the pole is supported by hand no. **2** the fingers of hand no. **1** can be opened, and we are back to the original starting position (shown on figure 31). However, while carrying out this routine, its cycle repeatable until the end of the shooting, the boom operator should constantly pay attention to keeping the microphone motionless and aimed in the right direction.

Fig. 31 - 33

Fig. 31

Fig. 32

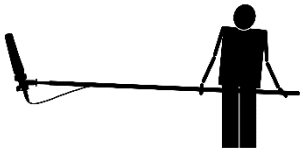


Fig. 33

The boompole can also be leaned against the hips (Fig. 32).

In certain cases, the shotgun microphone can also be aimed from beneath and upwards (Fig. 33), although this comfortable position has many counterarguments. In these cases the speech of the sound source becomes slightly nasal, several sounds caused by body movements can come across as noise (for instance the rumbling of an empty stomach or the sound of moving the arms can interfere with the quality recording of the main sound), and the pole can collide with several objects (parts of the set, equipment etc.) when the boom operator is turning with it. Therefore it is worth using only in exceptional circumstances, when the creative (directorial-cinematographic) concept requires that the space above the actor's head be left empty, and the microphone cannot be operated invisibly in that area.

Fig. 34

In the shooting breaks it is advisable to lean the boompole against a shoulder and rest it on one's shoe - in this way both hands are liberated but the pole doesn't get dirty, fall over, etc.

The job of the boom operator is greatly facilitated by an articulated boompole. The boompole, in this case is supported by the perpendicular rod which can be attached to the belt of the boom operator (figures 35a-b.) and can be easily operated by him/her with one hand.

Fig. 35 a, b

Fig. 35a

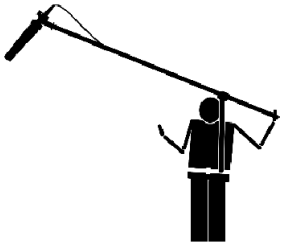


Fig. 35b

1.9. The boompole

When choosing a telescopic (consisting of concentric tubular sections designed to slide into one another) boompole, one should carefully check whether the length of the fully extended pole is enough to leisurely meet the challenge of the task at hand. On the other hand, a pole that is too long (e.g. 6.5 metres) has also excess weight that we will have to hold above our heads at the shooting locations (for long hours). Of course its material also affects the weight of the boompole. The poles made of aluminium alloy are more durable and heavier, but also much cheaper than the significantly lighter but more vulnerable poles made of carbon fiber polymer.

1.9.1. The closed boompole

Fig. 36

Due to their telescopic construction, even the longest (5-6m long) boompoles have a small transportation size.

1.9.2. Preparing the boompole

Fig. 37

Upon arrival at the shooting location, the compression rings of the closed pole (figure 38) should be loosened and every tubular section extended to a palm length and fixed in the new position, avoiding over-tightening of the rings.

1.9.3. Correct extension of the boompole

Fig. 38

Before the start of the shooting, the boompole should be opened to the desired length. When extending the tubular sections, it is advisable to follow the sequence outlined here.

The first section should be extended to maximum length, then (if the pole has not reached the desired length) continue by extending the second section. Thus, the heavy end of the pole will always be closer to the body, and if it is necessary to extend the remaining tubular sections, their compression rings will remain at a reachable distance.

A boompole of good quality will never emit clunky noises when moved, not even in fully extended position.

1.9.3. Correct shortening of the boompole

Fig. 39

When shortening the boompole, it is recommended to follow the reverse order, as shown in this figure (likewise, due to practical considerations).

Similarly to any work equipment, the boompole should also be kept clean and dry during use and when stored.

1.10. Shotgun microphone accessories

The microphone accessories presented in the following section are items which every boom operator needs - in order to create a high quality sound recording, it is with the aid of these that several sound phenomena that appear as noise can be eliminated from the sound field.

1.10.1. The shock mount

Not only air, but also every elastic medium is able to transmit sound vibrations. Its speed is influenced by the aggregate, density and elasticity of the medium. While in air, in conditions of normal humidity and a temperature higher than 15°C, sound waves travel with the speed of 340 m/s, in solid materials this speed is much higher (gold: 2080 m/s, glass: 5200 m/s, iron: 5000 m/s, steel: 5100 m/s etc.).

Therefore it is easily conceivable that the boompole successfully transmits the small noises of the fingers touching it, the cable coiled around it, etc., which the microphone will perceive and record along with the speech sound of the actor, adding unwanted noise to the recording.

Fig. 40 – 41

Fig. 40

Fig. 41

The shock mount (Fig. 40), installed in the place where the shotgun microphone and the boompole connect, disrupts the direct contact between the two, keeping the microphone in a suspended, floating position (Fig. 41). In this way, along with the necessary stability, it provides enhanced protection against the unwanted, low frequency vibrations coming from the boompole.

1.10.2. Shock mount equipped with (pistol grip) handle

Fig. 42

The shock mount is set up with a handle in cinema sound technology, as the shotgun microphone can be used to professionally record foleys as well as speech sound. Since the work process does not always require the use of a boompole, the microphone can also be aimed at different sound sources while holding it from the handle.

1.10.3. Wind protection accessories for shotgun microphones

One of the most frequent sources of noise in outdoor sound fields is wind; in the absence of wind protection accessories, it can reduce the quality of the recording to the point of unusability.

Foam windscreens bought with the microphone (Fig. 43) offer little protection from the (often) violent sound of the wind, so they are only used in indoor shooting. Its use is not recommended outdoors without additional wind protection, not even in completely calm weather.

Fig. 43 - 45

Fig. 43

Fig. 44

Fig. 45

The pistol grip handle shock mount can be equipped with an accessory called a blimp/zeppelin system (Fig. 44); its surface looks similar to the structure of wax cells and its overall shape resembles a blimp (zeppelin). The blimp system

creates a wind-protected chamber around the shotgun microphone attached to the shock mount (Fig.42), diffusing the wind rushing towards the microphone. Nevertheless, for an ideal degree of out-door wind protec-tion, it is necessary to (velcro-)attach a layer of furry material called a *windshield* or *dead-cat* to the exterior of the blimp (figures 45-46).

Fig. 46

Location audio operator Dean Miles and videographer Scot McDonald in action.

The use of these accessories is indispensable (regardless of budget), because they hugely contribute to the quality of a sound recording. However, they do not substitute human expertise.

1.11. Lavalier microphones

Shotgun microphones transmit a richer, more realistic sound quality to the recorder than small, lavalier microphones. As a consequence, the use of the lavalier microphones is recommended only in the following situations:

– dialogue recording of a scene with more than two people;

– in the case of too dynamic, motion-oriented scenes;

– if the sound source is not approachable with the boompole, being outside of the maximum reception area.

Nonetheless, lavalier (clip-on) microphones have many advantages as well:

– if the spontaneous noises around the actor are too loud, or are directly behind the actor (since the maximum reception area of lavalier microphones is approx. 30 cm, they largely cut off any sound source beyond that range).

– they can be attached directly (and, if necessary, invisibly) to body parts, clothing; this also means that their distance to the sound source will

constantly remain the same, ensuring the stability of the transmitted sound characteristic.

"An experienced sound engineer must have a personal toolkit for hiding clip-on microphones and for safely securing the cables onto clothing. The accessories offered as supplements to lavalier (clip-on) microphones are merely basic tools"[21].

1.11.1. Wireless systems

Lavalier microphones can be connected (through a short cable with a jack plug) to wireless radio transmitter units, which enable free movement to the speaking actor.

The microphone is attached to the transmitter, the recorder to the receiver.

The main drawback of wireless systems is undoubtedly the interference sensitivity (due to the use of radio waves).

Fig. 47

2. The portable digital (field) recorder

The goal of this paper is not to promote "blind" brand loyalty amongst its readers, but choices made in light of professional knowledge instead; therefore we will not present any specific model from the wide quality and price range offered by well-known manufacturers[22].

Instead we will only set out and briefly describe the most important parameters which are indispensable to creating a high quality sound recording.

Therefore, every professional field recorder must have:
– a recording setting of minimum 48 kHz, 24 Bit, wave file format;
– the option of saving the file to an SDHC memory card[23] ;
– the option of minimum four-track sound recording[24] ;

[21] P. Arasin, The Sennheiser Sound Academy …, op.cit., p.22.
[22] E.g. *Sound Devices*, *Edirol*/*Roland*, *Tascam*, *Zoom* etc.
[23] The saving method used by older recorders - saving to the Hard Disk Drive is less safe and more time-consuming (since the content of a full HD always has to be transferred).
[24] If necessary, it is possible to simultaneously record with four microphones, for example with 1 shotgun and 3 lavalier microphones.

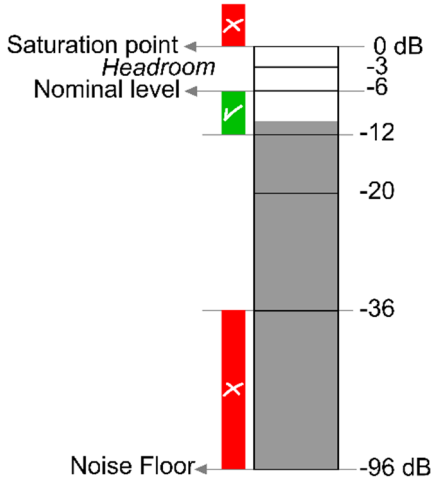
– phantom power option: the 48V power source for all tracks, necessary for condenser microphones;

– the low cut option: which makes it possible to cut off useless low frequencies below 80 Hz that come off as noise, damaging the quality of the recording (such as wind sounds, exhaling/inhaling etc.)

– quality preamplifiers (with a low noise factor) – the electrical sound signal transmitted by the microphone is too weak to be recorded, thus a preamplifier is needed to increase the signal strength. It is crucial that a good quality amplifier have good noise performance so that is does not add noticeable amounts of white noise to the sound signal while amplifying it.

It is exceptionally important to watch the volume proportion between the valuable audio signal that is being recorded and the unwanted background noise. The strength and richness of the received signal can be regulated in every detail with the Gain potentiometer in every track. If the signal captured at the shooting is too low, it has to be boosted during post-production, but the amount of background noise will also be increased in the process. On the other hand, a too strong field signal should be avoided for the reason that it may distort the audio material. It is the duty of the sound engineer operating the digital sound recorder to set the optimal audio signal strength, taking into account the field circumstances and the characteristics of the sound that is being recorded.

Fig. 48



The saturation point is where the sound reaches the 1% distortion threshold (clipping). Consequently, it would be ideal to keep the signal strength between -6 and -12dB, this way establishing a clipping-free, headroom too for the more extreme values in case of suddenly increased signal strength.

– the limiter option: in the case of recording material with content unknown beforehand, it is recommended to use the limiter option, which keeps unexpectedly and dangerously high audio signal values below the saturation point, guaranteeing a clipping-free, undistorted recording quality.

– audio monitoring option: with the aid of the headphones, the analysis of the recording can be completed in real time – a vital part of the recording process. Usually, the signal strength of the headphone playback can be regulated with an extra potentiometer, but one should not forget that this procedure does NOT change the strength of the recorded audio signal, but merely controls the volume of the audio monitoring.

– small size, lightweight, durable design, adequate accessories (e.g. carriers, bags etc.)

2.1. The headphones

Fig. 49

Good quality linear headphones are indispensable for audio monitoring, which ensure an undistorted and realistic playback.

When monitoring a field recording, our headphones should respond to the following requirements:

– they should be completely "closed" (in other words, isolate the audio playback from the surroundings of the wearer);

– they should come with a frequency range as wide as possible (16 Hz-22.000 Hz);

– one of the earpieces has to be rotatable (so that one does not have to remove the whole device when listening to the director or the cameraman);

– its cable should not be too long (which would tangle easily);

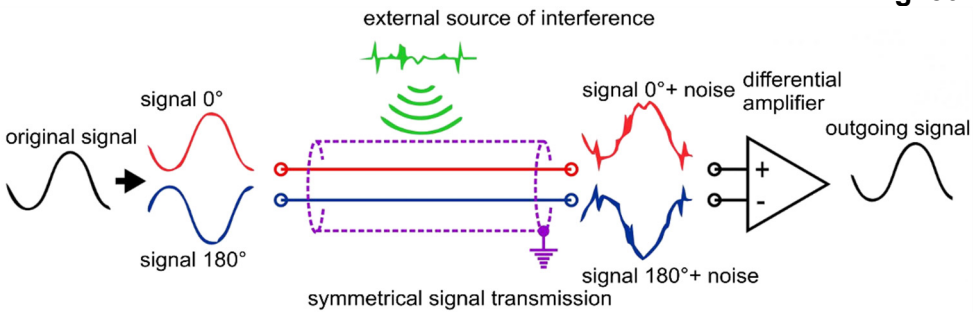
– every one of its parts (cables, speakers, earpads) should be easy to replace in case of failure (so one does not need to replace the whole device).

The Sennheiser HD 25-1 II model headphones

3. The balanced cable with XLR connectors

In professional sound technology, the sound signal is transmitted from the microphone to the digital recorder through a three-conductor (symmetrical or balanced) cable. Out of these, the two that are twisted together, called the "hot" and "cold" connections are responsible for transmitting the audio signal, while the third conductor acts as a shield (ensures the earthing).

Fig. 50



According to the figure published online[25] by János Hermann, the original signal from the microphone is transmitted through the red and blue cables doubled, but 180° out of phase with one another, and then the differential amplifier subtracts the two, opposite polarity signals that both carry noise, creating the useful, noiseless signal, fit for recording (containing, in our case, speech sound).

The acoustic signal chain (microphone - cable - sound recorder) is completed with the aid of the XLR connectors at the end of the balanced cable.

The longer the cable used for signal transmission, the stronger noise protection is needed, since both in- and outdoor environments contain many sources that emit electromagnetic noise signals.

Regardless of the shooting location, the abundance of cables lying on the ground, pertaining to the lighting system used to properly illuminate the scene is one of the most culpable sources emitting electromagnetic noise signals, interfering with recording quality. Therefore, the sound engineer must (patiently) wait for the lighting technicians to arrange their cables on the ground and only then can they plan the path of the sound cable. Intersection with the lighting cables must be avoided (if this is not possible, an improvised bridge must be used to guide the cable over the light cables), but it is even more dangerous to arrange the two cable types in parallel, within a small distance (0,5) of one another.

The boom operator must pay special attention to proper cable handling during shooting. The cable wrapped around the boompole should not lash against anything when moving the pole; they should also precisely measure the necessary loose cable length before shooting the scenes, considering the movement requirements. And keeping the cable clean and properly rolling is an unavoidable task at the end of every day of shooting.

[25] http://www.hangfoglalasonline.hu/20150401_es_tessek_mondani_mennyibe_kerul_a_foldhurok_1_resz

Certain boompoles come cabled with a balanced cable that runs internally, thus making the cable wrapping unnecessary. However, in these cases the extension and shortening of the pole requires more careful handling; another drawback is fitting the multiple cable fragments together.

Fig. 51

And of course, the transmitter systems used with lavalier microphones can be used with shotgun microphones as well, in such cases the transmitter shown on figure 53 (A) is to be connected to the shotgun microphone.

The Sennheiser SKP 100 G3 transmitter.

What counts as ART?

In a creative process, it is ALWAYS the authorial concept/intent that is of primary importance, the rest is merely a question of tools and style. To put it in everyday terms, before the physical realization (shooting) of our audiovisual project, we must be fully aware of and determined in our authorial intentions, as this is the only way that we will be able to choose the professionally adequate audiovisual solutions.

In the following, we will sum up our creative ars poetica, with two quotes as starting points. Only those who have something to communicate should become artists, yet:

"The painter who draws merely by practice and by eye, without any reason, is like a mirror which copies every thing placed in front of it without being conscious of their existence." (Leonardo da Vinci)

"Sound, as a factor of meaning isn't art in itself. The sounds that ring out in reality, in nature, don't form a system of aesthetics. The sound phenomenon is merely the raw material of sound itself, which has to be shaped by the artist in favour of the film and arranged into a system of aesthetics for it to hold artistic value." (Ferenc Lohr)

THE COPY OF REALITY	+ ART	= THE RECREATION OF REALITY
- captures both the significant and the insignificant; - the details are positions following nature's aleatory system; - they are of equal emphasis.	the ARTIST carefully filters the real experience, selecting, pondering elements, and arranging what is left in a manner in which the individual details and the whole both reflect his/her concept.	- reflects only the significant; - omits the obscure; - arranges the elements; - highlights the characteristic, effaces the secondary.

Therefore the artist creates with the TOOLS of expression specific to the chosen art form, constantly pushing the limits of creative freedom limited by the STYLE they have consciously accepted, engaging learnt WORKMANSHIP SKILLS, and in alignment with their subjective MINDSET.

Executing an audiovisual project in a professional manner

An audiovisual project is executed in a professional manner when an authorial concept is realized with a precisely adapted set of technical skills and with great proficiency.

A competitive film should have excellent sound- and image quality, regardless of its budget. And since one canNOT save money on the price of minimal technical equipment, it is the plot, genre, the visual language, the number and choice of the cast and crew, etc. of the planned motion picture that should be adapted to the budget.

Bad quality film sound brings the entire production down.

Consequently, if we only have a high-resolution image quality DSLR camera or cellphone at our disposition, it is best to formulate and get our idea across in a purely visual way. We can lighten the severe stony muteness of our silent film with the ulterior addition of music that is purely illustrative but chosen with exigence, thus achieving enjoyable quality for the end product (even in the absence of the optimal equipment necessary for a field recording).

Single system recording

The present paper takes on the detailed description of the characteristics of basic equipment necessary for excellent quality sound recording. The recording options below the quality threshold we have pinned down are inadequate to produce neither enjoyable nor competitive sound quality.

Although every element of the acoustic signal chain should be of excellent quality, the boosting of the built-in sound technology of DSLR and/or cellphones could be a partial solution. An external microphone attached to the casing of our smartphone (Fig. 52) or camera (Fig. 53) can attain an increase in quality. This method is called single system recording and in some cases (such as the shooting of an interview with one interviewee) it can produce a usable quality sound signal.

Fig. 52

Fig. 53

Double system recording

Undoubtedly the professional recording solution is double system recording (recording with a set of tools completely independent from the camera capturing the image). With the autonomous acoustic signal chain constructed of excellent quality elements, (chosen adequately for the creative needs and framework of the location), alongside the proper professional competence, one can create sound recordings of serious artistic quality.

The sound crew

The recommended "minimum headcount of the sound crew is of 2 people (sound engineer and boom operator), but for the more complicated scenes 3 people are recommended (sound engineer, boom operator and assistant boom operator). The one-person "sound crew", in the case of most scenes, is unable to record adequate quality sound, since one cannot manage the microphone, mix the sound and manage the cables at the same time, not to mention assembling radio transmitters when recording scenes with multiple microphones; in addition, the switching time between scenes increases, slowing down the shooting unnecessarily"[26].

[26] Balázs Gábor és Zányi Tamás, *A filmhang készítés technológiája, I. rész, (The technology of film sound production, part I.)* 2007.

External factors that influence the sound quality of a film

Before recording, the professional undertaking the task should identify the ambient sounds present in the sound field of the location that come across as noise and if possible, remove or dim them as much as they can.

Obviously, they will not be able to banish the songbirds from a forest, but loggers working close to the filming location can be asked to pause during the shooting. As for indoor spaces, every domestic appliance should be unplugged, the windows closed, the barking dog taken for a walk and the vacuuming neighbour bribed to stop, otherwise the sound produced by these sources will appear on the recording as unwanted noise.

In order to acquire professional skills in the film sound recording process, beyond the theoretical knowledge and the practical tips/solutions (carefully collected and ready to be implemented) outlined in this present paper, lots of fieldwork and practice is necessary.

Translated from Hungarian by Zsuzsa Székely

REFERENCES

BOOKS:

Arasin, P., *A Sennheiser hangakadémia vezeték nélküli rendszerek kézikönyve [The Sennheiser Sound Academy Wireless Handbook],* ISBN 987-963-08-6495-4, 2013.

Boré, G. - Peus, S., *Microphones - Methods of Operation and Type Examples*, Berlin, 1999.

Fazakas, Áron, *Filmhanglexikon [The Encyclopedia of Film Sound]*, ISBN 978-606-739-012-4, EME (Erdélyi Múzeum-Egyesület) Publishing House, Kolozsvár, 2014.

Jákó, Péter, *Digitális hangtechnika [Digital Audio Technology],* ISBN 9630944006 Kossuth Kiadó, Budapest, 2002.

Lohr, Ferenc, *A filmhang esztétikája*, Magyar Filmtudományi Intézet és Filmarchívum Kiadó, Budapest, 1966.

Miles, D., *Location Audio Simplified – Capturing your Audio ... and Your Audience*, ISBN: 978-1-138-01877-8, Focal Press, New Work, 2015.

Rayburn, Ray A., *Eargle's the Microphone Book: From Mono to Stereo to Surround - A Guide to Microphone Design and Application*, ISBN: 978-0-240-82075-0, Focal Press, 2012.

ONLINE SOURCES:

Balázs, Gábor és Zányi, Tamás, *A filmhang készítés technológiája, I. rész (The technology of film sound production, part I.)*, 2007. Published with the notes, contributions and support of: Dr. Erdélyi Gábor, Hubay Zsolt, Komlódi Gábor, Kovács György, Kőporosy János, Márkus Tamás, Oláh Ottó, Vámosi András, Várhegyi Rudolf.
http://www.haes.hu/dokumentumok/filmhangkeszites_2007_1.resz.pdf

Of the frequency range of speech:
http://www.kislexikon.hu/beszed.html#ixzz40dD2ipnX

Of balanced signal lines:
http://www.hangfoglalasonline.hu/20150401_es_tessek_mondani_mennyibe_kerul_a_foldhurok_1_resz

VISUAL MATERIALS:

(01), (02), (03), (04), (05), (06), (07), (09), (10), (11), (12), (13), (16), (17), (18), (19), (20), (21), (22), (23), (24), (25), (26), (27), (28), (29), (30), (31), (32), (33), (34), (35b), (36), (37), (38), (39), (48) – images created by the author, who is in full legal ownership of the rights

(08) – screenshot from the *Cool Edit Pro* software.
(14), (15) – *http://micrentals.com/sennheiser/sennheiser-mkh-416/*
(35a) – *http://www.boomaudiovideo.com/images/galeriekitcool_28.jpg*
(40) – *http://www.bhphotovideo.com/c/buy/Shock-Mounts-Shoe-Clips/ci/8650/N/4223841581*
(41) – *http://cdn2.rode.com/images/products/ntg-3/gallery/3.jpg*
(42), (44) – *http://www.rode.com/accessories/blimp*
(43) – *http://www.pako.hu/aruhaz/lista/1030/Hangtechnika-Mikrofonok-Mikrofon_tartozékok*
(45) – *http://rycote.com/microphone-windshield-shock-mount/modular-windshield-kit/*
(46) – *http://thelocationcrew.com/assets/IMG_0146.jpg*
(47) – *http://spaghettibeau.com/product/sennheiser-g3-radio-mic-hire/*
(49) – *http://www.dv247.com/assets/products/58920_l.jpg*
(50) – *http://www.hangfoglalasonline.hu/20150401_es_tessek_mondani_mennyibe_kerul_a_foldhurok_1_resz*
(51) – *http://en-s.sennheiser.com/global-download/file/1842/SKP100 G3_hires.jpg*
(52) – *http://www.itoys.co.za/iphone-boom-microphone*
(53) – *http://ecx.images-amazon.com/images/I/61fQp6n0AeL._SL10 23_.jpg*