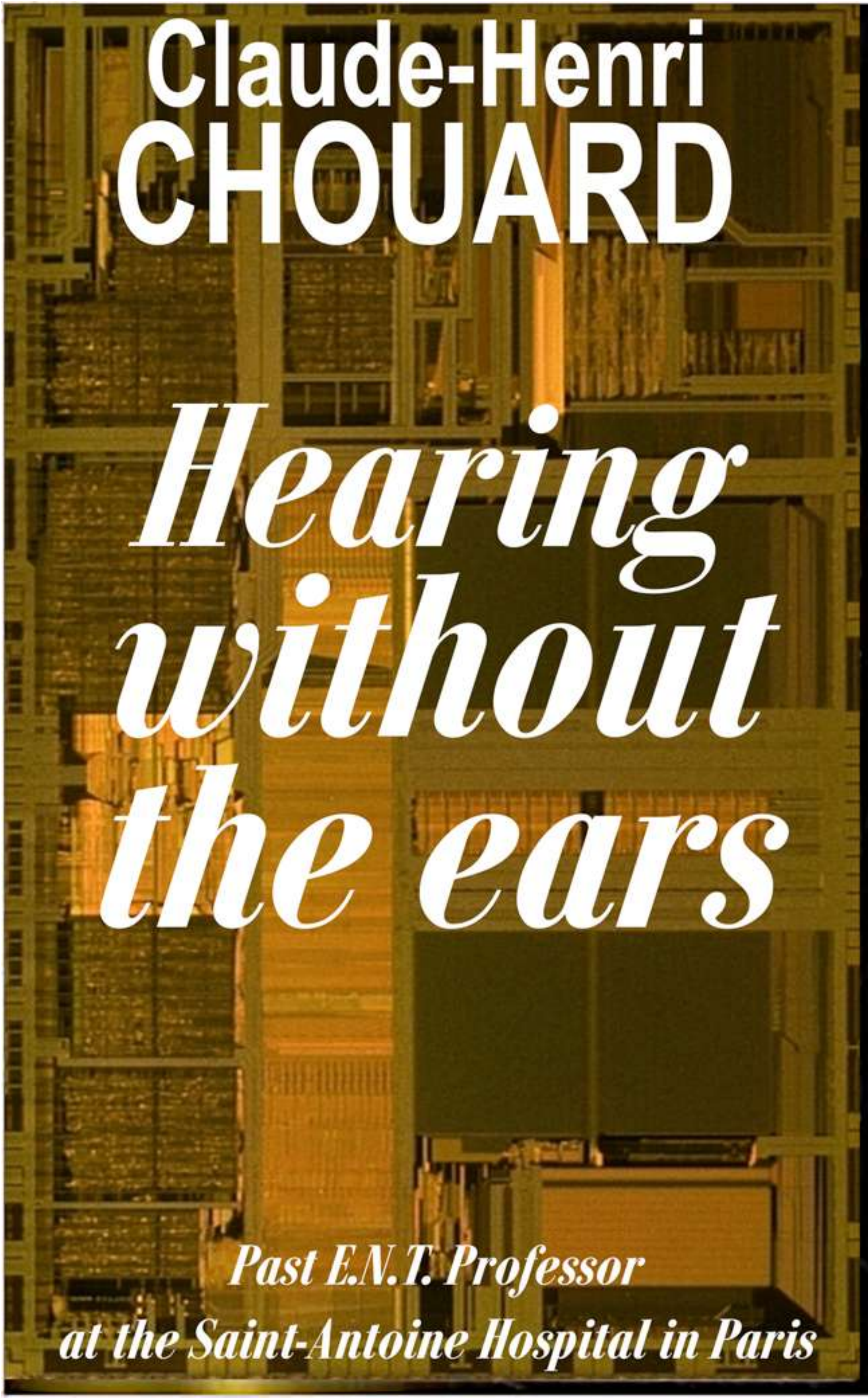

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CHOUARD

Hearing without the ears

Past E.N.T. Professor
at the Saint-Antoine Hospital in Paris

TO DOCTOR CHARLES EYRIES

1908-1996

1931-…

INTRODUCTION

There are 17,000 deaf-mutes in France and, one imagines, many more in the world. They ignore all the familiar noises that surround us, the calls, the words of their relatives. For them, the sound of words and things does not exist. In spite of all the efforts of the rehabilitators who took care of them during their childhood, most of them can hardly speak. Because, in their silence, they do not hear themselves, they cannot correctly reproduce the sounds of all the messages of the conversation. And, more often than not, their voice, distorted despite their efforts, remains incomprehensible to us.

For many of them, there is now hope. Of course, they will not hear as well as a normal subject. And, yes, they will be dependent on miniaturized and complex electronics. But, once they are out of their silence, they will integrate better into everyday life, they will speak better, they will understand better, they will *live* better.

Why? Because, in five years, in France, at the Saint-Antoine Hospital in Paris, a team has succeeded in developing a process that allows the majority of people suffering from *total* deafness to hear.

The technique consists of the implantation of electrodes in contact with the auditory nerve, to which the sound information can thus be brought in the form of electric signals, received from the outside from a miniature transmitter placed on the shoulder. This way, not only most of the total deafness caused by an accident or an infection, but also almost all cases of deafness can be rehabilitated today.

To get to this point, I was not alone. Gradually, a group of doctors, researchers, and nurses gathered around me and trusted me. During five difficult years, in the Department of Otolaryngology Surgery at Saint-Antoine, a department that I have recently taken over and of which I was for a long time the deputy head, this team fought step by step to solve the problems one by one. I brought together those who could help us. After having invented a surgical technique, we dared to try it. I took risks for my patients and for myself - calculated and reasonable, of course, but risks nonetheless. The development of this technique was not without its pitfalls, its worries and sometimes its anguish. We endured everything, not without difficulty at times. Often it seemed like a desperate journey through the desert or a crazy leap of faith. Never - almost never - did I really consider giving up.

At the present time - at the end of September 1978 - despite all the progress still to be made, the success of this technique is already such that French and foreign doctors who have followed us from afar during these long years have come to learn it here in Paris.

During the four days of a congress, we showed them all the details of the process, explaining the crimping, the impedance measurements, how to install so many electrodes in the so restricted space of the inner ear, how this complex equipment, carried in a sling by our patients, works and is adjusted.

During these four days, all these doctors, these surgeons, who came from the four corners of France and from all over the world, to learn how to carry out this rehabilitation, have worked a lot. Moreover, now that they know how to transform sounds and noises into electrical signals, how to penetrate the tiny spaces of the inner ear where disease, heredity and misfortune have left a void, and how to install microscopic electrodes that will replace what often never existed, these men are also aware that it is their turn to save thousands of disinherited people.

But this evening, before they parted to return to their respective posts, they relaxed and rested: it was the closing banquet of the congress, of this first International Course on the Multi-electrode Cochlear Implant. We are in the salons of a castle near Paris. The candles and lights seem to rustle in the warmth, unaffected by the multi-paned windows. A life of fire blazes the aged marble of the high chimneys and sets fire to the tablecloths and the golden chairs with reflections. The conventional waiters run the relay of the dishes and the guests. Bare shoulders and tuxedos play with contrasts. On the impassive woodwork of the walls, the centuries pursue their shadows. On the other side of the windows, the night has settled, devouring the lawns; the park has disappeared.

Now it's time for the speeches. A few sentences, then I leave the floor to the others. While the microphones of thanks, tributes, wishes and toasts begin to circulate, I still look at these eighty or ninety doctors, surgeons of the infinitely fragile, who will soon astonish the silences, electrify the uninhabited, create or resuscitate life, and I feel full of a happy calm: I am finished.

Slowly, I get up and slip away. On the narrow arrows of a parquet floor in the point of Hungary, opens a door-window. Outside, floors of darkness, the terraces breathe, insensitive to the hubbub.

Out of the others, leaning on this night as on myself, I would like to understand. What have I achieved that makes me so calm tonight? But at the price of what persistence? And why this persistence? Of course, no research work is simple and without adventures. But what is the reason for the perseverance of those who do it? Why are researchers strugglers? For what secret motives do they crystallize their efforts on such or such subject? What intimate desire do they satisfy, in spite of the criticisms, the jealousies to which they are butted by their attempts, their discoveries?

Certainly, in the mass of recent medical discoveries, hearing without hearing is a minor progress, compared to the great inventions that save life or prolong it. However, this work was often an adventure. Why did I dedicate myself so intensely to it, enslaved in a long daily labor for years? And what grace did I have in this slow journey that finally led us to success?

For twenty years, in my specialty, I have lived surrounded by horrible miseries - much more horrible than deafness. Why did I stop at these deaf people who cannot hear me, rather than at my cancer patients with no voice, or at my faceless accident victims? Was it the immense distress of these beings buried alive in their invisible silence that motivated me?

To understand. To go back in time until I knew why these deaf children, why these deaf-mutes, children poorly disguised even if they are awkwardly cut as grown-ups, burned my soul so hard.

The darkness of reason is there, I feel it. The dream of memory plunges into the moat. Soft, a silky shadow leans against the silence of the night. Acidulated, multiple in frail noises, the wet humus listens. The naked trees rush - just for a second, green pungency, clear as a wingbeat, the scent of elder trees...

So many things remain to be done! And yet, this calm, this impression of having arrived at the port. Because we did not sink despite so many storms? But what first pushed me to embark and to embark others in this crossing of immense solitudes and battles which, sometimes, seemed lost in advance? Where did I get this desire to win, this obstinacy in risk, these calculated imprudences, which only became acceptable because they turned out well?

Love of my profession and my patients, or vanity? Devotion or pride? Sense of human mission or pushiness?

The deep roots that psychoanalysis could dig up are not enough to account for the essential, primordial scent - of that joy felt at the smell of the elder trees, one day, in Venice, when we found the idea that would allow us to win. Why do I have the impression that everything started from that smell? That I owe my certainty, stretched out over these five years, to it?

To understand, yes. To take back one by one the elements of this story, to put them back in their natural order or their chronology, to gather, to adjust so many impressions stranded on the strike of time, from weeks to months, from months to years, to tell myself in order to see clearly - this is the book.

WHAT IS HEARING?

Hearing is both a miracle of complexity and infinitesimal, like all the mechanisms of life. But it is also very simple: it is enough to explain the nature and the form of the sounds, how a nerve among many others, the auditory nerve, is sensitive to them, how our brain receives them, our intelligence interprets them and understands them.

Sounds:

A sound is a shaking, a vibration of the surrounding environment. For us, most often, this is the atmospheric air in which we live. But for fish it is the water; we ourselves, while scuba diving with mask and fins, can hear the speedboat passing far above us, or the clash of the trident on the rocks. For the Sioux, whose ear is glued to the ground and hears the enemy's cavalcade coming from afar, or for a tuning fork that sings in our head when we put it on our skull, the sound can also be the vibration of a solid.

This vibration lasts more or less long, repeating itself several times per second. The frequency of this repetition defines the pitch of the sound. Its unit of measurement is the hertz, which represents one vibration per second. We distinguish between high-pitched sounds, which have a high frequency. But, beyond 16,000 hertz, that is to say 16,000 vibrations per second, we no longer perceive anything: the sounds are then called ultra-sounds, to which dogs and especially animals (bats, cetaceans) are still sensitive, and which, in order to move around, use what is called *echolocation, that* is to say a real radar with ultra-sounds. The frequency of low-pitched sounds below a hundred hertz is perceived as a beat, and when this one animates a solid between zero and three hundred hertz approximately, these sounds can be perceived in a tactile way by the sensitive terminations of the skin. This is why, often wrongly, the totally deaf believe they have some auditory remains on the low frequencies: they are tactile sensations. It is from this perception that we tried in the past, with the vibrators, to rehabilitate these deaf people by transforming the sound information into cutaneous sensations.

This vibration, by repeating itself, animates the surrounding medium, that is to say the air for us usually, of movements analogous to those of a string whose end is agitated. The amplitude of the movement imparted to this string represents the force, i.e. the intensity of its product. A lot of energy is thus necessary to produce a powerful sound. The shape of the waves described by this string is variable, like that of sound waves. This shape defines the quality of the sound. If the waves are regular and symmetrical, they are called sinusoidal; they provide a pure sound. If the waves are regular and asymmetrical, we have a complex sound.

It is very important to know that any complex sound can always be considered as the sum of a number of pure tones, of different frequency and intensity. The simultaneous realization of all these elementary pure tones allows to obtain the complex sound in question.

Thus, the vowel "A", for example, can be schematically considered as the sum of two intense pure sounds of seven hundred hertz and one thousand three hundred and fifty hertz; to these are added other particular sounds, of weaker intensity, which make it possible to recognize the various timbres of voice specific to each individual pronouncing this vowel. These two characteristic sounds are called formants. The vowel "1" is made up of a formant of two hundred and fifty hertz and another one of two thousand six hundred hertz. The sound "ON" consists of three formants of two hundred hertz, eight hundred and fifty hertz and two thousand three hundred hertz. And so on... The complex sounds of certain consonants are constituted by sound shocks of very short duration.

Speech intelligibility does not use the entire range of our sound perception. It uses only the so-called conversational frequencies, between about three hundred and three thousand hertz. This linguistic choice is due to the acoustic capacities of the ear canal, the eardrum and the ossicles. These, for physical reasons, are the best in this frequency band.

Man has become accustomed to speaking in the zone where he hears best: because of the shape of his ears, he speaks between three hundred and three thousand hertz. Since each vowel has two or three formants, the understanding of speech, finally, uses only a very small part of the possibilities of our ear. This is why some telecommunication devices, the *vocoders,* - the device used to retransmit speech over long distances - use only twelve channels, that is to say twelve different frequencies. It is as if, in order to play the symphony of language, all that is needed is an organ with twelve notes!

Music, on the other hand, uses all our acoustic sensitivity: each of the multiple components of the complex sound of a violin or a flute has its aesthetic importance. It is easy to understand why the faithful reproduction of music requires large and complex loudspeakers and baffles, whereas a mediocre loudspeaker is enough to transmit the voice.

All this explains how, by playing on the auditory nerve of our totally deaf patients, as on a piano where each of our electrodes would be a different note, we can give them back a little of the perception of speech; but nothing appreciable can be brought to them in the hearing of music: it would require many more electrodes than the ear could contain.

The auditory nerve is a privileged nerve:

The sound vibrations of our environment are communicated to the fluids of the inner ear, either directly, by shaking the skull, as a tuning fork does on the forehead (but the energy output is very low), or through the eardrum and the chain of ossicles. The eardrum vibrates like a drum and transmits these movements to the hammer, which makes the anvil move, which in turn makes the stapes vibrate. This small stapes plays an amplifying role, because it receives all the energy coming from the much larger surface of the eardrum; it floats on the liquids of the inner ear, which it thus puts in movement.

The inner ear is also called the labyrinth. It is located deep in the skull bone called the rock. It is composed of two parts: one, posterior, the vestibule and the semicircular canals (which contribute to balance); the other, anterior, devoted to hearing, the cochlea or limaçon. These two parts communicate, and diseases of one almost always affect the other.

The cochlea is a long thin tube filled with fluid and rolled up like a snail, hence the name snail.

The cochlea communicates indirectly with the air in the eardrum through two openings called windows. Inside one, the oval window, the stapes that fill it move, like a piston in its cylinder, in very small movements that reproduce the vibrations transmitted by the eardrum. The other orifice, the round window, is closed by a small membrane on which the vibrations of the cochlear fluids are damped. These two windows are easily visible when the eardrum is opened.

The shape and structure of the cochlear tube is such that the vibrations of the liquids it contains will settle in places that will depend on their frequency. High pitched sounds will vibrate the wide end of the tube, near the stapes. The low-pitched sounds make its tapered end resonate. Thus, as with all the notes of a piano, a topographical frequency distribution is achieved.

The auditory nerve is very close. It is made up of about 40000 nerve fibers. To perceive the vibrations, it is spread out along the tube, in a fan rolled up like it in spiral. Thus, to each fiber will correspond schematically a frequency. A fiber, alone or almost, will enter in action for a pure sound. A complex sound will bring into play several different fibers, distributed as it should be on this cochlear keyboard.

The message sent by each of the fibers of the auditory nerve is a signal of an electrical nature, which goes up to the nerve centers at a speed of about eighty meters per second. For a pure sound with low intensity, these signals - called *spikes* - will be infrequent. They become more numerous as the intensity increases, but never more than a thousand per second. When the sound becomes even louder, the frequency specificity of each fiber decreases; neighboring fibers come into play in turn, even though they do not correspond to the frequency in question: at high intensities, frequency recognition decreases.

But the auditory nerve is a nerve like any other: in order for it to be stimulated, that is to say for it to send messages from the periphery to the brain, it must receive sufficient incentive. However, the vibrations of these liquids are infinitesimal: their amplitude for a weak sound of 6 000 hertz is approximately fifty times smaller than the diameter of a hydrogen molecule.

This is why the creator has equipped this auditory nerve - also called the cochlear nerve - with a very special amplification system: the organ of Corti. This organ is responsible for detecting and amplifying the minute vibrations of the cochlear fluids. It looks like a long ribbon made up of numerous cells, equipped with vibrating cilia, distributed all along the cochlear tube, between the origins of the nerve and these liquids. Thanks to its rich arterial vascularization, which ensures an excellent oxygenation, the inner ear permanently produces electricity which would be sufficient to stimulate the auditory nerve if it were applied to it. It is the twisting of the cilia of the cells of the organ of Corti, triggered by the movement of the liquids, that modulates this energy at each point in the cochlear tube where a vibration appears, and thus activates the nerve fibers in a way that can be compared to that of a piano reproducing a more or less sophisticated melody.

This is why the auditory nerve is a privileged nerve. Thanks to this organ of Corti, it can detect extremely weak or complex messages.

Unfortunately, this amplifying organ is very fragile. And, when it is destroyed, there is no point in shouting louder or using a hearing aid: the energy will always be too low to stimulate the nerve.

Being deaf:

Being deaf means not detecting some of the sound vibrations, and therefore not understanding the messages they contain. One can hear less loudly all the sounds, or not perceive certain frequencies. One can even hear nothing at all: it is total deafness.

In any case, being deaf is a tragedy, because the people around you are always angry at the deaf person. His inattention to what we say is involuntarily felt as contempt. Above all, it disturbs us. He forces us, so that we can make ourselves understood by him, to all kinds of abnormal gymnastics: to speak more loudly, to get closer to his ear; or to move back to articulate carefully, with lips and mouth, the words cut out in slow motion; or even to speak by gesture, or to write quickly on a paper simplified sentences, summarizing without nuance what we wanted to say.

Talking to a deaf person means disturbing one of our most automatic voluntary activities: language. Our organism does not take this aggression well. This is why, no matter how kind we are, we always unconsciously blame deaf people for being deaf. We don't like them, because they disturb something very deep in us. A blind or paralytic person disturbs us much less. The efforts we make to alleviate their misery, to help them move around, to make them eat or drink, are gestures that do not alter our normal behavior: they do not require us, to alleviate their infirmity, to blink very hard, for example, while enduring a bright light, or to walk perpetually on our hands. So we love the blind: they are almost always cheerful. But the deaf are sad, because they lead us to derange for them the mechanism of our speech. Instinctively, we fear them, we flee from them. They feel it, whatever our kindness. They curse their misery much more than any other, because, because of it, we love them less.

This widespread unconscious distrust of deafness explains why the deaf person tries to hide it as long as possible. By learning to recognize words from the shape of the lips to pronounce them, they manage to compensate for their handicap, to a greater or lesser extent, by lip-reading. Wearing a hearing aid, even if he were to get a much better hearing, would be to announce his misery from afar. The hearing aid, as soon as it is visible, is for him more a sign of denial than a real help. He feels suspicious. What sells a hearing aid is often more its low volume than its acoustic performance. A prosthesis only becomes aesthetic when it is miniaturized, whereas, on the contrary, astigmatism, this sight disorder which can hardly be corrected by contact lenses, will often be, for a woman, a pretext for elegantly wearing the biggest glasses possible.

Total deafness:

When it is total, deafness becomes a catastrophe. No message, however intense, can be heard. Only low-pitched noises that are loud enough to be felt by the skin or bones are perceptible: thunder, the vibrations of a passing train or truck. The rest does not exist anymore. Not only the music or the words of others, or of the other, but also the sound of one's own steps, one's own voice, one's own set of keys falling out of one's pocket when one takes out one's handkerchief. The deaf person can no longer hear himself speak: his voice becomes altered, high-pitched, raised, but above all monotonous, unpleasant. In the street, at the crossroads, the underhand traffic frightens him; the silent cars rush by without warning. People, from afar, think you can hear. They don't see that you are deaf, while a blind man is recognized by his white cane. The deaf person's disability is only discovered when you try to communicate with him. Then, it is he who does not see you. You have to touch him to get him to pay attention to you - as if he is deliberately not hearing you, as if he prefers to stay in his own thoughts rather than listen to you. As a result, the deaf person shuts down. He feels resented, but he doesn't understand why. He is right: it is difficult to admit that he is disliked. So he becomes sad, and those around him resent him even more. He runs away from meetings, dinners, family parties, because he is tired of not being able to participate in them, of remaining there inert, like a piece of living furniture, to which, with applied kindness, one is only interested by moments. Neurasthenia, depression, psychic disorders appear - character and behavioral disorders, psychiatrists often declare. Some commit suicide. Most of them adapt, but badly: their life is diminished; their emotional and professional existence is diminished. However, their intelligence is the same. An engineer becomes a handler, but he is aware of his decline; his wife abandons him. An affable man becomes a whiner and a bore; a pretty girl, a bland, insensitive, worrying being, who answers badly, a being without attraction.

The despair of the totally deaf is all the more installed in him as he knows that there is nothing to be done; all the specialists consulted have repeated it to him: he is condemned to perpetuity, locked up for life in his silence. And this one is, moreover, often haunted by buzzes, parasitic whistles, incoherent subjective noises, deafening, stupefying in their non-existence, analogous to these horrible pains of an amputee, who always suffers from this limb left in the trenches. The ignorance of his sound environment is such that he would accept, provided that it brings him some information, the biggest of these prostheses that less handicapped people than him refuse with disdain. But nothing is strong enough to arouse his attention, nothing can transmit to him the simplest of our spoken messages, our calls, our answers. It is because of this powerlessness that the first devices we were able to offer them, so bulky, so cumbersome and impractical, so inefficient at first, were nevertheless immediately accepted by those who benefited from them.

Over-mutitation:

When this total deafness - called *cophosis* - occurs before the end of adolescence, it causes a severe disorder in the development of intelligence. This intelligence is essentially formed in the first years of life, from all the auditory, visual and tactile information that we receive from our environment. Among these, sound messages are the richest and most important; it is through them, in particular, that the essential part of our parents' experience, transmitted by education, is passed on.

A cophosis is all the more serious when it occurs in a younger subject, especially before the acquisition of language. A child who is deaf from birth, without being mute strictly speaking, because his vocal cords function very well, will never be able, on his own, to imitate his mother by repeating the words that she tries to teach him; because he has nothing to copy: he does not perceive the shapeless sounds that he pronounces and therefore cannot correct their emission. Gradually becoming aware that his efforts to express himself are useless, he locks himself up, he becomes mute, even if his silence is sometimes punctuated by unintelligible cries. He gradually resembles an animal.

Since the abbé de L'Epée and the XVIIIth century, we know that these beings are only like this because they are deaf. Following him, generations of reeducators have tried to compensate for this infirmity by replacing the absence of sound information with additional visual or tactile teaching, vigilant attention and intensive education, in which the presence of intelligent and available parents is an essential asset.

For a long time, these deaf-mutes were taught a sign language that was still widespread. But the esotericism of this language excluded them from normal people, ignoring their symbols and mimics. So, for the last few decades, efforts have been made to teach them to speak like everyone else. In specialized centers, boarding schools or day schools for hearing impaired children, private or public homes, the admirable devotion of speech therapists, teachers and doctors specialized in complex but effective rehabilitation techniques is exercised.

We teach these children, for example, the shape that the lips take to say this or that vowel. They are made to copy the vibrating sound of the larynx, perceived by the finger that feels the Adam's apple. Sometimes, we even use their preserved vision to replace their absent hearing by making the electric image of a sound appear on an oscilloscope and by asking them to reproduce this model as faithfully as possible. Finally, we try to make the best use of the auditory remnants, often only tactile, that they still have, thanks to conventional prostheses, which can give them the notion of a noise, a door closing, and especially the rhythm of speech. This conventional equipment for deaf children, however inefficient it may be, must be done as soon as possible, when it is possible, as the poorest information is so precious in this desert. But, often, it is totally useless. Many children wear their hearing aid only at school, because they are forced to do so, and at home they abandon it, because it is of no practical use to them.

A barely intelligible voice can thus be obtained, but at the cost of long efforts, often confining these beings to the ghetto of specialized schools. Their educational delay, always enormous, usually condemns them to menial jobs, even though they initially possessed a normal intelligence; but the vivacity of this one could not, at leisure, develop. To increase the sound information of these children, even a little, is to facilitate their intellectual and affective growth in proportions all the greater as this contribution is earlier.

This is why, as soon as our equipment seemed to me to be perfect, it seemed to me to be a real emergency to make these special beings benefit from it, that is to say the deaf-mute adolescents or children.

Causes of deafness:

Between their origin outside and their arrival to the brain which perceives them, the sound vibrations can meet multiple obstacles.

A wax plug in the ear, a perforation of the eardrum, the blockage or destruction of an ossicle will lead to what is called *conductive deafness:* this translates into a global but partial deafness that can easily be removed, if necessary by surgically repairing the responsible lesion.

This middle ear surgery, which can repair almost all lesions of the eardrum or the ossicles, has experienced an extraordinary development in the last twenty years or so, with the appearance of the operating microscope. And then, in case of failure, or when surgery is refused or contraindicated by age or disease, this type of conductive deafness can be very easily and very effectively palliated by amplifying all sounds with a hearing aid. Thanks to the progress in miniaturization and the fashion for long hair, there are now hearing aids that are practically invisible but still excellent. These conductive hearing losses are not serious and can be easily remedied.

But the very mechanisms of the inner ear can be affected. In certain cases - sudden deafness treated urgently, progressive deafness of the young subject, fluctuating deafness of Ménière's vertigo - the medical or surgical treatment can be effective, i.e. to decrease the deafness or to prevent it from getting worse. However, very often, it is illusory, uncertain. It is still worth trying. But its failures account for the very bad reputation of these inner ear deafnesses, all the more so as their fitting is often difficult and unsatisfactory: the prostheses do not bend well to the pathological whims of the nerve and its organ of Corti.

And when, in addition to these lesions, the underhanded destructions of ageing are added, we then see, in addition, a decrease in the possibilities of integration of the messages by the nervous centers: certain sounds, for example, are no longer understood as being part of words or sentences, but as a series of noises without meaning. The elderly person's understanding of sound decreases and hinders his or her relationship with others, even if the intelligence remains intact for a long time. This is why the rehabilitation of the elderly is always imperfect.

Total deafness can be due to a fractured rock, meningitis, streptomycin poisoning, or severe bilateral otitis. It can be secondary to a disease of the mother during pregnancy, linked to the chance of an unfortunate genetic encounter. Until three or four years ago, it was still believed to be due to a total destruction of the auditory nerve. This opinion, unanimously accepted, was based on the autopsy examination of the rocks of subjects who died in a state of total deafness. There exist, in different laboratories, the most famous of which is in Boston, real collections of rocks systematically taken from deaf people, and preserved for twenty or thirty years.

The explanation for these complete cophoses was unmistakable; these subjects had no cochlear nerve left!

However, together with two American researchers, we realized that by sending an electric current into the labyrinthine fluids of these completely deaf patients, we obtained a sound sensation. This meant that the nerve was not totally absent, and that the total deafness was mainly due to a complete destruction of the organ of Corti. The organ of Corti is, in fact, much more fragile than the nerve itself.

In the light of these findings, the re-examination of these famous rock collections showed that, in reality, the nerve destruction was not total, but that a small percentage of nerve fibers did persist, scattered here and there.

It is thanks to these few remaining nerve fibers that it is possible to restore a little hearing to these totally deaf people.

The principle is simple: it is enough to short-circuit the failing organ of Corti, by sending directly to the nerve the sound message, previously transformed into electrical signals. The modalities of this rehabilitation are explained in a note that we give to our future patients or to their families, and whose reproduction follows:

NOTE ON SURGICAL REHABILITATION OF TOTAL DEAFNESS AND DEAF-MUTE

It is now possible to restore some of the hearing of certain patients with total acquired deafness or deaf-mute.

In the normal person, sound vibrations are transmitted from the outside to the fluids of the inner ear through the eardrum and ossicles. The movements of these fluids are transformed by the sensory organ of Corti, a tiny cell cluster located in the inner ear, into electrical signals to which the auditory nerve is sensitive.

Complete deafness can be due to a lesion of this sensory organ, or to a damage of the auditory nerve and the nerve centers. These two lesions can be associated. But when the sensory organ alone is destroyed, i.e. when the nerve can still function, it is possible to restore a certain degree of hearing by short-circuiting the failing organ of Corti and by directly supplying the still more or less valid nerve with sound information in the form of appropriate electrophysiological signals.

This is possible in acquired total deafness and in the majority of cases of deafness.

On the other hand, if the nerve itself is destroyed, even if the sensory organ is normal, it is currently impossible to give these patients back any sound perception.

Thus, among these complete deafnesses, it is necessary first of all to divide them into sensory deafnesses and nervous deafnesses that no classical audiometric examination allows to differentiate.

A special diagnostic test is therefore necessary. For this purpose, electrical stimuli are applied to the vicinity of the auditory nerve endings. They reproduce the frequency of the main acoustic vibrations. They give a sound sensation if the nerve is at least partially preserved. They are ineffective if the nerve is totally destroyed. This stimulation is a test that must be performed in a surgical environment, because it requires the eardrum to be reclined in order to place the stimulating electrode in contact with one of the windows of the inner ear visible in the eardrum. It also requires local anesthesia so that the patient, keeping his consciousness, can give his response to the stimulations received. It is a very benign procedure, less unpleasant than a dental treatment and the only pain is an initial prick in the *skin of the ear to anesthetize the ear canal and the eardrum. This procedure takes about ten minutes. It can be done without hospitalization, and its aftermath involves only a cotton ball placed in the ear for about eight days.*

However, this test can only be performed in a simple way with local anesthesia in reasonable adults and adolescents. In children and pusillanimous subjects, the test requires a hospitalization of two to three days. General anesthesia is required to place the stimulation electrode. The subjective test itself is performed the next day upon awakening. To get an indisputable answer, it is often necessary to record the auditory potentials evoked by this test.

The principle of rehabilitation is to send electrical signals representing the sound message to different areas of the auditory nerve by electromagnetic waves. This requires a surgical intervention and the use of a portable transmitter device.

The surgical procedure consists of placing at least eight electrodes in contact with the auditory nerve, connected to a receiver implanted under the skin of the mastoid. This surgical procedure requires about fifteen days of hospitalization and requires shaving the hair. This inconvenience, embarrassing for women, is easily compensated by wearing a wig for a few weeks.

The handheld device consists of a circular antenna attached to the retro-auricular part of an eyeglass temple, connected by a wire to a metal case weighing a little less than a kilo and worn on a shoulder strap. This transmitter operates on batteries that can be recharged from the mains during the night. In the weeks following the implantation, successive adjustments of the external device are necessary, to take into account the normal electrophysiological variations of the electrodes accompanying the healing process.

The resulting hearing is worse than normal hearing. This difference is only noticed by people who have heard before. For them, the impression is that of a foreign language. On the other hand, in subjects who have never heard before, the improvement in the relationship is immediate. However, it is necessary to learn or re-learn to hear.

For this, very specific speech therapy sessions are necessary several times a week for two or three months. In deaf-mutes, the improvement of the voice is generally rapid: it follows the hearing obtained. In adolescents, the change in psycho-affective behavior and intellectual development is noticeable in a short time.

But how to code this message so that it is acceptable? How to bring it to the inner ear and distribute it to the different nerve fibers? It is to these problems that we have given all our attention during these last five years.

BIRTH OF AN IDEA

The first attempt was made more than twenty years ago in Paris, in 1957. Dr. Charles Eyries, an otolaryngologist and researcher, was the first in the world to restore some hearing to a totally deaf person, by placing an electrode in contact with the auditory nerve, stimulated by an apparatus made by Dr. Djourno, professor of medical physics.

For three weeks, the patient could hear. Then things got worse. The electronics of the time could not keep up with the surgical skill of the day. The patient became deaf again forever.

These tests, and all that we have done since, make our technique an essentially French invention.

In the 1960s, as a young intern, I was brought to work with Eyries. He was directing, in Professor Delmas' department, the microneuroanatomy research that I was carrying out on the high floors of the immense faculty of the rue des Saints-Pères, from where one can see all of Paris. Often, Eyries told me his story. I often questioned him about the electrical set-up that had been built for him, about his electrode, about the sensations felt by his patient, about the reasons for his failure. Frequently, we would dream about the great discovery that had become impossible. We talked, discussed what we could perhaps, once again, try to do. But the time had not come...

I continued to work. I was attracted to research, but in an ambiguous way.

The example of my relatives certainly encouraged me to do so. I wished I could at least remotely emulate the scientific career of my father, whose entire life was devoted to unlocking the secrets of plant physiology. It was also medical research that had filled the life of my mother's brother, much older than her: he had been one of the pioneers of French neurosurgery, and his strong personality had marked the beginning of my studies.

Vanity was certainly not alien to this deep desire to find new things, to be the first to discover this or that.

But I also dreaded being locked in a laboratory and not seeing patients anymore. My real pleasure was in my relationship with my patients. Seeing them heal, seeing their condition improve, feeling them happy, almost content, at the end of a treatment or even just the first interview, brought me a daily joy that I did not want to deprive myself of by working all day in a laboratory, as I would have had to do to be a real researcher.

This is indeed the dilemma of medical research, which I was trying to solve by trial and error: to see and care for patients on a daily basis, and yet maintain the open-mindedness, technical aptitude and rigor necessary for innovation.

Thus, after the end of my internship, I tried to work, to try to invent, in the fields where this kind of work remains compatible with everyday surgical practice. I was looking in all directions, without knowing what exactly. It seemed to me that I would only really exist if I proved to myself and to others that such work, even if obscure, would finally allow science to advance. That is to say, to improve the fate of these patients who were putting themselves in our hands, and for whom I felt both a feeling of domination and an immense desire to be taken care of.

These efforts, however demanding, often led to little. Their results, however original they may have been at times, were of little practical interest. In retrospect, they would make me smile, if they did not testify to this permanent desire to discover, to advance, to invent whenever possible; for it is precisely this state of mind that allowed me, when the time came, to go to the very heart of the problem of total deafness.

This work may also have helped me to be appointed, in 1966, to both the Paris hospitals and the faculty. This appointment was very important for me. Since the beginning of my studies, I had dedicated myself to this hospital-university career, and if, in spite of my efforts, I had not been able to embrace it, the disappointment that I would have drawn from this failure, and the material dependence that would have continued to restrict my work, would undoubtedly have led me to give up, in spite of myself, these research activities for which I felt made.

I was not without realizing that this double responsibility, which fell to me at the age of thirty-four, confers on the one who is invested with it an aura of which it seemed important to me to be truly worthy. The consideration that is attached to this title, and the moving confidence that accompanies it, were moreover precious, indispensable, in the moments of doubt and anguish that, a few years later, my research on total deafness would bring to my attention. This promotion gave me a strong desire to live up to the trust placed in me by my masters, and it encouraged me even more to continue my efforts.

Thus time passed. I abandoned Eyries and his anatomical work. I forgot a little the excitement that his memories, when he evoked them, had often aroused in me, at the idea that perhaps one day we would find a remedy to this painful and fascinating problem of total deafness. As an assistant to Professor Aubry and Professor Pialoux at the Lariboisière Hospital first, and then for a long time as deputy head of the ENT department at Saint-Antoine, which was directed by Associate Professor Debain, I was now focusing my efforts on other branches of the specialty: reconstructive surgery, oncology, and facial paralysis. But I kept for the affections of the ear, for its anatomy, for its innervation, a particular attention. I was constantly thinking about the electrical system, about the James Bond-like gadget that could have alleviated the dreaded handicap of total deafness, which was the dread of all otolaryngologists. I told myself that one day I could try my hand at it, because electrophysiology was making great progress.

However, I did not know which way to approach this problem with originality, that is to say with efficiency. Sometimes, reading foreign journals revealed to me that others were also thinking about it. Blair Simmons in particular, at Stanford in California, in 1966, had placed several electrodes in the thickness of the trunk of the auditory nerve of a patient, and the electrical stimulation of each of them had given different sensations. But his results were very transient and not encouraging. So I did not dare to try it yet, because I was afraid of trying something that would not work, something that would be regrettable, perhaps, in the long run.

In the early 1970s, William House, a renowned surgeon from Los Angeles, reported several times on the results he obtained by placing, like Eyries, a single electrode, but connecting it to the outside by a simple system: an antenna, placed on the skin behind the ear, sending an electromagnetic wave through the scalp and, in the bone, an included receiver transforming the oscillations of this wave into signals for the nerve. The electronics of 73 were already different from those of fifteen years earlier.

Immediately, I was fascinated by this achievement. The improvement that was obtained, according to its author, surely deserved that one was interested in it and that one at least tried to achieve it, because it already brought a clear relief to the handicap of the patients. During a trip to the United States, I went to see House operate: through the round window, which was easily uncovered, he inserted his electrode into the cochlear tube, the other end of which was connected to a receiver box, as big as a fingernail, which he then fixed between the mastoid bone and the skin of the scalp.

But if, with their antenna, the subjects heard the noises, the rhythms of the speech, they did not understand it. Because the electrode brought in bulk the totality of the sound information, without giving, according to each frequency, the corresponding topographical distribution along the cochlear tube, as it happens in a normal hearing. The auditory nerve of the patients was thus solicited in its totality instead of being solicited fiber by fiber, as if the keys of an entire piano had been simultaneously struck to play the so diverse concerti of our daily life.

I was a little disappointed. We had to do better, probably put in several electrodes. House had tried, stringing five well-insulated wires of different lengths, with the bare ends spread along the cochlear keyboard. But he had not achieved better frequency discrimination, nor had he attempted to build the transmitter device, which he sensed would be much more complex to build electronically than his single-electrode transceiver had been. The reason for this failure was, with hindsight, easy to understand: whatever the electrode concerned, the electric signals, instead of stimulating only the fibers located in front of the bare end of this one, diffused in the very conductive liquids of the inner ear and acted on the totality of the nerve, thus preventing any frequency recognition.

Placing several electrodes was surely the solution. But how to make each one give a different auditory sensation and thus make it possible to distinguish between low and high frequencies? Blair Simons had succeeded in doing this, but his wires, because they touched him, destroyed the nerve. By threading the electrodes through the "lumen" of the inner ear tube, the nerve endings were kept at a distance. This was probably the reason why House's patients had poor understanding, perhaps, but continued to hear for two or three years.

As soon as I returned from the U.S.A., excited by what I had just seen, and suddenly realizing the progress that electronics had made in the last few years in all the other branches of medicine, it suddenly seemed obvious that the time had come for me to throw myself fully into the battle that was to become, for a few years, the center of my life.

But after the failed attempts of Eyries and the imperfect successes of the Americans, I did not want to go on this adventure alone. To put all the chances on my side, I had to work in a team. The help of a physiologist and a renowned scientist was, in particular, indispensable to me. So I called Dr. Patrick Mac Leod, director of the laboratory of sensory neurophysiology at the Ecole Pratique des Hautes Etudes, to share my observations and ask for his advice.

Tall, thin, very long, Mac Leod hides his myopic eyes behind thick glasses, which he removes to inspect closely minute details that we, ordinary people, cannot see. He speaks little, listens a lot. He judges very quickly, thinks fast, and when he says something, each sentence, slowly expressed, has a carefully chosen meaning. He explains everything clearly and knows how to make the most complex processes simple. He had studied medicine at the same time as me. Then he had chosen research. A few years ago, I had met him again, on the occasion of some developments for which I had already needed his insights. These were particularly extensive in sensory neurophysiology and in electronics. He was the man for my new problem, I was going to call upon him again.

A great mutual esteem united us. I admired his knowledge and his selflessness. He probably appreciated my great respect for science and research. One day in April 1973, I explained my problem to him. He listened to me, thought about it and asked himself questions. To some of his questions, perhaps two Americans from San Francisco, whose work on the same subject had focused on the animal, could answer. In Venice, at the World Congress of Otolaryngology which took place a few weeks later, they were to present their results, as was House. In order to see more clearly, it was necessary to meet them individually, to listen to them, to talk to them to find out more. Venice was there for that.

Venice, in May 1973, is the usual whirlwind of the vaporetti, the morning sirens, the sonorous waves of the engines breaking over the perpetual crowd, colored by light and shadow, laughing in the 8:25 a.m. sun, the fresh air currents on the quays, in the alleys, where one walks fast, knowing one's way.

Venice, in May 1973, it is the Xth International Congress of O.R.L. and it was the Venetian life that we were living, down to its daily details, for eight days, tourists disguised as inhabitants of the city because of the work and its constraints - the island of Saint George and its conference rooms, the crumbling procession of the congressmen, doctors from all countries, gliding through the cold cloister and the flowery gardens, the heads that we greeted, those that we identified without stopping to look at them, and all the others, a crowd of strangers who had come there for the trip rather than to learn or teach.

In this amphitheater which had seen other festivals, we listened to presentations, watched more or less convincing films, followed passionate discussions. But nothing came of it! Everyone agreed, of course, that several electrodes were essential for speech recognition. But no one had found a way to implant them in a usable way. Even after talking more closely with the researchers, as one might do over lunch, no light came out of the words!

On the water of the Grand Canal, the canopy of the terrace of the Grünwald Hotel splashes with sunlight. The light plays on the tablecloths and the forks with which we occupy our fingers, during the effort to understand with difficulty the idiom of our Californians. But soon the incomprehensible accent of their native San Francisco becomes clearer, as they try to articulate better. For my part, I am mostly silent. I look around, letting my gaze wander among the shaded glasses against the light, the hubbub of the neighboring faces, the waters multiplied on the boards of the pier where we seem to float...

How to play the piano on this auditory nerve? In this tube of the inner ear the nerve fibers spread out in a fan-like pattern like the ivory plates of a keyboard ready to receive well-separated fingers. So far, with their single electrode, Eyries and the Americans have only managed to hit all the keys at once. How to play each key separately? How to place several electrodes, so that each one stimulates only a narrow area of the cochlear tube?...

That was the problem! The meal ended, inviting to coffee; the legs lengthened, sliding under the tables, the feet scraped the boards of the terrace, whose canopy filtered the two o'clock sun, busy on the backs of the shoppers, the tourists. We stopped thinking about all these problems, neurophysiology, laboratory animals, anatomo-pathology, deaf people and electrodes; we talked about other things. Gondolas passed by, banal and dull, a little indifferent to the waves of noisy and disrespectful motoscaffi. The few conventioneers seen at nearby tables were getting up to go back to work or to become tourists. We would see them strolling towards the pier leading to Saint-Georges Island, contemplating in the windows their silhouettes happy to have had a good lunch and to be almost on vacation. We followed each other in small groups, little by little multiplied by the meetings at almost every crossroads leading to the seaside punctuated by columns, a wooden shore bristling with skiffs and where the vaporetto station floats.

We were soon twelve around our Americans, heroes of the day. Newcomers approached them, spoke to them, jostled each other a little in the narrow streets which put us for a moment, as in a class, in line by three or four. They asked them more and more trivial questions, taking up the time of our hosts, of whom we had just understood that they did not have much to teach us, except the remarkable tolerance of the animal to all their implanted material.

We had to leave them. Like a raft carried away by the current, we found ourselves swimming in the crowd, moving slowly, still overtaken from time to time by some congressmen; then we crossed the steps of the bridge, on the right, that the others passed without seeing it.

As I turned around at the top of the flattened arch at the level of the windows, to see the last of them disappear, I felt that, since a while ago, I had not listened much to the words exchanged, much more occupied with watching us live in Venice than with following a conversation whose uselessness had become obvious. But, there, going back down to the shadow side, I had to get back to work, to leave the alleys and their wide-open roofs, the images, the impressions, the short barges stopped on the underground shadow of surely forgotten canals, to look only from afar at the stores and the people, the slanted shutters, the oranges and the walls, to listen to Mac Leod, to make him talk, to incite him to find the missing idea, to move forward. We would talk. As we recapped what the Americans had told us, it seemed that the extraordinariness of what they had already managed to do prevented them from going further. They needed to consolidate, to verify what they had found. We were new and shameless, taking for granted what they had brought. The desire to go further whipped our imagination. But how to invent the unknown within the constraints of our knowledge?

At a table in the sun, we took another coffee, in a large square away from the crowd, where, without wanting to, our talkative walk had led us. The impression was that the real inhabitants of Venice lived there: a few ochre trees and birds accentuating the asymmetry of the space, bordered by the echoes and cries of children probably going to school. Italians passed by, brown, lively, in shirts, or well rounded gentlemen, comfortable baldness, visibly satisfied to see us searching, searching on this scribbled paper, pushed back cups.

It had become, for a few minutes, the great imaginative outburst, the accepted but catalogued delirium. We had to find a solution. It was as if we had put in our minds a small advertisement, on which we would have read: "*We are looking for a way to place in the cochlear tube numerous electrodes, capable of stimulating, in an independent way, the* *different zones of the keyboard of the auditory nerve that are there. Dimensions and longevity requested = a few thousandths of a millimeter and a lifetime."*

We would let the wildest suggestions come to our minds, hoping to discover the revelation, the star. Each idea, even the most incongruous, was treated with respect until it was examined; we let it explain to us how, according to it, to play each nerve fiber of the cochlear nerve separately. One by one, our suggestions were auditioned before the jury of known requirements. More often than not, these candidates were born in MacLeod's mind, devoid of surgical prejudice; and I, an examiner sometimes panicked by so many extravagances, would try to explain why it was not possible, why, in spite of a flattering skill to make me accept the project, I really did not feel capable of such a feat.

From time to time, however, in front of a proposal more attractive than the others, I made an effort, condescending to suppose that I could, perhaps, approach the nerve like this, or penetrate in the internal ear like that, while wishing, if great seemed to me the audacity of this concession not to be enough and that the idea which had made it enunciate was nevertheless rejected.

We had quickly given up trying to stimulate the fibers one by one and were only trying to reach a few of them separately, when we headed back to the center of the city.

How can I describe the chance detours that led us to the Accademia, already in the shadows, with its wide wooden bridge whose brown and gray beams were multiplying, balanced on a Grand Canal that was monotonous in this place? The sun, on the other side, was still shining on the multiplicity of trees, gardens, gates, houses. Abandoning for a moment our search, we became aware of the world again. There were again children, students, boat engines. A stoop of foliage wore its stones in the light. The rounded limestone, hollowed out with memories where we had just sat, heated our hands. Privet, shady boxwood, wild hemlock beyond a fence, the smell of rust, the stiffness of ivy, the acrid smell of black berries...

Strange, this idea: between my fingers, the firm volume of one of these pungent fruits, ginned from a baluster - elastic presence that could perhaps isolate two electrodes in the coiled tube of the snail...? Compartmentalize the space with silastene - this elastic plastic accepted by the living tissue - dig a window to introduce a definitive plug...

How did it come, this idea, born among branches, in Venice? That smell of privet... And then, above all, the scent of elder trees and their serrated leaves, which, while we were talking, my eye was using to hide the sun... In this glare, something was appearing. The fruits of these shrubs were projected against the light on the Lombardy strips of a nearby church, from where my gaze, with a descending line, explained in space, drawing on the spot the forms to be worked, the gestures to be invented, foreseeing the play of the electric flows, of the tissue reactions, of the progressive healing. The psychology of each of these partners that we had to convince to help us was reviewed: the subtle play of electrons or tensions at ease in natural liquids, or opposed by bone barriers or by this wall of silastene whose role we had just invented. The angry reactions of the nervous fibers, of the interior environments, vexed by the incongruous presence of this foreigner, this silastene, this included body, this intolerable intruder! But, since it is precisely very well tolerated, since it has been living for years in hearts or brains, why fear the destruction of our nerve, if we isolate it from fiber to fiber with this material?

All the disadvantages of this process were gradually falling away. It became clear that it had to be tried. None of those we had discussed earlier were so interesting, so simple - so obvious that it seemed astonishing, soon strange, that no one had thought of it before. But surely this was the solution I had been looking for for weeks!

In the excitement of the resolved details that I would have liked to verify the same evening, a dreamlike certainty of having touched the sensitive point exalted me. I gave myself up to it without really believing in it, because I had often experienced similar enthusiasms, which had however disappointed me more or less quickly. We did not know what developments this idea would take. We had no idea that, five years later, we would use this idea, which now seemed almost banal, to methodically teach all those foreign doctors who had come to France to learn it. But, leaning against this rusty gate which, as if not to disjoin our inventive discussion, had never opened for several quarters of an hour, I felt a serene excitement cover all my projects. I explained it to myself by these atmospheres of bells, in the distance, for the angelus, of recreations full of children, of places rustling with steps and words.

I am one of those generations, old now, who grew up without hearing engines or almost. I like the sounds of the streets of Venice without cars, without red lights, which are those of our childhood. The shrubs, that day, the warm stones and the shadows played with this resemblance, to stretch our discursive and learned work with joy. The black fruits with dry tips were peeling under the fingers. My idea had just been born - I was far from suspecting it - from a very old memory, stirred by a pungent, tenderized scent, by the roughness of the barks and the raspiness of the leaves under the hand, but especially by this haunted odor: the initial odor of the elderberries...

EXPERIMENTATION

We had to try. But how? On the animal first, of course: it was inconceivable to use this process on humans, before having verified its harmlessness and its efficiency on the animal. It was necessary, with the rat, the cat or the guinea pig, to make sure that, with each implanted electrode, corresponded a particular sound sensation.

But how to make a cat say that it perceives a high-pitched sound? In theory, it's simple: we can teach him, by a long conditioning, to recognize the sound signal which, in a way, gives him food. Then, after having implanted electrodes separated by our silastene walls, it would be enough to see him looking for his food, when the electrode corresponding to the sound he has learned to identify is stimulated. We can also, in these numerous areas of the brain where the fibers of the cochlear nerve relay in a well-ordered keyboard, find the signals evoked by each of our electrodes isolated from each other, and observe their clear identification.

That's what we should do! But I will never be able to do it! Because it is about terribly complex techniques, of which I am absolutely not used to. Only researchers, learned laboratory physiologists, whose job it is, their specialization, could manage it, after several years of effort.

One could address them; there are some in France, capable of doing so. But only two or three of them, already overloaded with work, with experiments in progress, with personal research which is dear to their hearts. We would have a hard time getting them interested in this problem, and we would hardly be able to motivate them enough to decide to do it. Only I, who is close to these completely deaf people, blind to noise and speeches, perceive the importance and the urgency of the problem; only I am seized with the desire to solve it.

A chasm suddenly opened up. The immensity of the task would land me. I would never be able to do it. Even if I tried to do it, by learning the techniques, by retraining in animal and experimental physiology, by almost changing my profession, I would have to stop being a clinician, that is to say, a doctor on a daily basis, in order to be exclusively, if the task were great, a man of the laboratory, of the animal house, of the oscilloscopes. But this renunciation itself would be useless, because it would take so long to prove the idea that I would lose the essential, affective motivation: this violent desire to heal, drawn every day from the eyes or words of my patients whom I help.

I knew that, in addition, this animal experimentation would not bring me anything that we did not already know. The tolerance of the implanted material? It had been known for a long time, and our friends in San Francisco had just confirmed that the nerve, thus approached at a distance in the cochlear tube, did not suffer from being regularly and indefinitely stimulated.

What I didn't know was the practical value of this still fresh idea of partitioning the cochlea with silastene fragments. Would these artificial walls be electrically tight? Would these separate notes on the inner ear keyboard be sufficient to distinguish words, to recognize sentences? As I thought about it, it seemed more and more certain that the long animal training that could be envisaged to simulate such a discrimination would be insufficient in any case; for distinguishing one sound among two or three is a much simpler thing than recognizing two or three syllable terms from one another.

The only interest of our idea was to allow us to obtain a certain intelligibility of the language; this would be impossible to appreciate in the cat: we could not teach it to speak so that it repeats, with electrodes, what we wanted it to understand. It was therefore with man that we had to try from the start; only he could tell us if we were right or wrong.

This was, after all, a very different problem from those usually encountered in medical research. Experimenting with a heart valve, a new drug, a biological glue, can and must be done on animals, because these tests will provide, without danger for humans, all the necessary information concerning the safety and effectiveness of the process in question. For us, it was different: the harmlessness was already known, and the effectiveness could only be assessed by man himself. To want to experiment at all costs on animals would have been to misunderstand the problem we had decided to solve.

But how to do it in humans? How to dare to try, without being completely sure to win, that is to say without risking being accused of human experimentation?

Here I came up against the classic double moral barrier which, in research, draws the limits between what is feasible and what is not. First of all, the doctor's personal conscience is there, which, in his innermost being, leads him to try only means whose effectiveness has been demonstrated, especially in animals, to be surely superior to their disadvantages. When it is a question of measuring these advantages and harmlessness in order to decide on a trial in humans, the researcher's subjectivity comes into play, whatever the objectivity of the criteria used for this purpose. In a mind seduced by the mirages of a new therapy, this subjectivity would sometimes risk becoming partiality. It is then that another moral barrier intervenes, a sort of human respect or fear of scandal, a rigid and powerful safeguard against possible errors. This barrier is certainly made up, in the extreme, of the fear of the police, i.e. the fear of a trial, particularly developed, for example, in the United States, where legal actions for medical reasons are very frequent. But it is above all constituted by taking into account the judgment of others, that is to say of one's peers or teachers. All medical studies, and in particular the university hospital career, which is almost indispensable for clinical research, accentuate this respect for established authority and general consensus, this fear of what people will say and its consequences.

There I met this double barrier, and it seemed to me entirely impassable.

Human experimentation is indeed a dreadful term, which smacks of the Nazi camp, of contempt for the sick. For one subordinates the human being, one lowers him, by making tests on him, by holding as negligible the suffering that these will entail and the disappointment that will be born from their failure. It is this contempt which is condemnable, because it hurts, when he realizes it, the one who is the victim. The only way to remove this contemptuous note from the therapeutic experimentation is to warn the patient, and to carry out the experimentation only with his or her agreement.

This consent is the most important obstacle to the development of this way of advancing our therapeutic possibilities. But it is indispensable; it alone allows us to avoid excesses which would lower to the animal stage this human race whose condition we want, on the contrary, to raise by respecting the individuality of each of its members.

When this assent is obtained from the patient, he or she must be well informed of the advantages and disadvantages of what is being proposed. My project involved a complicated procedure and its efficacy was highly uncertain. Only a person whose life was in danger could accept such ignorance of the short and long term results of what was being offered. Of course, many completely deaf people are desperate and will do anything - some commit suicide - to change their situation. But I was particularly anxious to resist the temptation to take this despair into account in my first tests on them. For, in these psychologically fragile beings, I was very much afraid of the disappointment that would follow a failure, even if I did everything, beforehand, to warn them of its possibility. It could be heavy of consequences.

Suddenly everything seemed impossible. I did not want to do human experimentation at any cost. For a few moments, a few hours, I thought of giving up this idea. To give up. The road was blocked: there was nothing to do!

And then, somehow - we were still in Venice - the solution, the key, came to me.

What would be wrong would be to operate, perhaps for nothing, on a totally deaf person, because we would risk disappointing him. We would have to propose this test to someone who is totally deaf, but whose condition requires an intervention, and who, moreover, would not feel any dismay when he notices the failure of my attempt. Very simple! This situation exists, not very often, but it is encountered: it is the case of a healthy subject who, following an accident, presents a unilateral rock fracture, accompanied on this side by a total deafness and a facial paralysis. In order to restore mobility to the paralyzed facial muscles, it is necessary to decompress the facial nerve along the complicated pathway that it follows in the rock around the inner ear in order to free it from the crushed bone. To do this, the inner ear must be opened wide. It is then very simple - a few minutes more, over a two or three hour operation - to place the electodes and the silastene fragments. It then becomes possible to propose to the lost ear to give it back some hearing, whatever the quality and the duration - and this, while not hiding the experimental aspect of this test.

I had defined the ideal "guinea pig" patient: a total unilateral deafness, due to a trauma accompanied by a facial paralysis on the same side. I could try, without going through this stage, useless in our case, of animal experimentation. I had found a way to see if my idea of silastene, born under the sun of Venice and among the smell of elder trees, was worth trying one day on real complete deaf people.

From then on, everything seemed easy. I was in a hurry to act immediately. An impression of urgency followed me. I explained it to myself by my desire to be ready, when the road survivor with his total unilateral deafness - his cophosis - and his face paralyzed on the same side would show up, at random.

There were a lot of problems to solve. How to put the electrodes in place? How to reach this inner ear, such a fragile organ? We only learn to avoid it, to respect it, in the treaties or in the most modern interventions. It was necessary to imagine everything!

Back in Paris, I went back to microscope dissections on cadaver temporal bones, no longer as in the past to perfect a gesture, but to *invent* one: to find a path in the bone up to the tube of the snail, avoiding the noble organs that surround it, facial nerve, carotid, meninges. These bones came to me in their formaldehyde jars, skillfully taken from dead people without family. As jaded as I was, I couldn't help thinking - a classic reflection - of the person who lent me this part of his or her skull so that I could find my way in it. I was sometimes ashamed to make so little of it, to cheerfully tear out eardrums and ossicles (I knew the uselessness of it for the future, since I was inventing the case of a total deafness which had no more use for these fragile unusable organs), opening, milling, digging to see better.

How many of these dead architectures have I destroyed in order to better understand them, to better grasp their surroundings? From the top of the cochlea, the view of the carotid artery is unobstructed; here, you have a wall of fragile bone between the nerve of the facial mimicry and the liquids of hearing. It's amazing how far one had to go into the forbidden zones of classical surgery to discover this cochlear keyboard!... Soon, I learned to make holes - windows, as they are modestly called - similar to the holes of a flute, distributed along the limaçon, and to slip in more and more fine metallic wires, by wedging them with small cubes of silastene, cut on demand so that they wedge each electrode against the bony walls of the cochlea and, at the same time, isolate electrically and as perfectly as possible, the compartments thus created.

All this took place in a terribly small space: 1.2 millimeters in one direction, 0.7 millimeters in the other, where I drilled my holes. This gymnastics was nothing extraordinary: all otolaryngologists are used to it. What was exciting was the discovery of unusual surgical areas, the invention of gestures to achieve this, the little tricks to respect this, to refine that and, finally, to make as many well-calibrated windows as possible in the cochlear tube.

A little time passed. And, suddenly, there she was. Motorcycle accident. Dead fiancé on the road to Dampierre. She had just come out of a coma of several hours, spent in unconsciousness in neurosurgery. Amnesic and taciturn, she suffered her disgrace in silence. Obviously, she was destined for us. A few days of examinations, tests and X-rays, to be sure: yes, it was. The nerve was surely crushed, or perhaps cut; the inner ear, split by the shock, did not react any more to any solicitation.

- You need surgery to repair your paralyzed nerve.

- It won't come back?

- No, it won't. The electrical signs tell us that this will not recover on its own, or with so many after-effects that you will remain disfigured.

- Oh, no!

- That's why you need surgery.

- What about my ear?

- Your ear, I'm afraid there's nothing we can do for it, and it will be lost permanently. But, if you want, I can try to give you back some hearing. Maybe I won't be able to. Or maybe, if I do, it won't last. I don't know. But, if you want, we can try too.

- And I don't risk anything?

- No. The only risk is that you will get an audition that you are not happy with. The only risk is to get a hearing that you are not satisfied with at all. In this case, which is very likely, you will just have to remove the wires that I will put on you, and you will be like you are now.

- And if it works, will I have to wear braces?

- If it worked, yes. But nothing is certain.

- Oh, but I don't want to wear braces!

- In this case, it's best not to try. Let's just deal with your facial nerve.

This was done. I remember the operation. The nerve, trapped under a bone fragment, dominated the entrance to the cochlea. From where I was, one could see the whole bone strand, where I knew I could make my windows. The desire to go there anyway, to see, floated, tempting, in me, while I slowly cleared the nervous trunk of the bone which was packing. I didn't know when a similar case would occur. For these are fortunately rare cases.

I had not been persuasive enough! She had been suspicious. She hadn't trusted me. She must have sensed that I wasn't sure of myself. Because that was it: she had come too soon. I had not yet had time to be completely ready, and to check, for example, that the compartments were really watertight, or to see how my electrodes fitted into the ear. She must have sensed my lack of conviction in my attitude.

Wasn't I going to destroy what might be left of the nerve, by placing my electrodes like banderillas? And then, how to know if the cochlear nerve itself was not cut or crushed, like its "friend" the facial nerve? It should have been possible to stimulate it directly. But how?

I was going in circles. I was afraid of a false failure, of a failure due simply to a bad preparation.

So I called Mac Leod. We talked; he, calm and methodical; I, prolix and questioning. He looked at my dissection pieces. I explained my anatomical travels. He touched cautiously, a little respectfully anyway, scraping the dry bone with a fine hook, inserting himself obliquely into one of my holes, or pulling on an electrode. Then he came up with two or three suggestions, and it became very simple!

The electrical tightness of our compartments was checked immediately. A battery, an ohmmeter connected on our rocks soaked in salted serum: we could see the needle swinging along its dial; the resistance was very great between two electrodes, much greater than between one of them and the irregular and softened mass of the rest of the bone, which a pair of pliers was gripping in order to draw out its electrons.

And then, to know, before implanting the electrodes, if the cochlear nerve was still good, it was enough to send an electric current into the inner ear: it was very easy, Mac Leod showed me on a rock; because, just behind the eardrum, a simple membrane - that of the round window - separated the eardrum case from the cochlear liquids, in which the origins of the auditory nerve bathed. An electrical stimulator? He would lend me one! And he would come himself to help me with the first manipulation.

Finally, he asked permission to open and demolish one of my implanted rocks. Small sacrifice! I gladly let him gouge out a few of them so that I could examine the arrangement of my wires inside, which were placed far enough away from the nerve fibers so that I could be sure not to damage them. And, last but not least, we talked about the electrodes themselves.

This steel wire that he had given me, I wrapped it with a thin tube of silastene so that it would be accepted by the organism and well isolated. But, as thin as the crew was, its third of a millimeter of thickness was still much too big, and its insulation, undoubtedly fragile. We needed a special wire, which, alone in the world, was manufactured by an American firm. Fine as a hair, tightly sheathed in Teflon, used in humans for years, it met all our requirements. But to order it there, what customs and administrative formalities!

Fortunately, from a friend on a trip, I was able to obtain a few reels. Two weeks later, they were there, which were going to allow us to win, in their transparent boxes - long brilliant wire, magic, iridized platinum married with white Teflon clothes of one hundred and twenty-five thousandths of a millimeter in diameter, thin enough to gather at leisure and for eternity decibels and frequencies!...

THE FIRST TESTS

From then on we were ready. And we didn't have to wait long. A few days later, a young railway worker, an electrician who had fallen from a catenary, replaced our young accident victim who had come too early. Our certainty, this time, must have been felt in our words, because he accepted the experience, knowing well the uselessness it offered for himself.

But first it was necessary to check if the auditory nerve was good in spite of the total deafness, by carrying out the test that Mac Leod had proposed. There began my long apprenticeship of volts, buttons, oscilloscopes, all this practical electrophysiology of which I had only book knowledge.

... The ear emerges alone from the green fields that cover our awake patient, lying on the operating table. Mac Leod explains to him what he has to tell us, prepares his apparatus, installs the wires. I operate with the microscope. This one stands between my patient and me. Thanks to it, I extract myself from the normal dimensions. It translates into appreciable measures the tiny marks of my gestures. Thus projected in the external auditory canal of my patient, I incise the thin epidermis, previously insensitized by the injection of a local anesthetic at the entrance of the auricle. I advance slowly towards the eardrum, pushing back the skin of the canal, like a carpet that is lifted, taking off the insertion of the membrane. Here I am in the box, luminous ivory in relief, where sleeps, silent, the round window which does not hear any more and which it is necessary to stimulate.

Wrapped in plastic, I place the end of a thin silver wire at the edge of the niche, and I watch for the electrical flow that will penetrate the cochlea. The current passes. The button is turned, slowly, progressively. My patient says nothing. And suddenly, is it from watching intensely the shining end throwing its electrons, these emerge suddenly, invading the ear:

- I hear... ! I hear... ! Very loud... !

- He hears!

This ear, which everyone and all the examinations said was definitely dead, hears immediately. *What does it hear?* What does he hear*?* I don't know, for the moment. But sounds, noises, provoked by Mac Leod's will, are born and are recognized, identified, described.

We had anticipated that this would happen. But a violent emotion runs through me as we detail the test. Mac Leod, seemingly impassive, questions, varies the voltage, the duration of the stimulation, its frequency, asks for details, notes or reflects and reasons out loud with me, who is content, riveted to the microscope, to watch my silver wire, which I hold like a needle between two fingers, my hand glued to the cheek of my patient who is trying his best to answer.

Because, suddenly, he has become "my" patient. This surprising news that I have just brought him, this betterment, however ephemeral it may be, creates a new relationship between us, "paternalistic", some may say, but full of thoughtfulness, and which will last for a long time, until I feel that I can do nothing more for him.

However, the main thing remains to be done, for him and for me. He is waiting to be operated, to have his facial nerve repaired. I am waiting to know if the two electrodes that I am going to put on him will give him two different and distinct sound sensations.

Three days later, it is the intervention, of which I do not remember anything more, if it is not that my strangely fine threads appeared to me, thus, on the living, much more difficult to thread than on my dry rocks. Because, in my preliminary exercises, I placed at leisure my anatomical part in the best position to slip at my ease in its breast, deprived moreover of the fear of any anatomical imprudence, whose misdeeds would have been, there, without importance. But, on this sleeping patient, the living pinkish color of the bone and the irregular oozing of the red blood changed everything. Extreme caution slowed down my movements, hampered by the unusual position I had to take in order to penetrate so deeply without damaging anything. Decompressing the nerve of the face was much easier than opening my two windows, sliding in my irregular cubes of silastene and the two electrodes.

It was a Friday. The next day, the muscles of the face were already moving a little: it was spectacular, but classic, since the nerve, only compressed, was perfectly alive. My patient was delighted; I 't really care, considering what I was expecting, which we would not know until the following Monday.

The answer came from a small and heterogeneous apparatus, made by Mac Leod and made of some filters, a potentiometer, screws and three wires. I've kept it ever since, and sometimes, in my lab, it comes to my hand while tidying a drawer. It makes me laugh, but I am not ashamed when I put it next to our current machine. Because he is the one who told us that our idea was good.

By sending the same current successively on each of the two electrodes, we obtained two very different sound sensations, one, low-pitched, the other, high-pitched, which added up when we stimulated the two ways together. Then, at once, we tried to speak in this dead ear, by cutting our voice, with the apparatus of Mac Leod, in two low and high contingents, injected in each of its electrodes. The immediate results were surprising. In the soundproof cabin, where we had confined him so that he could not hear anything, the patient could only see us through a small window and speak to us through a microphone. We asked him to repeat words pronounced distinctly in front of him, so that he could see our lips articulating them, using successively the two electrodes, then one or the other of them only, and finally without the help of any. The intelligibility, very poor with two electrodes, was even worse with only one, and finally null without the help of this makeshift prosthesis.

The electrodes helped him to understand speech. A decisive step had just been taken! But how many of these decisive steps were there, beyond which, suddenly, everything seemed so simple until the next obstacle!

All that was left to do was to put in, thus isolated, the number of electrodes necessary for speech to become intelligible. Since, in the systems of telecommunication, twelve channels are sufficient, let us put twelve electrodes and we will be able to hear us. The results we had just obtained masked enormous unknowns; but I did not want to dwell on them: how to avoid these wires going through the skin? How can we be sure that the functional value of these electrodes will last forever? And so on. Before asking myself these questions, I wanted to be sure that they were worthwhile: I wanted to be sure that, with this procedure, we could really rehabilitate total deafness.

On my railroader, we repeated the tests several days in a row. Their results were the same and improved a little. The threshold of each electrode was very low, meaning that very little current had to be sent to get the beginning of the sound sensation. What were we going to do? We had to stop the experiment, remove the electrodes. But our patient understood even less this retreat as he had felt our enthusiasm for his performance:

- Why take my sons away from me, since I can hear them?

- But you don't have enough to understand: you need ten more, and that's not possible. Maybe later. And anyway, with your healthy ear, you will hear much better than with this one.

- But maybe later you can complete your operation, by adding the missing fuses?

The confidence of our electrician had no limits! I acceded to his request, simply removing the Teflon plug which crossed the skin and where the electrodes were attached, and I buried the free end in the subcutaneous fat.

He healed and disappeared, forgetting about us. I did not know that I would see him again much later, and that he would be very useful to us.

Indeed, two years later, he returned. The two tiny electrodes stuck out in his hair, a millimeter outside the scar. They bothered him when he was using the comb. To get rid of them, all he had to do was pull on them. But, before that, I had the idea of electrically stimulating the free end of each of them, to see what had become of his threshold, his discrimination. Nothing had changed! In the midst of the setbacks and criticisms that we encountered at that time, this finding was very encouraging. It was essential: if our results held up for two years, they had a good chance of holding up longer, or of being definitive.

The summer of 1973 was beginning. It was necessary to multiply the implantation sites, to bristle the cochlea with electrodes planted regularly along its helically wound tube. Only at this price could we obtain good intelligibility. I resumed my dissections, succeeding little by little in opening four, then five orifices, increasingly fine and well calibrated. I left on vacation, a little reluctantly, asking to be called back urgently if, by any chance, another "favorable" case presented itself. Then the sun passed. The sea, the thorns, the smell of the pines on the cliffs in the evening calmed my impatience. They did not call me back, and I calmed down a little the urgency of my projects.

It was at the beginning of August that he arrived, my Polish truck driver, with his already old paralysis and already operated without success. It was necessary to intervene again, because the lesions were very deep. He had been told that I was going to heal him, and he thought it was only natural that we should try to make him hear again.

The operation was long. The nerve was destroyed, crushed. It was necessary to make a graft, very difficult to install, then to look for the cochlea and to put in place all the paraphernalia of the wires, connected on the outside by two big multiple plugs in very white Teflon which emerged from the scar. I came out exhausted, depressed by so much work, a little ashamed to have had so much trouble, to be so hard-working. My God, how many similar fatigues were still waiting for me!...

But here too, it was a success. Not for the facial paralysis; the nerve took almost a year to recover and never completely healed. But the five electrodes were really five independent, different notes. My patient could even tell us the pitch of the notes, by equalizing the sound he heard with the one his good ear heard from an audiometer, and which he could vary the frequency. He was then entitled to another apparatus, to hear speech divided into five channels - a more complicated assembly than the first one, but just as heterogeneous and, this time again, meticulously cobbled together during the weekend by Mac Leod.

However, the performance of our Pole was disappointing, compared to what was expected of him. He didn't recognize anything, and didn't want to recognize anything, since he could hear with his good ear! The hearing that was proposed to him was undoubtedly too poor, too different, for him to appreciate it. Moreover, the division of our electric signals, their forms, were inadequate, we discovered it. We had to reduce this, transform that. Electronics and physiology overlapped. It was exciting, in some of the observations that the patient led us to make, to observe, thanks to him, and for the first time in man, the authenticity of laws discovered for several years in animals.

More channels were needed. But, by the way I had taken until then, I could not implant more. Another way was necessary to approach, in the depth of the rock, the hidden face of the cochlea turned towards the brain. By opening the skull, by lifting the meninges and the cerebral mass, one knew very well how to go there, because it was much deeper still that vertigo surgery was commonly performed, one of the difficulties of which was precisely not to open the cochlea. One of the difficulties was not to open the cochlea, so reaching the cochlea to place one or two additional electrodes was easy. However, this time we could not try it on an "experimental" patient. Indeed, it was a more serious approach than the previous one: the opening of the cranium is not a harmless gesture; the probability of risks and the gravity of these risks are, whatever one does, more important than in classical ear surgery, to such an extent that this approach including trepanation was always refused in case of dizziness or facial paralysis associated with total deafness, because the destruction of the cochlea allowed precisely to avoid this opening of the skull by crossing the labyrinth

The time had come to offer this new hearing to a truly deaf person.

DEAF PEOPLE WHO HEAR

A lady of a certain age, who had become totally deaf four years earlier after suffering from meningitis, and who was sad, taciturn, almost mean, and had recently committed suicide, was chosen to benefit from, and endure the hazards of, what was a "world first", we were aware of this while keeping it a secret.

I use the term "world first", which has been overused by mountaineers and journalists, because it corresponds to reality. But this premiere did not impress me: I knew the way; I was sure not to fail completely. My real "first", with its fears and uncertainties, had taken place with my pathfinder and his two electrodes.

The difficulty, this time, was the choice of this first patient. For it was a real choice. I had many completely deaf people in the shifting group of patients who had been coming to me for years. The word "clientele" would not be appropriate here. My patients, in fact, are not clients in my eyes, because none of them, or almost none of them, is able to appreciate my technical competence. The reputation they give me (which I certainly like and sometimes enjoy) is mostly based, I know, on subjective elements. Their recovery will not satisfy my professional pride, which is only fed by the appreciation of my peers or my masters, especially the older ones. No. The relationship that unites me with my patients is an emotional one: it is based on this oscillating confidence that I can read in their eyes, whatever their origin, and that I must absolutely satisfy by reassuring, encouraging and, above all, healing. I like to help those who make me believe that they need me. Of this relationship, what does it matter what the motives are? The main thing is that it makes me work to heal many people and relieve some. This is where this possessive expression comes from: "*I had among my patients"...* a bit like saying: "I had children", or "old parents", believing oneself responsible for them.

Many of these profoundly deaf people, who were totally inapparent, even with the biggest prostheses, saw me more or less regularly every six months or every two years. Why did they come back? Why were there so many of them, since I did not improve their infirmity at all? Perhaps, simply, because they and the people around them, almost as affected, felt that their problem interested me. Another, less motivated in this field, would have stated the inevitable, without having expressed the hope contained in distant research.

For several years, I had been turning over in all directions the problem of these incurable inner ear deafnesses, these nervous deafnesses to which nothing can be done, this therapeutic impotence where the classical teaching wanted to confine us forever. The operating microscope had, for ten years, already widened our possibilities. Moreover, a new way for the specialty had recently opened up: oto-neurosurgery. Inspired by the techniques of neurosurgery, but using our habit of the finest gestures, it consisted, by opening the skull, to bring the therapeutic intervention beyond the ear, to the proximity of the brain, when required by rebellious vertigo, severe facial paralysis, a cyst or a tumor. It seemed almost certain that cochlear or auditory nerve surgery would become a reality.

The attempts I had made so far were not very spectacular, even when they succeeded. But they were enough to maintain my desire to search in all logical directions. And this confidence, by transpiring in my words, undoubtedly gave hope to my patients, that is to say, a little of the relief they regularly came to seek by inquiring about the state of research.

It was therefore at the end of a real choice that I proposed to Mrs D. to undergo this implantation. The essential motivation was her suicide attempt with barbiturates, which had resulted from the long deterioration of her character, which had previously been cheerful and amiable and which now oscillated between prostration and impromptu anger. Such a decision to disappear, usually distressing and guilt-inducing for the therapist, was in this case very precious to me, because it was, in this uncertain future that I was going to start with Mrs. D., the certainty to give her back the taste for living. I had nothing to lose.

Doctors often identify with their patients in spite of themselves. It was Mrs. D. who had nothing to lose, and I speak as if I were her! This intimate osmosis with my patients and their families would make me suffer later, in the hours of doubt, especially since I would always have to keep this anxiety to myself.

In any case, despite what we already knew, it was a "first". Yes, we knew every move we were going to make. But, in the operating room, the surgeons all knew that the operation was going to be more difficult and, despite everything, full of unexpected events and improvisations. In the days leading up to the operation, with those of them who were going to "instrument" me - that is to say, help me by holding aspirations or rugins in place, by spreading, by sponging, or even more simply by giving me the desired chisel or scalpel, even before I had formulated my request out loud - we rehearsed on the table the crimping of the electrodes, the placing of each wire, the cutting of the silastics. They rethought the chronological order of our needs, enumerated the precautions, the necessary equipment, and constantly repeated the new gestures that had just been invented, in order to execute them as well and as quickly as possible. Because the intervention was going to be long.

Everything was prepared in advance, to save time; each electrode drawn to the desired length, each orifice of our Teflon sockets numbered and marked. We repeated several times the successive steps of what we had already done twice, but which was going to be much more complicated, since we had to open the skull to look for the hidden side of the cochlea.

We were used to operating in this region of the middle cerebral fossa. By this already delicate way, it was necessary to open the inner ear, to insert one or two electrodes, to place our fragments of silastic. Each detail was thus repeated, then taken up again, sometimes a little superstitiously. In this preparation, we were trying to save as much time as possible on all those hours that were essential to correctly perform the complicated installation. A general anaesthesia is indeed always for the patient all the more tiring as it lasts longer, even if, nowadays, the skill of the anaesthetists and the subtlety of the drugs they use have allowed the surgeons of our time to forget a little bit the speed of yesteryear to think above all about precision and meticulousness.

In any case, whatever his technical reticence was sometimes in front of these long interventions (which often lasted up to eight hours), the team of anesthesiologists who helped us, men, women, vigilant, silent, attentive, was always and entirely devoted to us, accepting our projects, understanding our difficulties, our requirements, using all their knowledge to help us during those whole days spent together in the operating room. What an amazing collaboration I found, not only in the operating room or in my laboratory, but in the whole department!

Such good will, attentive and silent, such competence, such professional conscience, exist, I think, only in the Public Assistance, where they are, I believe, the fruit of this kind of natural selection that operates, in spite of its ingratitude, the attraction of hospital work. Never, in the best equipped private clinic, would I have encountered such a team spirit, such a disinterested warmth, appreciating my efforts, guessing but respecting my anxieties, sharing with great heart the joy of our successes little by little. I only benefited from such devotion because I officially belonged to the hospitals of Paris. This function, earned ten years earlier, led people in the department, but also outside, to trust me in these attempts (which at the beginning, however, seemed quite crazy to them) and to help me in my still hesitant research. This is the strength of this title and its main advantage. In public hospitals alone, such a work of clearing is possible. I would never have been able to do it if I had not been officially part of it and, on the day of Mrs. D.'s implantation, this whole environment was very precious to me.

October 1973. We decided to operate. The operation was long, but without any problems. Everything went well. The next day, at the end of the morning, I silently prepare the measurement of the results of our efforts. The oscilloscope and the stimulator are on a rolling table, with a voltage controller, some current conducting clamps and sterile electric wires.

I am moved, but I deny it. I know that it is a "first" but, by modesty, I do not proclaim it; I would refuse to recognize it if, close to me, one claimed it, because I am afraid of the failure. I have been thinking about it terribly since yesterday. I have already planned what I will say, what I will do, if she does not hear. I refuse the solemnity of the moments which will come, to spare a future.

However, the two nurses who accompany me to Mrs. D.'s bedside know what is going to happen. Their attitude is similar to mine. They are natural, but I feel they are more attentive, quieter, more reserved than usual. For them too, this will be a "first".

We enter the room. They undo the big bandage, freeing the shaved head from the wet compresses of tari blood, the scar sewn with black thread and the two big white buttons on which I connect, very gently, but still a little painfully, my four double wires, linked to the seven electrodes which yesterday were kind enough to take place at the bottom of the naked head. I connect the first wire. My two nurses, suddenly, take all their importance. There are only two of them, but their presence envelops me. With them, the whole world, yes, the whole world, is watching me.

I put my right hand flat on the slightly warm oscillator for a moment, then I pick myself up again, relaxed, stingy with my gestures and striving to be efficient, as in all those moments when coolness is more useful than knowledge. Then, I slowly turn the volts knob; I go up, up; I see the image of the current on the oscillator growing... Nothing! I feel a spinal fear coming on; it's about to invade me all over, when suddenly :

- Yes, I hear! Ah! Ah, yes, it's too loud!

I stop immediately, pull back the current. I won, but don't say anything. We change electrodes; I test them one by one. All seven of them work well.

While trying to appear to find this normal, I let myself smile a little, to reveal a corner of my joy, to thank my acolytes in white who are nevertheless "bluffed", almost as much as me.

I speak to them when, suddenly, cries and moans resound next door, coming from the bed: Mrs. D. has burst into tears, from emotion, and mixes laughter and tears to tell me her joy, her joy of living again perhaps... !

Everything was there that day, even the melodrama.

The melo... ! I seem to be making fun of it! However, it was a real upheaval for me too. And at the same time, when I see it from afar, I don't know what false modesty prevents me from recognizing it. At the time, I am ironic, I don't want to be fooled by the facts: these different and distinct sounds, these noises heard for the first time in this ear since so many silent years, these tears, this emotion, I refuse to dwell on them; I want to see in them only appearances which prove nothing, and which in particular do not mean that we were right. There is still the test of time to overcome. Will the miracle last?

I often wonder where this modesty comes from. Perhaps it is an after-effect of the literature of André Soubiran and his *Men in White.* In spite of myself, no matter how much I have enjoyed reading this author, I have always been a little angry at him for having struck such a chord with such banal and serious things at the same time: it's too easy! Since the beginning of my medical studies, although I am spontaneously inclined, I defend myself against this kind of sentimentality, implicitly telling myself: it's Soubiran! Especially since these emotional thrills often prove nothing. It is not because a patient thanks you, tears in his voice, and praises you, that you have necessarily done the right thing, without imperfection or error. Mrs. D.'s sobs of joy, as pleasant as they were, were not enough for me. We needed many more successes to be satisfied, to feel that we had won: to see our results recognized, our efforts imitated.

For, however "miraculous" it may have seemed, this hearing recovered during the few moments in which I had sent the adequate electric current to my patient, was in itself of only relative value. There was, as always, still a lot to do.

This first success immediately made us want to go further, without waiting to know the quality of the results obtained, i.e. without knowing what practical improvement, in everyday life and conversation, these electrodes brought. In any case, it was an improvement of the previous state, and my instinct refused to believe that these results could only be transitory.

I have sometimes been criticized for going too fast, for not waiting for the necessary hindsight to be sure of the sustainability of the results. But what hindsight? Who could have told me how long it would take? Since, in our first experimental patients, the thresholds of each electrode were the same at the end of two months or six weeks, the normal healing time, why, if we required an additional delay, speak of six months or one year? There was nothing in the current state of science, other than vague and uncertain arguments, that would allow us to choose this period - or why not two years or ten years?

I had the intuitive conviction that, after the normal time of healing, the value of my electrodes should not change any more, as long as nothing new occurred at their contact. For they were far from the nerve itself, with such fragile ends, from which they were separated by one or two millimeters of liquid or scar tissue. So this fear, left in reserve in the background of possible hazards, did not hold me back. The big handicap of the technique was these transcutaneous buttons, allowing the connection of our electrodes with the external apparatus: I knew that, one day or another, they would be badly supported, suppurate and, finally, oblige us to remove them.

It was necessary to know quickly all the possibilities of the method, to convince the industrialists to manufacture the transceiver device which would allow us to remove the buttons. We certainly could not build it ourselves, as would have been possible if we had only had one electrode. With six or eight of these, the problem became extraordinarily more complex: it was absolutely necessary to avoid that the different information brought to each of these electrodes overlap each other, and the transmission had to be carried out in the very restricted space of a few millimeters of the mastoid region.

This technology did not exist. It had to be invented, mocked up, tested and miniaturized: this could only be the work of engineers, not of a neurophysiologist and a surgeon. But, in order to convince engineers to devote time and money to it, it was necessary to show them that there were outlets for this equipment. If we had tried to have the process developed before we could affirm, by first tests on humans, that it was going to be useful, never would the richest industrialist or the most opulent research organization have taken us seriously and helped us. Again, this sort of human experimentation that we were doing was essential.

This is my answer to the criticism that I was going too fast at the time. But, at the time, developing these arguments would have served no purpose, except to reassure my friends. The others would not have cared and would have refused to hear them, to stick to the specious reasons with which they masked their vindictiveness or their jealousy. In all fields, the researcher is left alone as long as he is content to search - too alone, in fact: often, he is alone and almost without help. But as soon as he has found something new and original, capable of improving more or less the daily life of his fellow men, as soon as he believes in his discovery, as soon as he wants to develop it so that it can be used by all those who need it, then, often, he arouses animosity or mistrust. Because he disturbs the established order. How many industrial inventions and technical tricks lie dormant in drawers, acquired if need be, to be better smothered, by large companies which, otherwise, would have risked seeing some of their interests disturbed!

In medicine, the realities are just as harsh. For many doctors, the need to have a "good reputation" is a source of jealousy; for many, in fact, the innovation proposed by another is an implicit attack on their own value; they then fight it all the better because they have at their disposal, in order to conceal their face, the defense of the interest of the patient, the very natural fear of each one of being wounded in his flesh: medical innovation always appears, first of all, full of risks, with regard to the experimented techniques, whose limits, but also whose effectiveness, are known.

All these difficulties are classic. They are normal. And such reactions are human. I had heard about them. However, at times, they were very painful to admit, especially since we often had to bear them in silence, to say nothing, to avoid any polemic, to know how to wait, to wait for time to prove us right. But we were quickly helped and supported by the astonishing nature of our first results, however fragmentary they were, and by the intuitive certainty, which had recently flooded my mind, that we had found a passageway which we only needed to widen in order to provide a valid solution to the tragic problem of total deafness.

From then on, it was necessary to go quickly and to extend the usefulness of this eventual equipment to the greatest possible number of these totally deaf people. Now, among my deaf adults, I had, coming to see me for other reasons, some deaf-mutes. To some of them, during the autumn, we had proposed to carry out the electrical stimulation test of the cochlear nerve, mainly out of curiosity, because, like everyone else, I thought that their nerve was totally absent. To our great surprise, the test was positive. The astonishment of the patients, perceiving a sensation never felt before, was extraordinary. Shouting with fear or joy, shaking on the operating table, they participated noisily in the intense excitement that their auditory perception brought me.

Classical official notions were thus suddenly put in check. We learned, with this very simple test, that a certain number of fibers of this auditory nerve, which was said to be totally non-existent, were in reality quite present. It was enough to send, "to see", a few tiny electrical impulses, to refute, at least partially, the most accepted conceptions. These were based, in particular, on studies made in the U.S.A., from collections of rocks of adults or children suffering from deafness: on the microscopic sections of these rocks, the auditory nerve, indeed, seemed, at first sight, totally absent. Following our first observations and those made by others, these collections of serial sections of rocks were, three years later, again carefully examined by American teams. It was then realized that there were in fact, scattered here and there, some nerve fibers that had been unnoticed or considered negligible, but whose presence, discovered retrospectively, explained our paradoxical findings of that time.

Although they were still meaningless for these deaf-mutes, we sensed that these sounds were going to sound, in the world of otology, the hour of a small revolution, which we had just triggered a little by chance and which immediately became the essential stake of my efforts. Because, from then on, it became possible to allow at least some of these people, who had been walled up until then without hope in their silence and isolation, to hear. It was urgent to try.

A man of forty, a tailor by trade, deaf and dumb from birth, but well established in life, amazed by the sounds he had perceived, agreed to be operated on. He knew that, if this operation was successful, we would build, in the following months, a special device, later implanted to suppress the transcutaneous buttons and the weekly bandages. *A few months! An* enormous delay, which I had expected to be extremely long (I thought), to give us time to develop the device. So slow had been the days! Since May, so many things had happened! The time passed so long that one month of waiting seemed to us immense.

- Same... not the same... stronger... very weak... I hear!

Ah! how to say the extraordinary, the lived miracle, the never seen, in front of all these wires and these circuits, this electric unpacking spread out on the operated bed. Since his birth, he has never heard, our tailor, and, this morning, he discovers what are a sound, a noise, a word. High notes, low notes, strong or weak! He distinguishes, is astonished. He does not recognize anything, because he does not know the equivalents of the language. He can only describe an unknown sensation. Strong, weak, were guessed. But higher, lower, rumble, whistle? If he knows these words to have said or read them, they are for him only words, of which he will learn the meaning...

He has now been living for a month with his device, huge, as big as two boots, fragile. It was Challier who built it for him, taking over from Mac Leod in the successive assembly of our makeshift apparatus. For I had an increasingly bad conscience to distract Mac Leod from the thousand and one other responsibilities of his laboratory. He always welcomed all my requests with the same warmth, but I felt that, if he willingly accepted to imagine, to draw the plans of the apparatuses that he invented for our patients, I could not ask him to build them all himself one by one, as he had done until then. I could not even consider it myself: my knowledge in the matter was at that time much too rudimentary. So I started looking for an electronics technician who was willing and able to build these assemblies.

Thus Challier, an acoustical engineer, seduced by our projects, came to help us voluntarily. It is his almost daily work that will allow us to build this portable electronics for all our successive operations. It is thanks to him that we will appear reliable. It is thanks to his help that the public organizations will be convinced of the interest of our process and of the necessity to build the radio-transmission device that I need quickly, very quickly, to remove the Teflon buttons before they disappear. Because the microbes coming from outside, despite all our dressings, will sooner or later inevitably lead to suppuration around these plugs that penetrate the skin, and they will surely have to be removed to avoid real infectious complications.

In the meantime, our tailor still hears, for more than five weeks now. He knows how to identify high and low tones, "recognizes" some words, learns the familiar sounds of his daily life. In his apartment, the doorbell has just been modified: in addition to the large lamp which was violently lit when a visitor activated it from outside, an audible alarm has been added, which he hears and recognizes, even when his back is turned. His astonished wife, also a deaf-mute, watches him gradually become normal.

But I still need a few more successful operations to be sure. A young woman, also deaf from birth. An old lady of seventy, silent for eight years already. A tall boy of eighteen, Jean-François...

Jean-François had arrived from the southwest of France, escaped from a psychiatric asylum where his deafness, which had gradually set in at the age of ten, had led to his confinement. Disorders of character, behavior, adaptation, said the letters of the head doctor of the psychotherapeutic center: delusions of persecution, hallucinations, schizophrenic tendency...

He told me his story. At school, at first, he could still hear, but less and less. So he was often beaten. They thought he was out of it, or dissipated. He was expelled. He got angry at all the people he didn't understand, who didn't speak loud enough to him. When you are ten or eleven years old, and your family is a bit rough, you should understand that you are becoming deaf, that you should not rebel or you will be taken for a madman, suffering from character, behaviour and adaptation disorders! Especially since, in addition, enormous buzzing noises masked the little hearing he had left. He often complained about it, describing these noises with his childish words and their images. But the adults only saw them as hallucinations, confirming that he was crazy. At fourteen, his deafness was total. He wandered from asylums to centers, from runaways to neuroleptic or tranquilizer treatments, often escaping to hole up for a few months in the family farmhouse, lost between moors and forested areas.

Anyway, he came to me; he tested positive, and everything changed. I implanted him very early, the fifth, I think. Like many of our first patients, he had some electronic problems at the beginning: badly adjusted filters, too violent sound sensations, circuit failures. Then, everything got better. He could hear and made rapid progress. The months passed. He went back to his native Rouergue. He started to work again, preparing a mechanic's C.A.P. between each weekly trip to Paris.

One day, he didn't come: he had been killed the day before in a car that was too old, on one of the roads of this vacation countryside where he lived every day. His plane itself had been crushed, destroyed...

Mrs. F. was slim, elegant. She was seventy years old, a certain kindness inscribed on her face, curly hair, mauve and white, a batiste collar, her features neat, slightly blush, as on a figurine of the XVIIIth century. Her restrained posture, her studied friendliness, her monotonous but rigid voice, the attention she paid to follow the words of her interlocutor on her lips, made evident all the will she had been deploying for years to hide as much as possible her deafness, which had occurred eight years earlier, following a nasty bilateral otitis. At that time, extensive interventions - complete middle ear surgery to remove the infection - could not save her hearing. I followed her for about three years, seeing her from time to time to clean the wax and scales that clogged the vast cavities that had become her ears.

She was aware of my efforts, and it was she who asked me to be implanted. I hesitated, because although she did not look it, she was still in her seventies. Long hours of surgery were not trivial at her age. Moreover, would she be able to learn to hear, to rehabilitate herself? But she had passed one or two of my first patients in the corridors, and she insisted on telling me:

- Doctor, I have only a few years to live; I would like to hear again, as I have seen this gentleman with his brace can hear. I don't care how big the brace is, and the operation doesn't scare me!

Not being able to dissuade her, not daring to tell her bluntly that she was too old, because she did everything to look less than her age, I agreed to do the preliminary diagnostic test. Of course, this test was indispensable, but I saw it as a delaying tactic: I was buying time, I was testing the authenticity of her desire to be operated on, and, unconsciously, I was hoping that the test would be negative, in order to have an irrefutable pretext to support my reluctance.

But she heard very well, distinguishing in particular, with a very low electrical threshold, the different stimulations that I sent her. It was difficult for me to step back. I tried to scare her, insisting on the risks of a possible return of her infection. But she persisted, calmly explaining to me that, in her opinion, there was no reason to have such a fear, that she accepted the possibility anyway. She made up her mind by adding:

- You know, doctor, I have canaries at home, but I have never heard them sing. And I also have two grandchildren, whose voices I don't know. Please operate on me; you really can't imagine what it's like not to hear!

It was true. But it was only then that I saw in her eyes, in her gestures, all the pain that I was used to seeing in other deaf people. Her self-control had prevented me from seeing any trace of it in her. Out of generosity, she hid her misery so well from those around her that I had almost been fooled into believing that she was well adapted to her infirmity. This is why my medical fears had taken over and had prompted me to refuse the operation. I could not resist her plea, as soon as I understood that her distress was the same as that of all the others, and that I knew so well. My reservations suddenly appeared to me in the light of a selfish prudence. So, finally, I agreed to his request.

I shortened the operation for her, by not implanting the electrodes that would have required opening her skull. This simplification allowed me to operate without too many risks. Of course, with five electrodes instead of seven, she would, I knew, understand sounds and sentences less well than the others. But I was counting on her desire to hear so that she would make the best use of the information that her five electrodes would already bring her.

She rewarded me well for my audacity. First of all, because she was able to hear her canaries sing; and secondly, because one day she came to the consultation to show me her grandchildren. Above all, I learned with her that a chronic otitis, contrary to what was logical to think, was not a formal contraindication to implantation. With certain precautions, it was possible to perform this procedure and obtain excellent results: my patient proved this to me every day.

So there are many of them now, in this spring of 1974. All have "walked", as we say, spaced out from month to quarter. For some, Christmas has passed, leaving them with the gift of returned decibels, or offered in their operating slippers.

My first implant recipient has been hearing for over six months. Of course, she still doesn't understand very well, but she is making progress and her desire to commit suicide has disappeared. She complains that she has to come in, like all the others, two or three times a week, to change the bandage that hides her pimples and her eight threads. All of them are waiting for the apparatus that I promise them and that will rid them of this tri-weekly subjection. However, the morale remains good, because the sensitivity threshold of all the electrodes does not move; their discrimination is identical; the performances improve in the recognition of words, syllables, usual sentences.

With the help of the department's speech therapists, and then of Dr. Fugain, a phoniatric physician, we undertook to re-educate these patients, that is, to help them learn to hear again. Because their new hearing was completely different from the one they had known. Indeed, our electrodes were distributed all along the cochlear keyboard, and their spacing corresponded to approximately one octave between each electrode. But, in order to concentrate our efforts on speech intelligibility, we were obliged to bring only the sound information that contained it - that is, instead of the broad range of 0 to 12,000 hertz usually perceived, a much narrower frequency band, between 300 and 3000 hertz. Thus, the details of these conversational frequencies were well reproduced by the seven channels of our apparatus; but the electrode implanted in the cochlear zone of the 10,000 hertz brought to this place external messages of 3,000 hertz, whereas the electrode located in the cochlear zone which would have corresponded to the 3,000 hertz sent external messages of 500 hertz. In this way, a given external frequency, of 2500 hertz for example, was perceived as 8000 hertz. There was thus a real decoding to be carried out: the formants of the vowels were not the same ones any more; consequently, those did not have their sonority of formerly. It was necessary to relearn how to hear.

In order to choose the best frequency division of the channels destined to the different electrodes, we later had a synthesizer made, a complicated device which reproduced for a normal ear what our deaf people were supposed to hear: the intelligibility, at first sight, was approximately that of an old loudspeaker heard in a neighboring room. The message was understandable only when it was known. But one felt that one could learn to translate the sounds, with a little learning. Indeed, that was what our deaf people were doing. They were taught to recognize syllables first, then words, and finally simple sentences, without being guided by lip-reading. These exercises were like foreign language lessons and helped them to take better advantage of their implantation. Moreover, for us, the performances they showed themselves capable of were very precious: they objectified the fact that, with several electrodes placed in the cochlea, as we had had the idea, we obtained, without lip-reading, this intelligibility of speech, non-existent with a single electrode.

Initially we did not fully appreciate the strangeness of this new hearing, and so we could not give our first patients sufficient warning. Some of them were surprised and sometimes disappointed for a moment. But almost all of them got used to it very quickly. The older the deafness, the less important the problem, as if the memory of the sounds had gradually faded. In any case, with our deaf-mutes, this memory had never existed: they had never heard; they did not have this previous memory of sounds; and the hearing that we provided them, however imperfect, was already a very precious contribution. All they had to do was learn to hear. As it takes a child about two or three years to learn to hear and speak, I anticipated, although the case was different, a similar length of time for the equipment to give the full measure of its effectiveness. However, it was in the first weeks that the progress was the most spectacular, notably on the shape of the voice. This one, in spite of the efforts of the rehabilitators who, in the past, had often demuted the patients, was very altered, because they could not hear themselves speak. But, with their electrodes, they could gradually correct, "by ear", the sound of their voice, whose improvement was progressively appreciated by those around them and by us.

We then started to look for the industrialist able to build the radio equipment. Many talks, presentations, polite astonishment feigning enthusiasm, but no decision. "To invent this device would be very expensive and the success is not certain; it is research, and the responsibility falls to the State...

After weeks of wasting time with the most famous names in the electronics industry, the chance of friendships made me meet Bertin, the inventor of the aerotrain. He had just created an automation department in Aix-en-Provence. Our idea interested him. Three days later, discussions began. With his team, everything went very quickly. In this type of research, where brainpower counts more than industrial power, small companies are more lively and efficient than large groups.

But a subsidy from the Ministry of Industry and Research was still essential, as the problem was so difficult. Nothing was won yet! Then began my first struggles against the inevitable slowness of the administrative machine. I learned to beg from research organizations, I learned not to be in a hurry.

In spite of my efforts during this long and painful apprenticeship, I felt that I was not made for this struggle: I had no pleasure in using these weapons of procedures, deadlines, regulations, or even school favoritism or cronyism! But we had to fight. So we made credit applications by the required dates, we filled out abstruse and complicated files in six or eight copies.

Time passed. A commission met, inquired, judged, issued an opinion, favorable of course, but useless, since we learned, a few days later, that there was no more money for this year! "Maybe in a year..."

We are in October 1974. Our hope is crumbling. To wait another year! But, in the meantime, what to do? In one year, my patients will not hear anymore, because the plugs deteriorate, ooze, lose their fixity under a reddened skin that the pus more or less detaches by places; their contacts with the electrodes deteriorate. Soon, it will be necessary to remove this connection with the outside, to avoid that, by accident, all the crew is torn off by a little abrupt gesture. We will, little by little, be obliged to deprive ourselves of these external buttons, to cut these electrodes at the level of the Teflon plugs, to close the sick skin by burying their extremities in depth, so that they await the arrival of the magic receiver. It is distressing, stupid, horribly sad for my poor implanted patients, whose shaky hope I maintain without believing in it anymore.

However, luck is with us. One day, a phone call: the secretary of the General Delegate for Scientific and Technical Research asks me for a note on our file. I try to understand. It is simple: the chance of conversations led him to be aware of our first achievements and of the stop they have just undergone. An exceptional grant would be possible. It is. It is coming. It is the Prince's doing, it is true. But the Prince was right; because it puts everything back in motion and the engineers begin to think, to propose.

The time started to turn again. This time I just had to wait, without having to do anything else. It was Mac Leod who now assumed the essential dialogue with the world of electronics into which he was taking me. Astonished, silent, I saw the invention being born, little by little defined by its physiological requirements and those of the technology. Like an added piece, vaguely ornamental, I attended these long discussions, of which, at the beginning, the essential escaped me, so vast was my ignorance. I discovered words, notions, the incredible properties of the proposed circuits. I was useless, only to remind these researchers of the urgency of the research, the anguishing necessity to find. Because each month that passed from one meeting to the other, for them without haste nor impatience, was for all my patients long days of waiting, of questions asked, of postponed hopes. Everything depended on the knowledge and goodwill of these engineers who agreed to help us. I knew this for a fact. I had not had any merit in defining the idea of the surgical gesture. Anybody could have done it, if they had felt the need as I did. My role was reduced to preaching the indispensable now.

But where did this incredible drive come from, this relentlessness, which made me relentlessly, for four years, motivate some and push others, until they found what I needed: the means to make deaf-mutes hear, to hear them speak among themselves and to understand them? What lack was I trying to fill, with this impatient quest? An unconscious distress sometimes floats in my memory. Is it her, in the thickets of memories, dug like marrow, closed cotton of bark, which made me support the bitterness and the acid juice of these interminable months? It is necessary to take again the details of this history...

PROTOTYPES AND EXPECTATIONS

For it was a long unfolding of facts juxtaposed one by one like the stones of a wall, obvious now that it is crossed, but whose uncertain daily life was very heavy to endure. The scattered memories that I rake up tonight in the innumerable detours of my memory come back, intense and spontaneous. Of these years, one should however only review the waves that carried me, and not recount this tedious and daily swell of hopes and worries.

All these patients were almost friends, whom I loved because their joy of hearing made me happy. They knew this and always greeted me with a broad smile, to let me know from afar that all was well. When something went wrong, they seemed to apologize for letting me down, as confused as they were for not hearing. Complications, electrodes torn off by mistake, defective insulation, device failure, broken antenna, unbalanced compressor: for four years, I was indispensable to all these people, the only recourse, the only responsibility, which took away my right to despair or to express my fears.

How many times have I had to lie, claiming that they were imminent, the long-awaited allocation of credits, the development constantly postponed, the delivery so long delayed. Lying. Never to say my disgust at so much wasted time. To keep my spirits up, as I had long been used to doing with my cancer patients, against all odds. But with my deaf patients, it was much harder, as I felt responsible for their misery: they were living until then, deaf perhaps, but quiet. It was I who had come to get them, to pull them out of their silence, no doubt, but at the price of what subjection for them, and for how long? Each of their worries, their skin or electrical problems came straight to my heart as a reproach, and the sum of them would have been unbearable if the progress we were making little by little had not regularly comforted me when nothing was going well.

End of '75. I implanted about twenty people. And they all heard. And all were satisfied to hear. All except two, Mrs. D. and Joachim.

Mrs. D. was my first patient. After the first few weeks of enthusiasm, she quickly understood that I could never give her anything better than a still very confused verbiage. A music lover, a violinist herself, she could hardly distinguish the word from the music. Her disappointment was great. She could never, at the age of 66, really learn to recognize what she was hearing, without following with her eyes the lips of her interlocutor. It was a mistake: I should have warned her more about the unusualness of what she would perceive, about the disconcerting nature of this "foreign" language that she was going to hear, about this re-education from which her age did not allow her to draw all the profit that we expected. But we were unaware of all these difficulties until she told us about them, with complaints and the same tears that her joy at hearing the first day had also brought.

Joachim was a cowherd in Seine-et-Marne and a deaf-mute. With his good round pink head and his 25 years old, while he was hospitalized, he put as much zeal in learning to recognize, with his device, the vocabulary that he was taught, as he did in gathering straw in his stable. Then he went out. He returned once or twice to the rehabilitation sessions, and was never seen again. A few weeks later, his mother came back, to give us back "our property", she said: it was, still attached to the wires of the apparatus, the two transcutaneous Teflon buttons and the six or eight electrodes, twisted and immodest, floating in the open air. Joachim had had enough of dragging this useless device around, now that he was living with his cows again. One Sunday, he tore it all off, and his mother, piously, brought it back to us "so that it could be used by someone else"!

This taught us to select our patients. We couldn't implant just anyone. Especially at the beginning. It was necessary to choose the "good cases", those whose results would be the best, in order to convince the censors of all kinds on whom the development of this technique depended, that it was good. But it was not always easy to resist the prayers of some, in particular those of the parents of deaf autistic children, locked up in their deafness and their mutism, in their specialized homes, in their fear. However, for these children, the example of Jean-François led me to think that the psychiatric disorder that excluded them from the world was perhaps the consequence of their deaf-mutism, and not an associated sign. Later on, we would have to try. But not now. I would be the one who, at this stage, would be taken for a madman, for being so bold and overbearing.

Sometimes, for these beings that the absence of communication has made different from their fellow creatures, and who have become adults anyway, half beast half man, as if sprung from a fairy tale, the parents demand that a diagnostic test be done to find out. But go and operate on an animal against its will! I remember this young man, red, blond and pimply, 23 years old, a human foal with squinting eyes, a lopsided nose, hunched over in his blue suit, wild, touching, gangly, scared and distrustful. His mother, whom we had dressed in white to accompany him and give him confidence, pushed him towards the door of the operating room. Reassured for a moment, he enters; then he rebels, escapes, and runs back to the waiting room, "listens" to the gestures of his sister who tries to convince him, hesitates, puts his head to the door, not daring to go further, thinks for a second, it seems, and then closes the door on a definitive refusal. Then, I give up, in spite of the supplications of his family.

- It's for his own good, doctor. You have to force him! He doesn't know what it is to hear. That's why he doesn't want to!

- But, ma'am, I can't operate on him by force! In any case, he must *want to* hear. He must not be subjected to me, but must trust me!

- So do it under general anesthesia, just like a child.

- But a child can be forced to stay in bed. He will run away, that's for sure! We cannot tie him up! If he had peritonitis, we would take him in spite of him, possibly several times, because his life would be in danger. But there, I don't have the right!

Everything is not simple. Where is the freedom of the ignorant? Why peritonitis and not deafness? Still, he returned to his province, proud no doubt in himself to have escaped a great peril. He must continue to live without growing old, in the middle of the rye fields and the turning seasons.

In different terms, this problem has often arisen. How many times have I seen, in my consultation, these great deaf-mute adults dragged along in spite of themselves by grieving parents, a worn-out old mother, an aunt or a friend full of good will! But they, well installed in life, did not ask for anything. What was the use of this complicated operation that was going to immobilize them for two or three months, interrupt their work and, thus, perhaps even compromise their employment? What would be the purpose of wearing this device all the time? To hear? But what is hearing? Is it really so valuable that it deserves such inconvenience? Deafness is terrible, especially for those who have already heard; but the deaf from birth, who cannot imagine this unknown sense of hearing, sometimes accepts quite well to be deprived of it; some of them even dread these changes in their life that we, hearing people, would call "improvement": what will happen to these friendships, these loves between deaf-mutes, if one of them gets implanted and not the other?

One of my patients had me postpone the date of his operation until the fall, because he wanted to visit Mexico during the summer, during a trip organized for handicapped people like him. In any case, he would not have been able to do so with the cumbersome and fragile device that we had at the time; above all, this patient was afraid of finding himself able to hear in the midst of his deaf friends!

I respect the wishes of my adult patients. But I'm surprised that I don't take more into account the fear, the refusal dictated by the panic in the eyes of this kid going to the operating room to undergo the diagnostic test. The test was requested by a mother and father, anxious to know if one day their child will be able to hear, when everything will be ready for such a young age, and thus seeking to regain hope, even at the cost of their son's despair. It is commonly accepted that it is up to the parents to decide what is good for their offspring, because their ignorance prevents them from objectively appreciating it.

This little girl who cries because she is going to be given an injection to put her to sleep, does not know that later, years after being implanted, she will undoubtedly thank her parents for having dared to have her operated on early, despite her cries and her sorrow. Isn't it a bit the same for those adults who don't know how much hearing can bring? But I don't feel I have the right to make them stop being deaf despite themselves. What is this exorbitant right of parents that allows them to do violence to their children? At what age does respect for the freedom of others begin? To ask the question is not to answer it. The difference, in this particular case, is perhaps that the child will always adapt to a new situation and will know how to make the most of the additional information that is brought to him/her, even if it is perhaps extraordinary and extravagant at the beginning; whereas the older one gets, the more one becomes a slave to one's habits, unfit for change, unable to learn.

In view of the progress made by my first patients, I quickly decided that children should be operated on as soon as possible. Of course, it was not conceivable to offer them this system with wires and buttons; it would have been much too dangerous for them: involuntarily or while playing, they would have torn off everything very quickly. We could only offer them a miniaturized, solid apparatus, and especially equipped with this radio transmission that we hoped to see soon realized. At home, surely, progress would be even faster. It was necessary from now on to foresee this stage, which I believed to be very close, when we would have a great quantity of these devices. So I started to stimulate some of these deaf-mute children, explaining to their parents that, thus, we would know: we could foresee the intervention, to carry it out as soon as it would be possible.

The normal pusillanimity at these ages obliged me first of all to proceed in two steps. Under general anaesthesia, after having reclined the eardrum, I placed a large sheathed electrode in contact with the round window, whose end, coming out of the ear, was maintained firmly in place by a thick bandage. The next day, in a well awake child, we proceeded to the stimulation. But the results were sometimes doubtful: even if the voltage necessary to obtain a painful sensation is theoretically much higher than the one able to give a sound sensation, in certain cases the child translated the hearing that one brought to him suddenly by crying or grimaces. Moreover, the awakening of these children was difficult; for fear that they would tear off their dressings, and in order to avoid their instinctive gestures of defense, it was necessary, as is commonly done in child surgery, to block their elbows in splints which maintained their arms tense. I was repulsed by these methods of force, and I left the operating room when the dressers, at the end of the operation, placed these soft carcasses in which I did not want to see, under the bands that bound them, these little arms disappear while starting to agitate themselves with impotent movements. And then, once the test was done, the bandage and the electrode had to be removed, often in the middle of tears and screams that nothing could soothe.

How can I explain to an eight-year-old child, who cannot hear me, that I might hurt him for a second or two, but then it will be over? I had the impression, by attacking them in this way, of ruining my reputation in their eyes, of compromising my image in their vigilant memory, of altering a precious capital: this trust between them and me, which I sensed would be necessary when the time came to implant them.

Everything was simpler when, in 1975, a particular technique began to become widespread, the recording of evoked auditory potentials from the brain stem, that is, from the lower part of the brain. This consists of recording, in the same way as an electroencephalogram, the electrical activities that the brain stem produces each time it receives a sound stimulus. The interest of this technique is that it can be applied to both vigorous and sleeping states. I adapted it to my problem, noting that comparable responses were obtained when, instead of providing a sound stimulus, one carried out an electrical stimulation of the round window, this orifice very close to the inner ear that is just hidden by the eardrum. From then on, my diagnostic test with children was much simpler: a general anaesthetic was sufficient. I obtained an objective document of the at least partial conservation of the auditory nerve, i.e. of the hearing that I had been able to give them electrically while they were sleeping, in the form of these very particular waves, preciously recorded on paper. I was thus able, within a few years, to realize that the vast majority of these children were implantable.

But, at the end of 1975, and since the summer, I no longer implant. The proof is now in the pudding that this implantation by multiple electrodes allows a certain recognition of speech. The commissions, the authorities were convinced; the credits were released. The automation department of the Bertin company has proven the feasibility of the equipment, which will allow the necessary information and energy to be transmitted by radio through the skin. It is a harmonious system of eight pairs of small solenoids, electronic components generating magnetic fields, tuned to each other, each singing in pairs with its counterpart, in unison on either side of the skin barrier. It is beautiful, it is hazardous, it is fragile. I'm worried. Will it really work? We are only waiting for the first three prototypes to be manufactured. This depends on the delivery of spare parts and, in particular, the famous solenoids.

And the time passes. January, a little snow, snowdrops. Nothing! It will be soon... Easter 76 comes. I travel, and propose to go to this unique factory in the U.S.A. where the part we are waiting for is made: but what's the point, since a strike has paralyzed the production for six months! We are still waiting... Sad spring: I am afraid, it smells like failure. How to trust such a complex process if it depends on a single supplier? Was I right to go to this company? My days at the hospital are punctuated by sessions of psychic resuscitation, where I raise the morale of my patients waiting for surgery, but from which I leave broken, depressed, so much I measure the fallacy of the assertions, of the promises that I have just made with smiles, pats on the back, warm handshakes.

Then, one day in May, I suddenly got angry. I take the plane, go down to Aix where the factory that works for us is located. I yelled a little, woke everyone up. Three or four phone calls in the big conference room to make some decisions. What took me so long? I have the impression that they were only waiting for my impatience to decide to move, to designate a new young engineer who will be specially in charge of the project, to reconsider the whole thing since it has reached a dead end. In a word, move forward.

And so we move forward. Or rather, the engineer moves on. He abandons these fragile solenoid loves. With the very recent C-MOS circuits, he has invented multiplexing our information, that is to say, making each one pass in turn, but very quickly, so quickly that they reach the nerve almost simultaneously. It is so much simpler! And it works. In September, the birth is announced. The birth is for the fall.

I summoned my first three patients. Two deaf-mutes of 17 and 30 years old, with important language disorders, and Mr. N... aged 30, suffering from a total deafness acquired since 15 years by streptomycin and whose speech is well preserved.

They arrive. They are surely moved, worried perhaps: for them, it is the big jump, the blind plunge. I pretend not to notice; in fact, I am just as troubled, even if, like them, I try not to show it.

Since then, I have been surprised by so much confidence; what was it based on? All the arguments that had convinced these patients, no matter how well-founded, appeared to me in retrospect to be derisory. Of course, my previous patients had all heard. It is true: most of the real problems they had encountered only came from the Teflon sockets, stuck in their skulls, and which the equipment, finally built and delivered a few days ago, was going to eliminate. But still: why not wait, as so many others had done? Why didn't they have the fear, quite legitimate, of wiping the casts, which, by not allowing me to operate them, would have prevented me from advancing?

I don't know the motives of this serene certainty which made them respond immediately to my call. But their patient cooperation was as indispensable to me as the most skilful inventions of engineers. I never hid from them that they were the first. They were aware that they were working for science. They said so openly, perhaps out of pride, perhaps especially to be reassured once again of the consequences of their courage. Of course, this voluntary work was perhaps facilitated by the fact that the long-awaited equipment was free of charge: the first specimens were indeed financed by research organizations. But I only kept the proof of an immense confidence in our team, which still moves me today, more than two years later.

The device is there, placed on my desk. I explain how it works to the father of Jean-Luc W..., my thirty-year-old deaf-mute, who works in bookbinding at the National Library. Mr.

W... works at I.B.M. He wants to know. I try to make him understand, in exchange for his promise never to try to open the machine "to see", despite his skills.

The device consists of two parts: an external box, which is a transmitter, and a receiver which will be implanted. Both are carefully placed on the white of my table. The transmitter is a grey, shiny metal box, a flattened cube as big as a two-litre car oil can. It weighs two kilos two hundred. At the top, six screws allow it to be opened by sliding the upper face out of the housing that forms the whole box. A few very simple words are engraved on this face: STOP - RUN, ANTENNA, MICRO, RECHARGE, and the name of the Bertin company, inscribed with as much tranquillity as if it were a system manufactured in thousands of copies! A black wire with a metallic sheath, not very flexible, is screwed near the word ANTENNA. It is a shielded wire that the emitting wave will travel. Its free end is screwed in the same way to a kind of small curtain ring sheathed in silastic; this ring contains several tens of turns of copper wire, in which the current will bend and twist several million times per second; thus a powerful magnetic field will be created, the slightest variation of which will represent, according to a very particular coding, the information we want to transmit. This ring is the transmitting antenna: today it is free, it can slide on two fingers. After the operation, it will be fixed on a branch of glasses, so that it finds easily its place on the skin behind the ear, just in front of the place where I will have implanted the receiver.

This one looks like a thick white host and, like the Blessed Sacrament, you can't touch it. It is there for all to see. But it is well protected under the transparent double wrapping with which it was dressed to sterilize it. I myself refuse to take it in hand to explain how it is made, contenting myself with leaving it in its bag, placed near the antenna, describing from afar its cylindrical shape, a large two-franc piece, one centimetre thick, of a matt white, from which emerge nine shiny wires protected by Teflon tubes, each bearing a color mark. I describe it with the tip of my pencil through its double window. This small octopus has in its belly another antenna, a receiver this one, which captures the magnetic field produced by the transmitting antenna, uses the power thus transmitted, decodes, to the nearest millionth of a second, the information represented by the variations of the magnetic field and then distributes it to each of the interested electrodes.

- But how is this distribution carried out?

- It is very simple (!). A "clock", i.e. a sort of circular sweep, rotates, "informing" each time the input of each electrode, giving it the order to send an electric impulse to the nerve, or to remain silent. This rotation, which, successively, brings their order to each electrode, is so fast - three turns in a millionth of a second - that, in practice, the time lag between each impulse is imperceptible for the nerve centers. Thus, several electrodes or all the electrodes can, at the same time, speak to the implanted ear. This decoding decrypts the corresponding coding, carried out in the transmitter box from the sound messages from outside. This coding is indeed the only way to make cross the cutaneous barrier with the multitude of electric signals translating these messages.

- Speech must first be translated into small electrical signals?

- Yes, I will explain.

I catch my breath. It's going to be a long one. But he has to understand, or feel like he understands, to be completely at peace. So I schematize. It is sometimes inaccurate in the details, but the main thing is that he knows the principle, senses the complexity of the work done by the box, why it took so long to build, why it is still so big, so heavy, as some detractors will soon blame us for minimizing the value of our first results.

- Do you know what sound vibrations are made of, low and high tones, low and high frequencies? Do you know that speech, like any other audible message, can be broken down in time into a succession of very brief sound units, about fifty milliseconds - they are called phonemes - interspersed with silence? Each phoneme is made of a characteristic assembly of frequencies, which allows the ear to identify it. The ear is a keyboard where all perceptible frequencies are represented. Our electrodes bring, at each place of the inner ear where they are implanted, electrical energy in variable quantity, in the form of micro-impulses. The duration of these is very short, of the order of a millionth of a second; but their greater or lesser number allows us to give a sound sensation of greater or lesser intensity. As for the serious or acute impression of the acoustic sensation thus provided, it depends on the location of the electrode concerned on the keyboard of the inner ear. Thus, it is possible to "play" on this auditory piano almost all the subtleties of the sound information.

- But then, Jean-Luc will hear normally? Why did you warn us that his hearing would be different?

- There are many reasons for this; I will try to summarize them. From low to high pitch, we are normally able to distinguish more than a hundred different tones, which means that in the keyboard of the inner ear, there are more than a hundred keys. But, surgically, it is not possible to put more than eight electrodes. And still, these eight electrodes, instead of striking each one only the single key located at its contact, stimulate in reality a great number of them at the same time: as if, instead of playing the piano with the fingers, one pressed here and there with the whole hand on fifteen or twenty notes at the same time.

- But the information must be very confusing?

- Yes, it would seem very poor, it is true, to us hearing people who are used to the luxury of normal hearing. But a totally deaf person learns very quickly to make the most of the most rudimentary sound information that can be given to him, a bit like certain peoples still in the process of development manage to live in an economy of scarcity, in which we overdeveloped people could not last more than a few days. But, in addition, we have concentrated the information by privileging the word. You know that this one calls only on the frequencies included in the range of 300 to 3 000 hertz, whereas music interests much higher frequencies, 8000 hertz and more, to which correspond zones of the keyboard of the internal ear where, precisely, it is surgically easy to place several electrodes: the information contained in these high frequencies thus contributes nothing to the comprehension of the spoken language. We have therefore carried out a frequency transposition. The sound, at the arrival in the microphone of the box, is filtered, so as to eliminate all the frequencies which are not included in this range included between 300 and 3000 hertz. Then, this remaining range is cut into eight frequency bands, which will then be re-injected into our eight electrodes. But the electrode placed in the 10,000 hertz zone will receive messages translating sounds located around 3,000 hertz; the electrode located around 8,000 hertz will carry messages reflecting the 2,500 hertz of the outside world, etc. Everything is thus shifted and concentrated around these conversational frequencies. There is therefore a transcription, which gives the implanted patient the impression of hearing a foreign language, at least for those who have already heard. This means that the patient has to learn to hear again, just as one learns to understand that *guten Tag* means "good morning" or that *window* means "window".

- And you think that, with the rehabilitation you have planned after the operation, Jean-Luc will eventually be able to hear normally?

- Yes and no. For Jean-Luc, who has never heard, the problem will be simpler. He will not be bothered by the difference between what he will hear and what he remembers hearing, since he has no such memory. Moreover, for someone whose total deafness occurred only after the acquisition of language, the importance of the initial handicap represented by this frequency transposition depends on the age of the acquired deafness. The memory of the sounds fades with time. This impression of a foreign language, provided by the new hearing, is only really described or deplored, during the first few weeks, by those whose infirmity is only a few years old. But, for your son, this temporary discomfort will not exist, the effort of adaptation will not be necessary. On the other hand, as a newborn, he will have to learn to hear, and learn to speak according to what he hears. It takes at least four or five years for a child to be able to speak normally. Even if things are different, because Jean-Luc already has an intellectual background that will help him, but on the other hand, a thirty-year-old brain adapts less easily than a young child's brain, I think it will take him several years before he stops making progress in identifying the sound messages he receives.

- But the phoniatric rehabilitation you told us about won't last that long?

- No, of course not. I think three months, maybe six at the most, will be enough. These sessions, especially in the beginning, will be essential. But the best re-education will surely be the permanent use of the device, and a conscious effort to put into practice what Jean-Luc will have learned to say or recognize during these phoniatric sessions. However, even if he does not have to suffer from the decoding required by the transcription of frequencies, his hearing will not be normal. Even if eight electrodes are much better than one or nothing at all, it is probably still not enough. The engineers of the C.N.E.T., the National Center of Tests of Telecommunications of Lannion, showed us that the vocoders, system of transmission which resembles a little our process, gave a satisfactory information, with only twelve channels. We are missing four. But, surgically, it is not possible for the moment to place more than eight electrodes: there is no room! (However, we managed to do it a year and a half later; but that day, when I talked to M.W., I really thought we were at the top of our game!) Then, don't forget that if the diagnostic test Jean-Luc underwent a few months ago was positive, it doesn't mean at all that his auditory nerve is completely normal, but simply that there are still at least a few nerve fibers in working order, without knowing their percentage or their distribution on the keyboard of frequencies of the inner ear. Moreover, the process that completely destroyed the organ of Corti - you know, those cells in the cochlea that transform mechanical energy into electrophysiological signals for the nerve - not only more or less damaged the auditory nerve itself, but also partially damaged the hearing nerve centers in the brain. Also, whatever the richness of the information brought by an apparatus which would comprise twelve electrodes or even more, this one would undoubtedly be integrated with difficulty by the conscience. Therefore, Jean-Luc's hearing will never be truly normal. But the nerve centers are capable of adapting, and all the more easily as they are younger. You will see that, despite these reservations, Jean-Luc will experience a certain change!

- I know. I saw your first surgeons with their wires and dressings. They told me.

A pause. We stop talking for a moment. M.W.'s gaze falls on the case and curiosity takes over. He wants to see the inside, where he knows the settings are. I accept. He *has to* trust me. I don't want to play the distant wizard. It is necessary that he knows why the camera is so complicated.

So I try to explain the prodigious work that is going to be done so that his son can hear. All these electric impulses created by the transmitter - several thousand per second and per channel - will cross the skin and find, each one without mistake, the electrode to which they are intended. It is this transmission of so many signals in such a small space that was difficult to achieve. Imagine a troop of soldiers marching at a walking pace, in a row of eight lines, and who must cross a river, while finding themselves in line and in order on the other bank. Technology does not have a bridge that can carry more than one soldier at a time, because there is no transmitter system that can carry multiple pieces of information through the skin barrier of the skull at the same time. Of course, you can put eight bridges on which your infantrymen will march without changing pace. But I couldn't put eight antennas, scattered over the skull like curlers in the hair, and, under the skin, eight receivers implanted everywhere. Theoretically, it would have worked. Practically, it was unfeasible.

While talking, I removed the cover screws from the case. The cover is carefully lifted. Six plates appear, vertical, clean, varnished, shiny, covered with components encrusted like seaweed or shells on a wreck. No wires, no inextricable mess like there was in our first handcrafted machines. Only metal lines drawn and weaving admirable printed networks, myriads of black circuits well arranged, series of switches, big batteries cluttering half of the volume. M.W. leans, amazed, on this small silent factory. Then, after a moment, his questions resume, and I continue.

- Look at this assembly," I said, pointing to a small, seemingly unremarkable group of circuits. These are C-MOS circuits. Thanks to them and similar systems, Bertin's engineers have found the solution. Instead of putting in eight bridges for our eight rows of infantrymen, they had the idea of putting in only one, but to make soldiers pass through it one by one and at a gymnastic pace, that is to say in a fraction of a millionth of a second. As soon as they are inside the skull, the receiver receives them and puts them back in order, so that they continue their march through the electrodes and towards the auditory nerve. Without this transmission system, called multiplexing, we would never have succeeded in developing a device as satisfactory as this one. We were lucky, because at the beginning of our research, this technology did not exist. The principle of multiplexing was known, but it required a big equipment, unusable in our case. The engineers, after many efforts, had finally stopped at this idea of solenoids, theoretically reliable, that, only, problems of delivery had prevented them from realizing. But what a providential delay! Because, in the first formula, the receiver would have been enormous, the separation of the eight voices, less good, the consumption of electricity, much greater than in the system which is there, on this table! We would have known undoubtedly many difficulties, and perhaps we would never have reached our ends. It is a bit of a miracle that the miniaturization of these multiplexer circuits appeared almost at the moment we needed them, without us having to wait more than a few months. The first components arrived on the market around 1975. The industrialists quickly understood the interest and used the fruits.

In explaining all this to M.W., I would like him to understand why, for two years, we have been putting off, month after month, the delivery date of this equipment. I would like him to feel our growing anguish at each aborted electronic test, at the idea that perhaps we would never succeed, or my anxiety at the not very satisfactory solution that was promised to us every week since spring and that never arrived. He would have to feel what, for me, remains a grace of fate, an extravagant chance, the occurrence, just in time, of these magical circuits. But M.W., fortunately, does not care. He questions again, detailing with his finger the colorful assembly, plunging his glance in the narrow space between the plates, counting for a moment the components, recognizing by places, since he is used to it, a series of diodes, a row of capacitors, a familiar circuit. I tilt the device and show him a small silent hole on the case:

- The sound arrives there, through the microphone. It is immediately filtered of its frequencies without interest for the speech. And above all compressed, so that the great variations in intensity are proportionally preserved, but reduced in amplitude. The auditory nerve is indeed so sensitive that it would not support the great variations that temper, in the normal state, the eardrum, the ossicles and the liquids of the internal ear. This compression is very complicated to obtain without deformation. Look: it requires this whole plate...

I show him the compressor board, completely covered with black circuits, neatly arranged like school desks in a classroom. Time passes. I continue to explain, but I feel that he is listening less. He has understood the essential, even if he can no longer discern the details. He knows now that they were true, all those delays, interminably renewed, all those disappointed hopes. They were not evasions, delaying tactics intended to hide our impotence: it took time, money, work to build all this. I still continue:

- Then the sound is divided into eight frequency bands, here, in this part. Each fraction is thus transformed into electric impulses, the number of which will depend on the intensity of the sound in the considered frequency band. The strength of these impulses can also be adjusted by hand for each electrode, thanks to this series of switches. Because the efficiency of the different electrodes varies a little according to the way in which each one is implanted, the distance that separates it from the nerve, and also the healing process, which modifies the electrical permeability of the tissues. Therefore, during the first months, we have to check the sensitivity of each electrode from time to time and adapt it, to be sure that the patient perceives the message well, neither too noisy nor too weak. Then the messages from the eight channels are collected. The sensations from earlier are put in order and in single file, here, in this multiplexer; they then go to overlap the electromagnetic wave made in the generator, here, and that the antenna sends through the skin to the receiver implanted in the mastoid.

We still talk for a long time. The details, the batteries that need to be recharged at night on the mains, the precautions: do not drop the device, make it work all the time or as often as possible, except in too noisy an environment or if it risks being hit during the exercise of a too violent sport...

I close the box. M.W. is reassured, satisfied. Many will be, one day, those who, like him, will ask me the same worried questions. But, if he was the only one to have asked me so many precisions so long to bring, I know that I will have, later, for all the others, an impression of repeating myself which will sometimes annoy me slightly, so much the things will seem obvious to me then and so much everything will have become simple in appearance. When, in a year's time, a sort of routine will gradually settle in, a delicious habit born of the smooth running of our technique, I will have to make sure that I remain as available for everyone as I was for the first ones. But we are not there yet. And, of course, I still don't know what to expect. Fortunately, because it will be hard!

When I think about it, what luck, or rather what bad luck we had! Because, of our three prototypes, only one worked well, immediately and without any problem. The one of B., this tall boy of 17 years old, whom we will see on television, six months later, about whom I will often be spoken, and whose photo, published in *Match,* was reproduced shortly afterwards in dozens of newspapers, even in a daily newspaper in Ryad where I recognized him one day, enthroned in the middle of splendid and incomprehensible Arabic characters.

The second prototype, placed at M.N... worked just as well. But M.N... was a handyman and, a few days after leaving the hospital, he came back to bring us his device in spare parts that he had not been able to reassemble, after having opened and explored it. It had fallen on the floor, he told us, and he had wanted to repair it! Alas, it was irreparable, and M.N. had to wait more than a year until the Social Aid of his district, touched by so much misfortune, agreed to finance its reconstruction. And during one year, he came to see us from time to time: we made sure, with one of the two other devices, that he heard well; but he did not learn anything. And I could not include his case in our list of results.

As for the third prototype, that of W..., it broke down after three weeks, and this was one of the most difficult passages of these five years for me.

W... could hear well. His smile lit up the service. He was listening, laughing, mocking, almost insolent, to the television program of Antenne 2 reserved for deaf-mutes. And I, moved, had filmed him like that, in front of his television set, wearing his equipment and following with laughter the announcer who was waving his hands, lips and arms to translate and comment the images. His family praised me. I had been walking on flowers for a month, because my first three prototypes could hear well. I was being modest on principle; but it was happiness.

One Sunday, shortly before he was to come out, healed, open to his new life, he heard a loud noise, a deafening din that made him waver. Then, nothing; silence. Intrigued, worried, he recharges the batteries of his device, tries it again, in the evening: he perceives then still some very weak, distant sounds, without any relation with the rich information he received until then. He falls asleep. I learn that the next morning. I redo the tests: nothing more, not even the small noises. It is the breakdown, the complete silence!

First of all, keep your cool! To smile urgently; to say: "It's nothing, it's not serious"; not to show my concern to him or to anyone. And to invent on the spot: "There are several verifications to be made; I prefer that you do not go out again today, in spite of what was planned". Because I was on familiar terms with him. Like Jean-François, in the past; since I had taken charge of him, that is to say since I had promised him, after a positive test, to make him listen, a mutual tutelage had been established, a faithful reflection of the confidence that we had in each other. He believed in me. I felt that he was going to make progress: his voice was so distorted and he wanted to hear so much, that I was sure he was going to be an excellent case. And he was the one who was breaking down!

What remains of the days of anguish that followed? Finally, the unpleasant impression of having been fooled by electronics, of having carried the pain and the anguish of the other, of having calmed his morale by appeasements which, sometimes, seemed like lies, and then of having suffered, for nothing, of the doubt and the fear of failure, of having been unhappy, questioned by myself, worried to the point of being almost sick for a banal story of circuits.

Because the dilemma was the following: was the failure due to the receiver, this famous small miniaturized computer, as the journalists will pompously call it, a few months later, or did it come from a progressive destruction, and this time definitive, of the remaining nerve fibres of W... ? Personally, I thought it was the receiver. The engineer, for his part, feared the alteration of the nerve; because, during the preliminary diagnostic test, it had been necessary to send a lot of current, six volts at least, to obtain an auditory sensation. On the other hand, the two other receivers worked well, and one did not see why, given all the precautions taken, the reliability of the components could be questioned. No matter how much I defended myself, recalling the experience I had gained from the time when my patients had their wires and buttons, and citing as an example, unchanging for two years, the electrical levels of the electrodes of my cheminot reviewed from time to time, my confidence was laminated by learned hypotheses of progressively defective silastic insulation, increasingly low impedances, disturbed electrical fields, etc.

The whole principle of our rehabilitation was called into question, during those few days spent in endless telephone discussions with the Bertin factory in Aix, one or the other suddenly calling back as soon as an idea, an argument sprang from our continuous reflections. During that week, I thought of nothing else; whatever else I did, my subconscious turned the threat on its head: was this the beginning of the end? Were we touching the previously ignored obstacle? The uncertainty was eating away at my life, preventing me from deciding, from acting. Waiting for the verdict, as usual, was worse than the sentence.

All this expectation was due to my desire not to operate W... for nothing, not to take it back too precipitately, without being quite sure that its receiver was well out of order and that it really had to be changed. Especially as the engineer, who continued to be certain that his electric assembly was without defect, hesitated to see employing uselessly one of the few receivers that we had in reserve and of which each copy was worth nevertheless more than one million old francs. I understood him.

Mac Leod, consulted, admitted both hypotheses. There was no argument that would allow him to think that either the engineer or I was right more surely than the other. He could not decide between us. He wanted to know how the W.'s receiver worked, to know the information that it was perhaps still sending to the electrodes, to estimate the value of this capacity that each electrode formed with the cochlear tissue. Then an intense and dramatic research continued, to understand what was happening, there, in the depths of the skull of my patient.

Proportionally, it was the same problem that Cape Canaveral engineers had to solve to detect the failure of an orbiting satellite. The same "distance" separated us from our receiver. How to interrogate it? How to force it to answer? How to play with the electric and magnetic fields? How to measure the impedance of each electrode by pricking, with local anaesthesia, each crimp under radioscopic control and with an insulated needle? How, in the same blind way, to try to fish the ground wire? What manipulations, all more eccentric, impractical and crazy, did we not discuss by phone during this long weekend!

Cruel winter! A cold and nasty rain, horribly wet, was pouring shamefully on the trees, the huge old oak at the back of the park, and the derisory elder trees, hopeless under their dead bark. To two faithful friends, present that Sunday, doctors too, I explained, by the corner of an uninteresting fire, this worried and often absent air that they had noticed since the day before, despite my efforts to be normal. I explained my dilemma, I told my certainties, why the engineer's assertions prevented me from acting according to my instinct, that is to say, to operate again immediately to change the receiver.

- But why are you still hesitating? If you think it's right, you're the boss. Go for it!

They were right. I was the one responsible, the only one responsible. My still great ignorance of electronics led me to show a probably exaggerated respect to its high priests and their opinions. A week's delay was enough. We had waited long enough.

On Monday morning, I told the engineer that I intended to change the receiver the next day. He recognized that it was necessary, that it was the only thing left to do. He took the plane the same evening, with, for this kind of electronic diving that we were going to do, all the material intended to test my electrodes during the operation, then his receiver, before changing it, so as to understand well what had happened.

It was a simple procedure, theoretically, since everything was under the skin of the skull, even the receptor, which was outcropping in its niche dug at the bottom of the mastoid bone. But what a job! For it was necessary to follow each electrode one by one, to dissect them all from the scar tissue in which they were embedded, without scratching or hurting the thin Teflon sheaths that insulated them. Eight hundred and twenty-five micron wires, as fragile as W's hearing... Imagine the dissection of eight silk threads in a concrete wall! What patience, not only for me - it's normal, it's my job - but for W... himself! He had to be operated with local anesthesia, so that, once he had reached the crimps of his electrodes, we could, by sending him an electric current, know if he could hear or not, know if his electrodes were good and his receiver was broken, that is to say, know if it was me who was right.

Thus, for two hours, we conversed with W... isolated under the operating fields, by means of large papers on which the surgeon wrote our encouragements and our explanations:

- Already three electrodes cleared. Five more to go... !

- It's long, but it works very well...

- As soon as all the electrodes have been tested, we will put you to sleep for the rest of the operation...

- Progress: only two electrodes left...

- Be careful! If you hear, you move your hand...

- You wave your hand as soon as you hear, even if it's a little bit...

The miracle happened... He could hear! Through the crimps, which had been detached from the receiver, I sent, with a sterile probe, the current that the engineer was giving me. And W... heard. That meant that his electrodes were good, and that this junk, this receiver was rotten! Good to put in the hole! I looked with immense anger at the filthy pile of silastic that he was forming there, shamelessly, well installed against the temporal muscle, stretching his useless wires. Because of him, we had been through a lot for eight days, for nothing, and W... had to be operated again!

My silent fury did not express itself aloud, so as not to aggravate the engineer's embarrassment, who felt responsible. And he was, just as much as I would have been if my electrodes had not worked. But, it should not be forgotten, he was also the one who had invented the system and, without him, we would still be waiting for the delivery of our utopian and fragile solenoids. I trusted him completely. He was going to find the cause of the breakdown and fix it. I respected his science and ingenuity as much as I did before.

He found the fault and remedied it. It was not the only one. We had, with other patients and a few months later, another incident, also of electronic origin, quite different, but just as unpredictable. However, I had much less difficulty, it seems to me today, to assume this new complication; because I knew that it did not call into question, as I had feared for eight days, the essential principle of this rehabilitation, of which an erroneous interpretation of the facts had almost made me doubt.

And then, time passed. In January, our three patients were still hearing, and the two deaf-mutes, who were continually wearing their braces, were beginning to make progress. W., of course, was further behind, but everything was going well. And I was told that the more time passed, the lower the risk of breakdown.

Then judging little by little the equipment satisfactory, in spite of its servitudes, I decided to propose it to those of my future patients who could buy it, while beginning, in the maze of the administrations which deal with the Public Health, a long way, intended to make our device supported by the Social Security.

This decision seemed premature to many. Of course, we had no hindsight. But what could happen? A late failure of the receiver, or of the transmitter? Theoretically, this risk was certain; but the technology could make it almost null. A progressive destruction of the sensitivity of the nerve? This was the great threat, brandished in the congresses by the detractors of the method, falsely cautious by principle, hypocritically wise, ignorant or jealous. Because with the hindsight we had, for more than three years with our first patients, we knew that electrodes placed in good conditions were still effective. Taking into account the observations made on the cochlear nerve of the animal - usually the guinea pig - following aggressions, notably mechanical, carried out in its vicinity, it was certain that such a period of three years in humans corresponded to a definitive integrity. Of course, a banal otitis could call everything into question. Of course, the ageing of the patient would undoubtedly alter the performance of the equipment in the long term. But these long-term reservations were not obstacles to a wide diffusion of an equipment whose prototypes gave us results already much superior to what the traditional prostheses brought.

True, the first deaf people who would be able to pay for the device would benefit from a less sophisticated system than they would have had if they had taken it two or four years later. But they would benefit now, in 1977, not in 1980 or 1981. This difference was critical for adolescents, whose education and behavior could be transformed at a critical time in their development and growth.

Moreover, the perfection of the technique required that it be applied to as many cases as possible. It is true that practice makes perfect. Already at the surgical level, the gesture was becoming more and more refined. But above all, the electronic improvement, and in particular the long-term reliability of the system, required financial support. This money was now refused by the research organizations, who argued that we had already achieved good results thanks to them. When we asked for subsidies for the implementation of other devices, they answered that their financing was now the responsibility of social organizations. This was normal. However, these organizations informed us that three cases, operated for only three months and of which, in practice, only two were significant, were completely insufficient for the decision to be taken, to generalize this method. This was logical and reasonable.

We were locked in. To break this vicious circle, to convince the administration, to force the confidence of the unbelievers, to find the self-financing essential to the improvement of the equipment, I needed to have many patients operated on. It was therefore necessary that the well-to-do patients decide to take the plunge, by paying for the equipment I was proposing to them. But they hesitated. And very few answered positively to this proposal, when I made it to them at the beginning of 1977. I understand them too, because I had few arguments to guarantee the quality of the results I was promising them.

It is here that television did us a great service. During a broadcast, which took place in March 1977, we were able to give an objective account of what we had achieved to these patients or undecided parents, while specifying our current limits, our reservations and our hopes. The serious and cautious atmosphere of these few minutes of air time convinced us, because we could see the essential, that is to say, in real life, in real images, the understanding of words, pronounced without the patient being able to read the face of his interlocutor. This information, because we felt its sincerity, had a certain impact.

Bertin wanted to have at least ten firm orders before starting the production of the first series of devices. At the beginning of March, before leaving for Buenos Aires, for the new International Congress of L.R.O., only three patients had decided. The television broadcast took place exactly on March 13. A month later, we had fifteen applications and had to warn the last applicants that they would have to wait for a second round, scheduled for September.

By bringing us convinced and reassured volunteers, decided to buy the machine, these five minutes of television allowed us to make a big step. We would certainly not be where we are now, if they had not taken place. And in spite of the small temporary enmities that they earned us in the medical world - some of which were very unpleasant - I would do it again, if I had to do it again.

However, I didn't quite understand the need to proceed in stages. The prototype seemed to us to be perfect, and nothing, except the color of the casing, was to change on the model that was built. So, why make these people wait and not manufacture fifteen devices right away, instead of this ten or so, the minimum number fixed by the manufacturer to decide to invest. But the industrial world explained to me that this was the rule. Because, from the experience that we were going to draw from these first patients, modifications would surely emerge, unsuspected at the moment, which would then seem indispensable and which could not be carried out if the chain was made for a greater number of devices. I bowed my head, but did not believe it, because everything seemed perfect. In my haste to convince my patients by bringing in a large number of patients as quickly as possible, I found it difficult to express this principled reservation to them. However, this precaution was wise, because the second generation of the following year was indeed different.

While setting up these first ten people, which took place during the summer, I undertook to fight in the administrative maquis of Public Health, to give our device the right to exist. And so I resumed, in the thickets of this ministry, a "crapahutage" similar to that carried out, two years earlier, in those of Industry and Research. It was an irritating game of goose, in which one was shuffled from box to box, from delay to reflection time, from commissions to sub-commissions, from regulatory texts to exceptional measures. There were enemies, opponents; those who, for very diverse reasons, were against and remained incredulous, despite my most convincing presentations. There were the neutrals, curious and benevolent, but who dared not commit themselves by leaning in our favor when a decision had to be made. And then there were the friends, few in number at the beginning, those who had seen our results. They helped us efficiently, guiding us to save time in the subtleties of the corridors, putting us on an already busy agenda, defending us at crucial moments of the discussions. From a few at the beginning, they became more numerous as time went by, consolidating our technique. Finally, there were those who liked me, trusted me and, for that reason, helped me without having seen or judged our efforts: they warmed my heart and were often very effective.

In the medical world, too, I had to fight the same battle against the skeptics and opponents. In the previous years, people had listened to the presentation of our first results, but without passion, because they did not lead to anything practical. Now, bringing this apparatus, exposing its advantages and the good that its users got from it, announcing that it was necessary from then on to generalize its application, we suspected a hostile reaction from some. This reaction grew as time went on and our results were confirmed without any setbacks. It came from all those who, with a little paranoia, I sometimes qualified as jealous. They were mostly dealers of classical devices defending their livelihood, managers of homes for deaf children worried about their future, or surgeons depressed at not having been able to invent the same technique. This growing hostility affected me, as it sometimes took unpleasant forms. But it also encouraged me: we were beginning to be taken seriously! If our equipment worried the supporters and the high priests of methods that had been very useful until then, but that we were largely supplanting, this proved that its advantages were beginning to be felt by many, doctors, parents, and reeducators. This opposition took on a thousand faces: unjust criticism, erroneous assertions, deliberate ignorance of the facts, even refusing to visit our patients, as was proposed. In the congresses, these great theatrical cenacles, every speaker must be an actor, and the tenors of otolaryngology all play an act, whether they are old authoritarian and wise bosses or peremptory young wolves. One day in September, the critics got carried away and took on a Homeric tone that is still talked about today; but they were so outraged that they sank into laughter. These undoubtedly did much more than our most learned publications.

And, little by little, all the competent masters in the specialty rallied to us. We were gradually winning, because time, confirming our hopes, erased the reserves.

The spring of '78 came, and with it our new devices, simpler, lighter, less cumbersome, more efficient - twelve channels instead of eight - easier to handle.

The engineers were right: we should not have frozen our achievement too quickly. Our first ten implants had taught us many things. Certain precautions, especially in the dynamic compressor, were superfluous; thanks to the progress made in only one year in circuit technology, the shaping of the signals could be entirely reconsidered, thus reducing the volume and weight of the transmitter box. Moreover, its handling became much easier. To adjust the level of each electrode, it was no longer necessary to unscrew the cover with difficulty, risking each time to lose one of the screws, dropped on the right or on the left: the casing opened easily on a table equipped with twelve sets of sliders, very simply moved to the desired volume. An adjustment knob allowed the user to take into account the intensity of the sound environment where he was. A directional microphone could be adapted to facilitate conversations with several interlocutors. Various gadgets appeared, the presence of which testified to the manufacturer's certainty of having gone beyond the stage of prototypes and development. Thus, the batteries could be carried separately, in the belt, which reduced the volume of the transmitter by a third: it became camouflageable under the armpit, like a revolver, if a discreet tie microphone was added. These batteries could even be removed for more than an hour, and replaced during this time by a simple pencil battery. The transmitter was capable of operating on its own, simply by drawing its power from the cigarette lighter of a car. Some of these small improvements seemed to me a little superfluous: they were the coquetry of engineers feeling their work was almost finished.

Moreover, the results obtained with our first twelve devices gave the manufacturer financial confidence. He started to consider miniaturization and mass production of the equipment. But these two steps would have to be taken simultaneously. Miniaturization was horribly expensive to put into shape: perhaps more than a million new people to design the electronic chips and their microscopic wiring. Such a high cost could only be amortized with a mass production, which we hoped would result in a lower price than the one of the machines manufactured one by one and by series of ten.

But there had to be an outlet for these cohorts of miniaturized devices. Even when lightened, the cost of the device would still be a major obstacle for most of those who could benefit from it. It was therefore necessary to have it covered by the social security system. This registration on the list of equipment giving the right to reimbursement to the socially insured was the indispensable endorsement for this rehabilitation technique for total deafness to become official, classic, and soon commonplace, and at the same time, to be perfected by following the progress of electronics and the improvements that each surgeon, who was going to be able to practise it, would not fail to bring to it little by little.

As soon as I got this registration, my task would be over. I could think about something else. Fortunately, the talks with the National Health Insurance Fund were going well. At our request, the Fund had granted us a loan to finance about ten devices, in order to evaluate the results obtained and to be able to decide on our application for registration. This official help was psychologically very precious: it meant that the responsible administration took our achievement into consideration. Its attribution was decided, largely, I think, thanks to the favorable opinion of one of the medical advisors at the national level, Dr. T..., who came to Saint-Antoine to see and hear some of our patients and to chat with them.

It was a beautiful session, where the future of our invention was undoubtedly at stake. It took place at the end of September 1977, during the French Congress of R.L.O. I had invited all those interested in this problem to come to the department to observe our results. Only about fifteen of them showed up, most of them foreigners. They filled the back of the room, standing up or sitting in groups on the armchairs, trying to keep silent so as not to disturb the demonstration that Dr. Fugain, our friend, a phoniatrician, was carrying out with each of my patients successively. Masking her face, she pronounced words chosen from the lists of vocables that had been worked on and learned. The deaf person, trembling in front of this areopagus, moved as if at an examination, would repeat them immediately or after having searched for a few moments, without error or with approximations which meant well the quality of his hearing. With each answer, or almost, a wave of astonishment would emanate, barely audible, from the choir of visibly impressed visitors, as each operated patient succeeded in the same performances with the same happiness.

My emotion was at its peak when, gradually, we were interrupted by the sound of louder and louder voices coming from the small room next door where all our patients were waiting, gathered together. They were chatting among themselves, like normal people. Their heckling was the best proof of their rehabilitation. They had to be silenced and, laughing at their unexpected and involuntary demonstration, they were sent to the hall to chatter. When, a little later, I accompanied Dr. T. to the exit of the department, he, in sharing his happy impression, could still see them, scattered in the corridor, their apparatus slung over their shoulders, chatting among themselves or with other consultants. Of course, no other prosthesis allowed this!

Whatever the imperfections were for the moment, progress was certain, and I thought that this would soon be achieved, one way or another. I still think so; I still hope so.

Finally, it was summer again, and the International Course that we had decided to organize in September '78 approached, in order to teach all the French and foreign surgeons who were interested in it, the details of a technique that now seemed to us sufficiently advanced to deserve to be disseminated and taught.

The adventure was coming to an end. The story of my desire to "get there" ends with success. That the world is interested in our technique means that it is viable. Others will make it grow, transform it, improve it. My efforts will be forgotten, and soon these results, which are so satisfying and which have asked so much of me, will seem derisory.

I rejoice for all those who will benefit. I did not work for fame or notoriety. It is for another reason; I don't know what it is; I can't define it yet. It is probably very simple, instinctive. Perhaps it has value only for me.

I am here. I am searching within myself. On the terrace, the guests stray, as if feeling the night with their faces, not daring to go beyond the area of light, respecting, without seeing me, the silence where I hide to search for why I did all this. I stir up my memories; a childhood image, a smell of leaves... To better understand this passionate impulse, this urgent need to win, I analyze my desires and my fears, I disturb the chronology of the facts. It is necessary to take again my anguish. Why did I have all this courage? To justify my choices, to explain my audacities, I have only my deaf-mutes, the uneasiness of seeing them, of hearing their bumpy voice, the harshness of their incomprehensible look, the bark of their rough and deaf silence, like that of these elder trees which sleep at the bottom of the moat.

CALCULATED RISKS: LUCIEN, MRS. AND THE OTHERS

In the eyes of others, I may have made mistakes. Several times, two or three at least, throughout these years, from 73 to 76 especially, in order to win, I made questionable decisions, forbidden bets, suffocating responsibilities.

We had to. This intense desire to succeed drew its strength, certainly, from the vanity of being the first to succeed, but above all from our progress, from these fragmentary successes amassed little by little. The desire to find, to prove, sometimes made me choose, no longer as a doctor, but as a warlord. I sacrificed to the general good, to that of discovering quickly, the particular interest of some. Because it was necessary to discover quickly. For all the deaf children, each year that passes without hearing is heavy with consequences. But it seems to me that I broke one of the rules of my medical morality, the one that subordinates everything to the good of the patient, the one that refuses euthanasia and eugenics - and all the rules that my uncle and grandfather, surgeons of the past, taught me throughout these stories that were sown in my childhood and that made me want to follow them.

From these few mistakes, from these two or three "faults", I am left with a latent guilt. It fades with time, in the wind of success. It comes back, burning, when I see again some of my first patients, who are still waiting for this sound world that I had promised them and that they have known only a few months.

In the night of September, near this moat, I will empty my scruples. Tonight, behind me, the music in the park of this castle, the candles, the speeches, these strangers who have come, everything proclaims to me that I no longer have to fear being wrong. I want to dissipate the latent anguish of this erroneous guilt, to get rid of it by telling it to myself; deep darkness on the grasses and the steps, humid smell of summer happiness, to justify myself because of this scent, of the ever-present shadow of these elder trees...

Let's go back in time. May 74: Neuilly, on the edge of the skyscrapers. That morning, the Palais des Congrès is surrounded by light, draped in brilliance: *IXth International Congress of Audiology.* We relate our first six cases. Less than a year after Venice, we bring the solution to the problem of frequency discrimination: complete deaf people hear, start to understand. The otorhinolaryngological world is astonished. Some incredulous people criticize. Others are amazed. The press, radio and television, fond of the spectacular, broadcast the discovery, explaining what remains to be done: to have the hindsight of time, to invent the device capable of eliminating the transcutaneous buttons, the multiple wires, the repeated bandages.

My morale is high. In front of the television, my patients have been "performing". They only have this big tabletop device, this big tinkering machine full of wires, which they use for the moment only a few hours a week; and yet their answers, the tests are already convincing. We make them work hard, to teach them to recognize sounds, words, sentences, so that they are ready to go before the D.G.R.S.T. commission which must give us the credits to build the portable device without a bandage. They know that, on the opinion of this commission, depends the manufacture of the device that they wait with confidence. They apply themselves. They encourage each other. It is for two or three weeks, undoubtedly... The D.G.R.S.T. is the General Delegation for Scientific and Technical Research. It includes various commissions, in charge of judging the validity, the interest of the research proposals which are submitted to it in all disciplines. The one on which our project depends is called: the Biological and Medical Engineering. The G.B.M. must meet at the beginning of June.

And then, shortly before this date, we learn that our application has not been retained for this session. There are too many files! It will be examined at the end of October. We have to wait. Discouraging: wait, and then? Certainly, the performance of our patients will undoubtedly be better. But how to maintain their enthusiasm?

Time passes. The habit is established of meeting them three times a week. The nurses now know how to do the dressings. The rehabilitation continues. October is coming. It is for Monday. Eight people I have hardly ever seen, scientists, doctors, two physicists, will come to see our patients and hear them answer questions, talk, repeat words, check that everything we have said is true, and decide if it is worthwhile to release credits to build this "gadget".

One after the other, they see my surgeries, discuss, observe and criticize. After their departure, we are confident: it will work! The impression was good, they told us. Their final answer will be given in eight days. Phew! It was about time. Because the Teflon buttons of most of our patients - my God, that term is appropriate in these circumstances! - have started to move in the last few weeks. The collar of skin that surrounds them is widening, becoming red and oozing. In some cases, we can see, in the depth, the white plate where the electrodes are fixed: already, some of them have broken, or have been removed from their attachment to the button, and are no longer usable. I foresee that, in a few weeks, we will be obliged to remove these external power outlets, to close the skin on the electrodes buried deep down, also sinking the implanted ear back into silence, and then to wait for the construction of the device to definitively give back to our patients the hearing they have just recovered. But who cares about these troubles, if everything works out!

Eight days... nothing. I ask around, I call: they don't want to tell me anything. The decision is not made yet. They will let me know. After three weeks, I insisted again and, finally, I was told that there was no more money for this year, that I had to wait until next March. The commission will meet again and will summon other scholars, experts in this field, to hear their opinions - because it is difficult, isn't it, to make such an important decision!

Catastrophe: in one month, there will be no more of my patients who are presentable, that is to say demonstrative. It will be a failure, because my explanations will not convince anyone; the dripping discomfiture is there, humiliating for me, certainly, but above all very sad, simply despairing for my six victims, these patients, semi-voluntary guinea pigs that I have been carrying at arm's length for a year towards a hope, so close at the beginning that, to see it probably fade away definitively, I collapse internally for a few hours, for a few moments...

The only way out is to win. The only way not to disappoint the expectations of my six patients, is to be able to convince the members of the commission, that is to say to be ready, in a few months, to show them total deaf people who hear well, who understand a little. It is therefore necessary to implant other deaf people, "new" ones, who will be very "beautiful", very "presentable", for the spring. The others? I will explain to them that it will work, but that it is necessary to wait for the administrative delays; it is long, but it is certain: we will succeed!

That is why I continued to operate, knowing that the results obtained would only be temporary. I had just learned how slow the workings of public and private organizations are. I felt that after this delay there would be others. This is probably where I lied by omission to my patients: I did not tell them that after hearing for six months or a year, they might become deaf again for an unpredictable time. I did not tell them that I needed them to save the first ones.

I had to repeat this human sacrifice three times. Because, from commission to control, from semester to year, until October '75, we had to convince the directions, the offices, the experts. Time passed. We succeeded. We won. But they remained about twenty, who heard for a year or sometimes two, then returned to their silence. And now they are waiting. They are still waiting, because the equipment that they saw arriving as they passed in the corridors, carried in a sling by the first ones who, little by little, benefited from it, was not for them, and will not be until the Social Security has accepted to pay for it, unless they can pay for it themselves.

Recently, I sacrificed the interest of my first patients to the success of the adventure. It is not yet to them that I am sending the ten devices that the National Health Insurance Fund has just granted us, to find out if, in view of the results obtained, the technique and the equipment are really reliable enough to be included in the list of benefits available to the insured. This is a very important test, which must be passed without risk. As soon as it is reimbursed, the device can be widely used, especially in France, and even abroad. And, as we have seen, sure to have large outlets, the industrialists will be able to invest what is necessary in order to miniaturize this portable transmitter, still very cumbersome. From these ten free devices, it would have been normal to let my veterans, my deserving patients, who had the right to be the first to benefit from the generosity of the social organizations, benefit. But inserting a receiver on these long-buried electrodes poses difficult problems - I measured it on two of them, who were able to finance their device themselves. The scarred skin is fragile; the electrodes may not all be recovered intact in a difficult dissection, or one or two of them may be broken, and the whole set may be reduced to only four or five connected electrodes. Random results sometimes requiring one or two preparatory skinning times.

It was not necessary to offer this spectacle to the censors of the administration. The ten cases proposed had to be, this time again, new patients, without any special problem, in order to demonstrate the reliability and the quality of the development we had achieved. Only then could I repair the damage suffered, by fitting my fifteen or so "veterans" who were still in demand. But these will be difficult interventions.

Mrs. A.'s face painfully appears on the list of these victims. Deaf-mute from birth, she was twenty-six years old and worked as a typist's assistant in a ministry. Frail, slim, intelligent, she had difficulty coping with her infirmity, which she masked as best she could by incessant efforts with her large black eyes to read the lips of those around her, speaking as little as possible to mask her malformed voice. She had married a tall boy with a good, shy, affectionate smile, who was very affectionate towards her; she returned the favor, helping him as best she could: he was almost blind. (Christ, in his Gospel, did not invent anything; his parable is often played out in handicapped households.)) The husband was also in the civil service: he was a clerk in a General Directorate - but he had tenure.

Mrs. A.'s desire was to be granted tenure as well. But her deafness was a major obstacle. She explained this to me in the weeks before I decided to operate on her. Because this decision was not easy to make. It was a delicate problem, with multiple data. First of all, Mrs. A. was not, surgically, an excellent case: one of her ears, following a childhood otitis, had no eardrum. I feared, at this level - the continuation confirmed my fears - delays or defects of cicatrization. Of his two deaf ears, it would have been necessary, theoretically, to operate on the one whose normal anatomy allowed me to hope for worry-free consequences. But, whatever the quality of the results we were already obtaining, I was always afraid, in this avant-garde surgery, of mortgaging the future. My technique would undoubtedly improve; I was not yet sure enough of it not to reserve, on principle, the best ear for possible future procedures, simpler and more efficient.

It was thus necessary for me to leave with the handicap of this tympanic destruction and the risk to see the old infection reawakening, which I always feared, in spite of the denial that my old Mrs. F. had provided me. Moreover, if the tenure of Mrs. A... was the reason of her desire to be operated, no commitment, of course, had been taken by the administration in case she would recover some hearing. I was therefore in danger of disappointing her. It seemed to me, however, that her re-education would be effective: astute, lively, she was demanding, and would certainly not spare her efforts. Finally, I needed her: to convince the members of all these commissions on which our indispensable credits depended, I was looking for good cases.

I operated on her in April. In June, without lip-reading, she was able to recognize eighty percent of the words in a list of thirty words learned by heart! Her voice was changing. She was making amazing progress. She had now, with her elegant wig of a young surgeon, a smile and an assurance that I had never known. She went back to work in September, with her bandages and her big brace. At first, she stopped it when she was typing. Then, she used it all day long, because, very quickly, she could distinguish, among the typing noises, the sentences that one could address to her behind her back. She got used to the machine despite the clutter.

At the time of the demonstration that we were asked to do again in the fall, she was one of our best cases, and I did everything I could to hasten her long-awaited tenure. This was obtained in extremis, at the end of the year. In extremis, because the transcutaneous buttons were moving and suppurating more and more, and in February, she had to be re-hospitalized to remove them and try to protect the electrodes. But the infection started again, necrosing the scar: three times I had to intervene to perform skin plasties and grafts, which finally healed her, but leaving her without hair in an area of the skull behind the ear.

She's waiting now. I see her regularly, every two or three months. Maybe hair transplants will fill in this partial baldness. But first, as soon as it is covered by the Social Security, I would like to put her receiver on, so that she can hear again, to find in her eyes, in her husband's white eyes, the quiet joy that I had read in them during ten months.

I made all these decisions with an aftertaste of a guilty conscience, accepting the risk that it would become remorse if I failed. And I won. But how lucky I was! In retrospect, I am scared to my core. Where would I be now, if everything had gone wrong?

My decisions in the case of the child Lucien H... are also questionable, as criticizable. The intermittent waves of remorse with which I was assailed, at the time of the least of the incidents which enamelled the continuations of his implantation, punished me well strong to have applied these decisions, erasing then completely the serene peace which gives me in addition the certainty to have been right with him, and to be winning on the whole of the chart.

Lucien is a nine-year-old deaf-mute. He has a beautiful blond child's head with large hair in waves on the forehead, but a look of frightened fawn, almost sly so much he is worried. He does not know how to speak, can only articulate borborygms that only his parents know how to interpret. He does not hear anything. His right ear has some vague remains, which we have rightly tried to fit. Thanks to this, for the last five years, we have been trying to re-educate him in a specialized home for deaf children, to teach him to speak, read and write. I have known him for three years. I tested the other ear: it responds. We could implant it.

In May 1977, his parents learned that the device I had been promising them for months and months was finally ready. They came back to see me and asked me to operate on him. I was a little hesitant: I had never operated on such a young child. But the circumstances are favorable: the family environment is good. The chances are excellent to obtain good results. And then you have to start. So, I accept, but I specify that, after the implantation, Lucien will have to be put in a school of hearing children: it is essential, so that, throughout all the days, he hears normal speech and learns to understand French, and not the gurgling noises of his current companions of misery. The beginning of August was therefore chosen as the date for the operation, so that he could have a real vacation and then time to start his rehabilitation. But the decision is subordinated to the acceptance of Lucien to enter an ordinary school: his mother will manage and is strong to achieve it.

Things get complicated, because the director of the specialized institute where Lucien had been going until then violently contests the decision to operate. He believes that the technique is not up to date. Although he is obviously not aware of the results we have already achieved, financial considerations are probably not unrelated to his attitude; they have, at least unconsciously, guided his approach. He runs a private school for deaf children, and he also sells conventional devices. It is obvious that, if our re-education process proves its efficiency, he will sell fewer devices and will soon have no more students. In a few months, we will find this opposition from certain groups; but this will comfort me: being judged dangerous by them, we will see the sign that people are beginning to believe in our effectiveness. However, that day, the disagreement of this director makes me hesitate, leaving me fearing his sarcasm and the campaign of denigration that he would not fail to trigger if we had some problems with Lucien.

And why shouldn't we have one? Apart from the three prototypes, I have not yet operated anyone else. As a matter of principle, as in any enterprise exploring unknown areas, we must logically still have surprises, difficulties, which we cannot foresee. If we could define them, we would guard against them, to know the remedy before they occur. I can live with this reserve in principle in my relationship with my patients, because they know that they are among the first, the pioneers. But this reserve becomes unacceptable if criticism is to sanction each hazard. We must not take such a risk: it would be suicidal for the patients, for our team and for the technique that we want to develop.

However, Lucien's case seemed ideal to me. There was no danger in implanting him. The technique was perfect: our first three patients were there to testify to that. The only risk, very unlikely, was a new failure. Of course, we no longer had any reason to fear it. In any case, the penalty would be, after a few weeks or months of hearing, only the disappointment of a *transitory* return to silence. Some people might find it preferable to wait a year or two until the method is even more secure, even more confirmed, to reduce the probability of unpredictable hazards to zero. But, in two years, Lucien's intellectual delay would be much more noticeable than it is now. In my opinion, it was much better, since now everything seemed to be in order, to make him hear as soon as possible and try to give him the means to become a normal adult.

But, of course, as a matter of principle, one should not increase the possible difficulties of the company by accepting that they be magnified and distorted. We had to go for it, that was obvious in Lucien's case, but in the best possible conditions. This consideration of the company's psychological environment was also essential.

Nevertheless, by implanting this child, I hoped to obtain successes that seemed very valuable to me. I was counting on them a lot. I sensed all the benefits that Lucien would get from it and I knew how much weight it would carry in helping us to have our method accepted and to help other deaf-mute children. This argument finally got the better of my hesitation. But a vague guilt remained for some time, because I felt that this decision had been taken, not only for the good of my little patient and his fellow men, but above all to prove the effectiveness of our technique.

- You've got a nerve! Professor Pialoux, one of my older teachers, would sometimes say to me when I told him about my projects or our successes.

I had once been his student and assistant. He supported our efforts from the beginning, and often helped and defended me against criticism or attacks. But he also frequently urged me to be careful. And he was right. Because to be "inflated" is unforgivable: it becomes imprudence, unconsciousness, the aftermath of which is nothing but the desire to flee, to melt, to not have dared, to not exist anymore.

This failure, the brutal failure, the one that, in an instant, calls everything into question, I met it twice and, always, it was due to a failure of the electronics, that is to say to the unforeseen meeting of the inconceivable breakdown, that one thus learned to know and to prevent. Only, of these breakdowns, the first one, that of W... has dented my confidence; because, for a few hours, I had considered believing that it was the ear, the nerve which was out of order. The other problems we encountered exasperated me, made me rant intensely, but without reaching the bottom of my faith.

It is a feeling quite different from the fear of failure that invaded me, when I felt the threat of the "incident of course" hovering over Lucien. For him, I suddenly felt a real guilt for not having known how to wait, for having wanted to go too fast. Imprudence, burnt steps, haste, what did I not reproach myself for... And then, what grievances would the detractors of the method, informed by the bitter sarcasms of the director of the school of re-education, not burden us with, thus ruining all the progress we had made for a few months in the medical world, in the administrative circles of Health, in the public opinion?

Because, there, I had taken the risk of operating on a child. All the criticisms were going to come from this audacity: daring to intervene on a child, a tender, fragile thing! But is this delicate thing really more delicate than an adult? Isn't failure psychologically harder to accept in a grown-up, who understands what is happening to him, than in a nine year old, who suffers his misadventure day by day? In the eyes of others, in the eyes of this part of my conscience that I have thus mistreated, the therapeutic trial on a child is condemnable. Even if, precisely, the issue could only be proven in a child. Because I wanted to demonstrate the psychological, scholastic and affective improvement brought to this age by this implantation. However, I felt that I could be rightly reproached for this trial if it failed. Because I did not have enough distance, not enough experience to attack the children. To "attack" me! All the reprobation in the world is in this term. With Lucien, I thought for a few days that I had met this failure. In the interest of the method, to prove its effectiveness, I had taken the calculated risk. A sort of double or nothing.

Even if no one ever reproached me for it, because, afterwards, we won, it was a questionable risk. My God, how I suffered from it, a few weeks later, how I hurt, how I cried out internally when I was alone, during those few days when I thought I had lost the bet in a ridiculous way, once again because of the electronics! However, this risk, the burn of which I measured, I would undoubtedly take again, because all that it brought us was extremely precious, because, thanks to it, we gained several years for other children.

This means that, thanks to what this implantation has proven in this boy, we can now offer it, without waiting another five or ten years, to others, who will thus benefit from it earlier, before their intelligence has progressively frozen in the sclerosing silence in which it has languished since birth.

This is how it happened. In late June, early July, we implanted three patients. I say "we" because I feel that way. In fact, I was the only one operating at the time, so I was the only one responsible. But it was really a team effort, where everyone, instrumentalists, dressers, interns, nurses felt concerned, dedicated, supported me by helping me in a very active, responsible and forward-looking way.

In August, three operations were planned, including Lucien's - one every Wednesday. Then, at the end of September, it would be the turn of the last of this first series of ten operations.

I'm going on vacation for a while at the end of July. My first patients were doing well. They were out of the hospital and starting their rehabilitation. The sun, for me, the sea, it was good. I returned. I implanted Lucien first. Everything goes well. The next day, he hears. The joy bubbles in the heart of all. His room is beautiful to visit, full of decibels and flowers. I am happy.

Four days later, a phone call from the parents of one of our patients from the previous month, Didier S... : his device is out of order ! Didier is a tall young man of 18 years old, deaf and dumb from birth, well rehabilitated, very intelligent. He has just passed his baccalaureate, and, since his intervention, in three weeks, with his new device, he has made great strides, already recognizes words and syllables. This is an excellent result, full of promise.

But that day, nothing matters anymore: Didier was out of order! A big spontaneous noise, the day before, brutal and ephemeral, a bit like for W... a year before; a few rhythmic cracks, then nothing more: silence. His parents tried everything. They recharged the batteries of the device, of course, changed the wire of the antenna, waited twenty-four hours; nothing did it. That's why they call me.

I ask them to come immediately. I test the external equipment: on the oscilloscope, we see it immediately, the emission is good. The failure comes from the implanted receiver. But why did it stop working? Is it the same incident as this winter: it is theoretically impossible. So, what is it? In any case, it will surely have to be changed. I warn Didier and his family of this possibility, but tell them that, before taking the decision, I need the engineer's opinion: "I will phone you tomorrow or Wednesday, to tell you what to do.

They leave. I stay a few moments appalled, my legs wobbling: what is this story that starts again? Then, I pick up my telephone and, masking my anguish, laconically, I explain things to the engineer, detail the cracking, the shape of the unusual and terminal noise, the tests, the size and the voltage, on the oscillator, of the image born in the transmitter. The similarity of this failure with that of W... is striking. However, on the new receivers, this incident has become impossible. The engineer thinks. Long silences separate his questions, brief, precise, emitted in low voices. Time passes; finally, it appears quite obvious that it is there still the receiver which is in cause; it will undoubtedly be necessary to change it. But, as a matter of principle, he asks me for a few hours of reflection and we hang up, saying "see you tomorrow".

The next day, he calls me back: the receiver must be removed. But he thinks it is wiser not to replace it immediately, before having defined and remedied this new incident, and then built another receiver, which will be modified according to these findings. But I know how long it takes to innovate, verify and then build: it will surely take several weeks, maybe two months. However, to make the standard exchange, in one time, of the defective device would mean to put in place the same receiver as the one which fell into defect, with, therefore, the same risk to see it stop in its turn. The engineer recommends two interventions: the first, to remove the receiver; the second, a few weeks later, to implant another device born from a new and improved generation, which will benefit from the lessons learned from this second failure and will therefore be protected from a recurrence.

I understand him. His reasoning is logical. But I hesitate to leave Didier in silence, while in the cupboards of the operating room, there are still eight sterile receivers waiting and could make him hear again. What a disappointment he will be! And that of those around him! And what a slap in the face for our method, which I was convinced was practically perfected! According to the engineer, we should wait until we have found out what is going on, admit that we don't understand anything, confess our uncertainty, whereas a few hours before, we were sure of ourselves. An understandable attitude, normal for a technician. But he was unaware of the psychological consequences and did not know the disadvantages of letting Didier go deaf again for several weeks, even several months. And what did I risk to make this standard exchange, whose illogicality put him off? After all, the receivers of our three other operated ones of the previous year were working well! Why was this failure bound to happen again? By immediately replacing the defective receiver, I could perhaps avoid the third intervention, which would finally be necessary, in order to give Didier a modified and improved device, only if this second receiver also broke down.

I explained this to the engineer and convinced him easily. But I did not speak to him about Lucien, whom I had just operated on four days earlier. It was he himself who, during the day, thought about it, and called me back to tell me that it was necessary to stop the other implantations, to cancel everything, not to plan anything before the responsible defect had been defined and compensated.

For Lucien, it was too late. I alerted the two other future patients, scheduled for the next day and the following week. I cancelled them, using as an excuse a delay in the delivery of the receivers, mentioning the vacations, the factory closed in August, in order not to give a precise date to their new operative appointment, to gain time, to know, to find a way to overcome this new incident. I did not tell them the real reason for the postponement: it would have been to accept for our method the label of "experimental" that many of its detractors wanted to give it in order to better stifle it. It would have been to give reason to the critics, to give way to the "I told you so, that it was not perfect", to incite to reflect and to retract the future patients, those few volunteers who were impatiently waiting for their turn. That is why, without really lying, I did not tell them the truth. All the more so as it was not even sure that the engineers, by dissecting under the microscope the hundred or so miniatures contained in the damaged receiver, would surely find an answer and a remedy to the breakdown. The causes of the failure, perhaps, would never be known. A component could have snapped like that, without being able to do anything about it. This was the whole problem of the reliability of the implanted elements, which we thought we had solved by making the device "run" for long hours, before sterilizing it, then implanting it.

But Lucien was operated on. Lucien could hear. Lucien was perhaps in danger of breaking down in his turn, that is to say of falling back into silence, of not being able to enter this school of normal children which awaited him at the beginning of the school year. It was, for his parents, the obligation to find with great difficulty an establishment of deaf children, different from the one he had just left; it was surely to disturb his meager and difficult schooling.

Like a heavy cloak, this fear enveloped me, weighed on me during the days that followed. It was necessary to know as soon as possible the nature of the breakdown which stopped Didier. I operated him, the following Monday, to change his receiver - exhausting work of ant, that I knew to have practised it at W..., grueling uncertain tension, which, however, oh reward after so much evil, allowed him, the same evening, to hear again at leisure. And I thought, while crimping these wires and these teflon sheaths, in front of these curved metallic loops, shining on the golden red of the fabrics revealed to the day of the scialytic, that, perhaps, in a few days, the same work would be imposed to me on the young flayed skull of Lucien.

Four days later, we learned the cause of the breakdown. It was just as unpredictable as the first one, but quite different. Like Columbus's egg, it now seemed very simple to avoid. The spare receivers could be easily modified; we could implant them safely when we returned to school. Moreover, it was not impossible that this incident would occur in all the receivers already implanted - and the more time passed, the less likely it was to happen.

Then the suspense set in. Lucien was doing very well. He was getting used to his device. He was interested in the noises, the sounds, the words. He began to understand a little; he repeated sentences; his voice, already, was not the same. Time passed. For our electronics technicians, the risk of circuit failure, maximum around the fourth week, decreased rapidly afterwards.

So I was waiting, anxiously, but without saying it, for this anniversary for Didier and Lucien. I often thought about it. The failure of Didier's second receiver would have been painful for him; however I would have assumed it. But what would happen if Lucien broke down in his turn, especially since, in the meantime, his parents had learned that Didier had to be operated on again? After all, it was not certain. Two other receivers had already been running for two months, without counting the first three prototypes, mounted in the same way and which had been working for almost a year. So why Lucien's? I dismissed this possibility. My optimism was fed by the child's performance, whose progress made me happy to have operated on him.

However, I took this fear with me when I took a fortnight's vacation, at that moment at the end of August when the dazzling sunsets are already veiled by the clouds of September. I walked there my latent anxiety, in the middle of the port, among the sails, the pines - subtle anxiety, often invisible, but distilled wave on wave of my guilty subconscious, and against which, sometimes, lying on the sand, eyes closed to the world, I reacted consciously, analyzing the reasons, taking back the terms of my choices, of my decisions, reassuring me by repeating to me the weak risks to lose, that is to say to learn a failure of Lucien. I kept telling myself the advantages that doubled these risks. If everything went well for him, he would make great progress at school; his relationship with his family and his entourage would be transformed. If I had waited a year or two to have more perspective, I would have operated on him only at the age of twelve, already older, more sclerotic in his silence. What he gained by hearing now was surely worth the risk of perhaps being operated on again in the weeks to come.

Yet my fears could not disappear. This insurmountable fear gave me a kind of absence, of retreat, which made me measure my rest without being able to taste it completely. Without enjoying anything, everything was lived through the hard transparency of this fine anguish, which isolated me from the joyful world of laughter and friends.

Tuesday, September 6. Phone call that morning, around 10 o'clock, in the waking white house. It is for me. It is Dr. Fugain. His voice is not the same: usually cheerful and warm, it is flat, white, as if to mask the anxiety and disappointment that inhabit it. The child Lucien broke down last night. Suddenly, like that. I question, I look for clues, for details. There is nothing.

Immediately, I mask both my anguish and especially my ignorance. I decide in myself, and in an instant, to make believe that the wire of the antenna is broken: easy, there is only to go to the hospital to look for another one and change it. I am precise, peremptory, methodical, therefore reassuring. Thanks to what I invent, thanks to what is surely a lie, I will be able to play easily the calm, and thus to contain these cumulus of Parisian panics, piled up in a few hours on the entourage of the child; the panic would go, if I did not bend, to ravage all in the heads of the parents, of Lucien undoubtedly, then of the others, of those who will know... to know that Lucien is broken down too, that I do not know what occurs! First hide my anxiety, hide it at all costs to appease theirs. Then we'll see.

Immediately, over there, everything calms down. The wave of anguish ebbs. In the sound mesh of the telephone, the tension gives way with warmth, I recognize it with the clear sound of the reassured voices. All is arranged. Paris breathes: there is no more problem. I can feel that they all regret having been so worried since the day before: they apologize. I answer that they "did the right thing", that "that's why I'm here". We hang up; they are calm; I am white...

White ! Grey... Informed, the gestures, the sea; denatured, the sky, the trunk of the palm tree, the whiteness of the walls, the fog of the conversations, the inanity of the desires suddenly without life, cold of inattention the sun, desperate the habits that one exhausts oneself to pursue, to mask the inexpressible, the collapse. One questions me, because, in spite of my efforts, my disarray is undoubtedly seen. I reassure with the same lie, and I find myself alone.

I don't want to say again everything I thought during that time. I was in too much pain. And then, I have already said or implied it. I was filled with remorse, appalled at having dared, at having made a mistake, at having believed that the worst was not certain, at having tempted the devil with this child. I tried to reason, to plan a fallback strategy. But the uncertainty, the incomprehension of the facts, their imprecision born of these thousand kilometers which separated me from it, wove in spite of me an inextricable veil where my hypotheses got stuck. Impossible to reassure myself in the action. I had to wait without knowing. For there was no question, as I was burning with the desire, of taking the first plane to Paris: this senseless gesture, by testifying to my anxiety, would have communicated it to all those I had to preserve, all those whose confidence I had to safeguard above all, that is to say, the joy of living. And it would have been useless, since our new receivers would not be available before the end of September. No, I had to stay, do my duty, that is to say, take a rest, be normal...

But the light is no longer the same. A filter of anxiety extinguishes the air. Time wears out in false pretenses, in efforts to smile, when anguish intoxicates me, long inappetence taking away all flavour from the day, or wakes me up suddenly in a burst of evidence where I explain my wrongs to the moon, whose severe face looks at me through the window of my room.

This shredding pain became less acute during the few days of idleness that I still had to endure. One gets used to everything, even to failure, whose unexpected emergence often came back, at the turn of a sentence, a smell, an idea, violently impregnating me with fear and shame. I was haunted by the idea of not being able to do anything before September, haunted by the idea of a generalized failure in all my patients, the irreparable failure, the failure of the whole technique, the great fiasco. I didn't even want to call Dr. Fugain to find out. In spite of my sadness, I felt that it was essential for me, as a last resort, to keep up appearances, to save face, not to show him my concern, nor even the importance that this possible breakdown could have for me. Yes, Dr. Fugain had to believe, too, that changing the receiver was nothing at all, that everything was reliable, that there were no problems, only small ones. It was therefore impossible for me to call her.

In these crises of despair maintained by inaction, I was ready to admit everything, to give up everything to find calm again, to stop being harassed in the immediate, tarabusted in the daily life, martyred in my most intimate affective. Mediocre days, days of sometimes intense disgust, but crossed by dots of boredom, where all the pleasures of vacations were false, curdled, and really existed, took their true value only later, retrospectively, when I knew that Lucien was not out of order, had never been.

The antenna wire was well broken, as I had invented it to protect us all. All I had to do was change it. It was so obvious that my team had not seen fit to warn me (after all, hadn't I myself said the reason for the breakdown?) when, two hours after having phoned me, we could see that Lucien could hear well, that the fears had been vain.

I had paid for my boldness, my desire to succeed quickly, with six days of mini-calvary. Because, always, the urgency to make all these children hear, locked up in their infirmity, was on my heels. For them and for all the other deaf people, I had dared to take a certain risk, even if it meant suffering the consequences. And, for the peace of mind of those who trusted me, in order not to transmit my anguish to them, I had condemned myself not to be delivered from it. This is how it is. Before all the choices that life forces me to make, I always measure the possibility of failure; when it is acceptable, I assume it entirely, once the decision is made. But when, by chance, failure occurs, God, it is hard to live with!

Life is weird. Didier's second receiver always worked well. But, at the end of September, Lucien finally broke down, around the thirty-fifth day of the operation, within the expected time. For his family, it was a drama for three days. For me, I had already traveled the path of this ephemeral despair. Our new receivers were ready. I operated on him right away. He entered his new school just a week late and was immediately comfortable there. He could already read and write a little; but when, around Christmas, his mother told me that he was doing dictations and learning the concordance of tenses, I was happy: under the pretext of avoiding this transitory and calculated risk that we had taken for him, should we have closed the road to such progress to this child?

RED AND GOLD

I love to operate. I have always loved operating. The satisfaction I get from it is as intense as the one I have always found in relieving or curing my patients. But the reason is probably different. What is the surgeon's love for the gestures he performs? Perhaps it is because he performs one of the last crafts, that is to say, a craft whose purpose is to carry out, with human hands alone, a well-defined work, with an end and a beginning, and through which perfection is sought, as did our ancestors, the master builders of the Middle Ages.

The pleasure I took in the operating room played an important role in these years of struggle; it rewarded me for having to find the courage to relearn, to search, to retrain myself in a way that was so often demanding and tedious. The joys I had in surgically applying the fruits of this work paid me well in return. The atmosphere in the operating room is so extraordinary... Thinking about it from afar, tonight, I dream a little...

At the bottom of a red cirque, bordered in the distance by steep and crevice-like cliffs, we both advance cautiously, but quickly. We know this part of the route well. It is the one that most of the people who come here to "do" one or another of the summits that can be seen not far away - a dangerous route if we are not careful, but without pitfalls, because everything is known: the smallest ridge, the most remote valley, the risks of overheating or the direction of the water.

With great care, Gauche, my faithful helper, lends me a hand. In this preliminary approach, which makes us cross immense valleys where the road is easily cut, polishing the turns with care, advancing meticulously in the dangerous defiles, always ready to prevent and catch the slightest misstep, Gauche clears the road around me, while, perched in unsteady balance on my cutter, I cut the way, cutting down large sections, evacuated downwards under cascades of water immediately sucked. The mountain discovers itself, the reliefs define themselves. Scraping the hard ground in front of me, I insinuate myself under the thick coat that covers it, pushing back with my back, my hand, my head, the soft fabric that doubles it in depth. I lean on my rugine, gently releasing here and there a tense bridle, without tearing it off, while Gauche, supporting with his vacuum cleaner the weight of the carpet that he raises, leaning, not to damage it, on a big wet cotton, lends me a hand, encourages me, often guides me.

Because, from where he is, he sees better than I do, sometimes, what is happening where I am. In the enormous din of my drill bit, which spins at twenty or thirty thousand revolutions, in the noise of the suction and the water that runs off, Gauche works with astonishing discretion and efficiency. He does everything to avoid being noticed. Once or twice, when I ask him to do something he is not used to doing, the careful slowing down of his pace reminds me that there are two of us working. But what a wonderful helper! He guesses my every intention. I don't have to give him any orders. It's almost as if he knows before I do what I'm going to do. Thus, these debris piled up by my milling machine and which obstruct my sight, hop! it aspires them even before I could formulate in me their presence. From each swirl of the permanent waterfall on which we advance, he takes advantage to make me see the ground better, wetting the points of my diamond head, using the enlarging reflection of several drops piled up on my spade, while protecting with his vacuum cleaner the dangerous zones, when, with my drill, I approach them. I really couldn't do anything without him. But the water suddenly dries up... I stop for a moment...

Taking my eyes off the microscope, I find myself in the operating room. We change the bottle of serum. The flow resumes. For a second I see my entire environment: the light blue tiled walls of the room in the half-light; the distant presence of the anesthesiologists, working on their own and seemingly ignoring me; the silent, but motherly and efficient dresser; the closer silhouettes of my aides; their hands acting on the great undulations of the green fields stretched everywhere around me, dark meadows whose folds converge towards this quarry dug in the skull, repressed skin bordered by red fields, spread muscles, auricle, annoying importunity, pulled down, pushed forward. And then my two hands to me, posed on both sides of this luminous spot of the microscope revealing in the depth of the ear the universe from which I emerge.

My left hand, my faithful companion without a face, is now reduced to a few gloved fingers. My right hand, my self delegated to the unbound index finger, to the strength of the thumb, schizophrenia digitized to the point of an instrument that I clasp...

When I operate under the microscope, I am no more than the head or the cutting edge of the instrument that I hold in my right hand. I am nothing more than the rounded or serrated edge of the bur, the back of a rugine, the tip of a lancet-shaped scalpel. I struggle, fully involved, caught between this bony wall through which the nerve passes and the fragile skin of the ear canal, so carefully peeled away - for the thinnest of tears, and that is the risk of further infection, that is, of complications and problems. My kidneys, my back, my legs, which are sometimes embraced by aches and pains, no longer exist or are only distant acolytes, which are sometimes used to operate a pedal or relieve an effort. "Gauche", my left hand, is my closest, most considerate helper. I don't need to talk to him to tell him what to do: he often guesses even before I think of it, and sometimes I really feel like we are working together.

It is the microscope that is responsible for this projection, this miniaturization of myself. With the "micro", one sees nothing but the tip of one's instruments. Then, one forgets the rest. One lives only what one sees. In a neck, a face, when one removes a larynx or rectifies a nose, one sees one's fingers, the hand of one's assistant. We exist in relation to the gesture to be accomplished.

When I start these implantations, it is first of all a normal fight with the naked eye. I can see myself in my entirety, facing my adversary, that is to say, facing my difficulties: the exact shape of the skin incision, the dissection of the temporal artery, the detachment of the skin and muscles, a thousand other small problems, light enemies, none of which frightens me, but all of which hold the attention of my gloved gestures, armed with clearly visible compresses, instruments of recognizable proportions. My intern, who spreads, pinches, collects or sponges, shows me his fingers, his hand, and his presence is so obvious that we don't even need to talk.

But as soon as I pick up the microscope, everything changes. Its rubber-coated eyepieces - so as not to damage my glasses - are like a diving mask. The underwater illusion, brilliant, luminous, is reinforced by this permanent water, irrigating the progressive drilling of the bone to avoid its heating. Then everything becomes different. But the apprehension of reality is not a dream. Everything is terribly concrete: this fragile dome, in this patient who entrusted himself to my hands, is the one of vertigo; this sleeping dynosaurus, is the anvil with the other ossicles; this path, invented without seeing it in the bony wall which blocks my way, is the facial nerve. This transfer has therefore nothing dreamlike. It is only a means, an involuntary artifice, which confers to my gesture all my energy, my knowledge, and can thus give it orders, or counter-orders, whose field is sometimes only of a few tens of thousandths of a millimeter.

I return to my climbing, to my speleological expedition. My mocking lyricism would have me sing these abysmal dives to the inner ear... Rescue mission! Some auditory fibers are still alive, buried under the rubble of this total deafness. They responded weakly, a few months ago, to electrical signals, distant calls that we sent them during the diagnostic test. We must save them, deliver them, connect them to the open air with our electrodes. Mission of clearing in the middle of the irrecoverable ruins of this auditory collapse: tympanum become unusual, ossicles without object that we eliminate, walls that we remove with great blows of gouge, because they obstruct our approach and are useless...

But all this easy symbolism does not exist when one operates; it is only experienced when, thinking retrospectively of this work of approach so often repeated, I line up words to evoke it, to remind myself, not to forget all these efforts and their intense joy. Operating is difficult, it is demanding, but it is exciting. You don't feel the time passing, like when you are happy. Like lovers, you are somewhere else in the midst of others.

I felt this abolition of real time, a short time ago, when I saw again on the VCR the televised recording of the last step of the implantation: the long and meticulous crimping, at the different outlets of the receiver, of each of the corresponding electrodes, one by one drawn, threaded in its tube, insulated, crimped, checked, and then taken again before going to the next one.

When I operate in these detemporalized spaces, nothing reaches my conscious mind but the topographic red of the tissues, the thinness of the Teflon, whose twenty thousandths of a millimeter shine, transparent, on the undressed electrode, the enormous clamp that holds this narrow tube where my two platinum wires must slide. Nothing can be heard but my brief requests, the crunching of the entangled antennae that are freed, the silent grinding of the crimping tool. Everything else is filtered out.

However, the other day, on this television screen, I was seeing my gestures again, but I was no longer participating in them. I was listening to the whole thing, not only to my orders or to the thin noises provoked by my fingers, but also to a whole range of information that I had never heard, infrasounds too small to rise to my consciousness, and that the tape of the VCR had, without filtering them, recorded stupidly without understanding: a moved stool, "What time is it? "the slide of the ligature closet, the coughing of the surgeon, and, throbbing, always repeated, the regular sound of the artificial respirator directed by our anaesthetists - an essential rhythm, that one, registered relentlessly throughout the operation, which would remind me, if necessary, that, alone, I would never have been able to do anything, that everything depended on this spirit of teamwork, of cooperation, on which I relied, often without showing how much I appreciated it.

I resume my route. We must not delay too much: the operation is long. I dive back into the microscope. Where was I ?... Let's suck up the blood and the water that have settled and hide the path I have taken, let's remove the useless eardrum, reclined, de-inserted, pushed out with, like a glove finger, all the skin of the auditory canal now scalped bare. I gnaw the bone again, greedily, diluting well, in the serum which runs, the sawdust abounding under my drill. The sharp sides of this one, organized like the parts of a cake or the slices of an orange, swirl under the order of the engine, with a stridulence of muffled siren, attacking violently the living limestone which collapses.

The sight clears little by little. From where I am, one can already admire the entrance of the Eustachian tube. The muscle of the hammer is drawn under its bony shell. Soon, I will be able to dig my holes. The facial nerve appears, far ahead, up there, under the meninges: it is a long white cylinder, often invisible and only imagined in the bone where we know its passage. It crosses indeed all the rock in a long toll course. It is sometimes quite visible when it dominates the stapes, overhangs the oval window, passing at full speed at the level of the semicircular canal, like a beautiful mountain highway, to turn abruptly downwards in a short corbelling around the anvil and disappear in the mastoid cliff, which encompasses it in a long tunnel from which it will emerge only very far away, abruptly in the open air, behind the parotid. There, for him, the bony mountains are finished: it is the calm of the soft parts, where he rests while sliding towards the muscles which wait for him at the edge of the lips and the eyes - those of the smile, the astonishment, the grimaces and the diction. It is one of the most precious elements in our relationship with others. It is the face you make when someone surprises you or pleases you. It is the one that freezes your features when you remain unmoved, that plays the good apostles or the Tartuffe, that persuades or seduces, that knows how to make you cry or allows you to laugh. That is why, surely, he flirts endlessly with our hearing. Cheek against cheek, it rubs the cochlea, dances with the ossicles and criss-crosses the eardrum. Everywhere we find him. He is all the time in our paws, importunate, cumbersome, threatening sometimes, or falsely innocent: "Yes, I am there, behind the oval window; but please, I do not want to disturb you, do not pay attention to me, I do not move!"

That would be the last straw! Fortunately, this is one of the facilities of our surgery: it does not move. You can take your time, aim well, calculate your move, nothing will have changed its place. In neurosurgery, it moves, slowly, but it moves: a brain or a cerebellum, it moves. An artery to be grafted, not only bleeds, but jumps. And a heart! The gestures must take into account those of the myocardium, which struggles, gets angry like a drowning man, fights against its rescuer. For me, this is the most difficult surgery. In an ear, it is much simpler, or so it seems to me. After all, there is nothing unpredictable about these problems with the facial nerve. It is enough to know its route, to imagine it, to know tricks to approach it without frightening it, to tame it and caress it without hurting it.

Time passes, but I'm making progress. I'm attacking the cochlea now. Well, here is Jacobson! I am surprised every time I meet him: Jacobson's nerve is rarely touched, in ordinary times. It is a small nerve branch, small, say the anatomists, but that the microscope individualizes well. It runs in the thickness of the cochlea bone. Its encounter means that I am soon to arrive. And, indeed, in the continuous trickle, I feel under my drill a change of color under the watered tones of the bone. His head rolling at ten thousand turns, soft and diamond-shaped this time, touches, caresses, palpates the bulging side of the inner ear, makes it exist, gives it the desired shape.

I learned this shape in my dissections, three or four years ago. I did not invent it: it is the one that the bare cochlea will take to let itself be captured between my electrodes. It is necessary to seduce it, to make it do the big back, to caress and define its base as well as its dome, to release it gently from this arm that the facial nerve has passed around it. And then, when she is ready, beautiful in the eyes of all, who watch her appear - interns, assistants, anaesthetists anxious to see the goal of this journey so long for them, diving to join me for a few moments through the eyepiece of a long periscope which connects me to the surface - then, one must dare, make the first hole in this defenceless cochlea, hesitate for a moment in front of this classic prohibition, but, for the patient, dare? dare anyway!

Because it is worse than incest! All our otosurgical education is based on this taboo: opening the cochlea is to kill hearing. Of course, here, there is no more hearing, and it is precisely this opening that will bring it back. But, instinctively, in us, everything rebels before this gesture. The hand refuses to press on the instrument; the finger freezes, bristles; it is necessary to rape oneself, to force oneself, to take oneself by the burr and to put oneself gently, almost by closing the eyes, on the thin tender bone...

That's it! Then everything changes. Around this pellet opened on the magic, the arrangement of what remains to be done is ordered: the drawing of the spaces, the tracing of the partitions to be respected in the bone. And the holes follow one another, regular, oval as one pleases; and they are so beautiful that they cease to be only holes: they are now surely fenestrations, a title of nobility well deserved, so majestic is their spiral alignment. Six, eight, and here is the tenth, the most difficult, over there, in the deepest part. To see it, you have to bend over until you risk falling over the facial nerve, almost losing your balance at the foot of the carotid artery which passes close by, indifferent to all this display of acrobatics and cunning. Then when they are all together, like friends around a table, in a family circle, happy to be all together, well arranged, I let them rest and move on to the next step: the opening of the skull.

I emerge abruptly from my microscope, a moment disoriented, because there was no landing between these depths and the area where my team watches over both of us, my operated and me, gone in this long dive. No decompression time, between the minuteness of my gestures and their sudden heaviness when my eyes move away from their ocular. On all the bitters that surround me - the table and its instruments arranged, a serum stand, the door to go out later - I find myself a little out of place, I have to find my way in the sun of the scialytic. And off we go again.

This time, it is with the naked eye that the work starts again, at least to begin with. I suddenly feel much less alone, becoming aware of all those around me, of their warmth and what they say. This surgery of the depths, whether of the ear or of the remote regions of the nose or sinuses, has always been a solitary undertaking, because, at the bottom of the wells that must necessarily be drilled to get there, the lighting, centered on the axis of the gaze, allows only one to see at leisure. Since they have existed, that is to say less than a century, otolaryngologists have therefore become accustomed to operating alone.

These particular conditions did not encourage proselytizing, and kept away from these regions the operators with panache who made the prestige of the great surgery of the past, those amateurs of spectacular, visible virtuosity calling for praise. This solitude without emulation explains in part the little favor in which our L.R.O. fathers - or rather our grandfathers - were held. Of course, since the arrival of the operating microscope, some twenty years ago, everything has changed: a lateral eyepiece allows the assistant to really assist, that is to say to follow the whole operation, and not only to be the blind servant to whom the master throws a few indications on the course of the operative adventure. But the eyepiece shrinks the visual field and, as it is made for only one eye, it does not provide the essential relief to guide the slightest movement. This surgical assistance remains passive. It leaves the surgeon's gestures their solitude, to which I am so sensitive and which sometimes weighs on me. Because, often, many things would be easier or quicker if a helping hand, a well-placed pair of pliers, came to assist me.

Diploscopes, these two-seat microscopes, have recently been introduced. They allow you to operate with two people, that is, with four hands. I would like to have one, but they are very expensive and I have not yet managed to convince the hospital bursar to give them to me; I think I will have to buy them myself.

So for now, I'm getting ready to work in the open and with the naked eye. Ten hours and a half! We have been operating for almost three hours. I stretch a little, but let's not waste time. I prepare the opening of the skull by cutting a beautiful rectangular flap, well drawn, well centered on this zone where the hidden back of my cochlea sleeps in depth. This is where I will put my last two electrodes.

This time that the implantation inside the skull lasts has always scared everyone. It is however quite classical, but it frightens those surgeons who are not used to it, as well as my future patients or their parents (at the idea of "opening the head") and even some public health officials who are surprised that, in order to hear, it is necessary to take what, for them too, seems to be an important risk. No matter how benign this gesture is, I am also reluctant to do it when it is not necessary, because it takes a lot of time to place only two additional electrodes. But that is why it is essential. In the past, my makeshift equipment had only seven channels. At the time, I was unable to place more than five electrodes using the conventional ear canal. So I invented this intracranial approach to place my seven wires. For a long time, I thought that I would never be able to insert more than eight. That's why the first prostheses made by Bertin had only eight channels.

But, little by little, by operating a lot, I acquired a skill that hundreds of dissections on dry rock could not give me. I was able to place my eight electrodes by the easy way of the ear, without having to open the skull. I even realized that, by this way, one or two additional orifices were feasible. So we asked Bertin to make us, for the second generation, twelve-way devices. Because, by increasing the number of channels, we improve comprehension. By going from eight to twelve, you get about twenty times more information. If we reason in quantities of information, for four electrodes, we have sixteen units; for six, we have sixty-four; for eight electrodes, two hundred and fifty-six; for ten, we have one thousand twenty-four units, and for twelve, four thousand ninety-six. Each additional electrode doubles the information. Putting in one more electrode is therefore an essential gesture, and my fingers are infinitely attentive when I place the last ones, which will be the richest.

It is true that my first patients do not hear as well as the more recent ones. I feel some discomfort. But they have been hearing longer. So they don't have to regret not having waited another year or two. For a teenager or a child, this time spent in silence would have caused a much more serious deficit. And then - but this argument can't touch them, I understand them - the technology now allows us to put on twelve electrodes only because we were given the possibility, for several years, to put on eight.

Later on, we may be able to do even better. Theoretically, we have to be sure, even if, at the moment, we don't see very well how. But twelve electrodes is already a lot. It is, as I have already said, the number of channels used by vocoders in telecommunications. These four thousand and ninety-six pieces of information surely exceed the transmission capacities of the remaining fibers of the auditory nerve, whose damage is never negligible in total deafness. This is why I do not think that we will improve our results much by increasing the number of channels indefinitely.

However, the more electrodes you place, the easier it is to "learn to hear". That's why, now that I have this twelve-channel device, the time of opening the skull has become indispensable again. But we hope to be rid of it. In fact, the Bertin company is currently manufacturing a miniaturized electrode holder, whose intromission will surely be much faster and simpler than that of these multiple metal wires. It will be made of a small cylinder in silastic, carrying twelve to fourteen electrodes well arranged every millimeter. It will be sufficient to insert it, like a chuck or a suppository, into the cavity of the cochlear tube. Of course, it will not be possible to use it if the inner ear is poorly formed, which is frequent in deaf-mutes. But it will still make a big difference in our lives.

In the meantime, we must continue to play the picadors and thread our electrodes one by one, bristling the neck of the cochlea with our sonorous banderillas, and wearing out what remains of our youth in long operating hours, carelessly added up in a slow aging, whose stigmata little by little accumulate: whitened hair, darker wrinkles, stiff back and slow muscles

I've worked so hard for the past five years on these electrodes that each one of them has become a platinum wire on my temples. They gave me a lot of trouble afterwards, when I had to make them work or convince others of their qualities. But they gave me nothing but pleasure to implement them. Because operating always makes me happy, puts me in a good mood. By operating, I satisfy an essential taste, that of "power": to recreate what does not exist any more, to make deviate perhaps a destiny which seemed frozen, to act on the distant future of this deaf person who will hear. Astonishing impressions that are similar to the divine in this action on the future of men. Such power exists only here. Of simple power, I have tried all other sources. All of them are adulterated: one always finds more powerful, which can impose its law on you. In high politics, in administration, in money or knowledge, there are always circumstances where other men dictate their will to you. In the operating room, my only interlocutor is God, that is to say the law of his nature, the rules of life, of blood, of healing. It is, believe me, a very gratifying relationship.

I therefore had no merit in inventing this new surgical technique. I was only working for myself, for this dazzling sensation of being useful, indispensable perhaps, for this inexpressible joy experienced in giving a man his true dimension in time and space. This immediate pleasure largely compensated for my sorrows.

TO MAKE ACCEPT A NOVELTY

March 1977. We have operated on twenty-three patients, and all have heard. We must now make known abroad what, in France, in the eyes of the administration, the ministries, the official circles, is beginning to be a French achievement.

But, at times, I can only see in this approach the aspect of a commercial traveler selling his junk. Where is the limit between information, knowledge and advertising of bad taste, if not illicit?

Publicity! I have had to answer this accusation so often myself, throughout these four years. Dilemma: how to make a technique sufficiently known so that everyone, doctors and patients, benefits from a work, but without the initiator being reproached for taking advantage of it to make himself known, to attract fame to him...

The clientele... the money - such is the motivation of the jealousies that the different information campaigns have triggered during these four years. If I had not been a private practitioner, if I had been a true scientist, ignoring and despising the privileged relationship, even if it is of money, which links the doctor to his patient, I would never have been so violently reproached for exposing our results to the general public. The temptation came to me to abandon my private practice in order to escape these criticisms and to allow myself all the publicity that would be indispensable, in fact, to launch our technique, to sensitize public opinion to it, and thus to lead the public authorities to facilitate its development. What has been called "advertising hype" exists in oncology, where the members of certain centers have unofficially received instructions or permission to "sell" cancer through the mass media. Doctors of the deaf, otologists, less well organized, are still accusing each other of the sin of advertising, which only the absence of private clients could absolve.

I have given up this absolution, because the money my patients give me is not used to live luxuriously. It has allowed me to buy books, instruments, even the operating microscope that I use every day in the hospital. It also gives me the freedom to go and watch a surgeon friend in Spain or California operate. Above all, this money gives me my independence. Because devoting my time to the hospital, to research, to teaching, is a real choice, not the professional obligation of a civil servant who wants to be sure of his job and his salary. From one day to the next, I can resign and "move to the city": my clientele would follow me there, all my public patients would join them, and I would then really earn a lot of money.

The truth is that I don't want to have that much. I want to earn a living, but that's not what I was looking for when I chose to go to medical school. The reasons for this choice were initially unclear. To try to clarify my ideas, I distinguished between the "doctor-garagist" and the "doctor-good-sister". But for a long time I did not know that there could be "doctor-slaves". In the attitude or in the modest way of life of these two generations of surgeons, however famous in their time, and who oriented my vocation, nothing had let me guess that medicine could be a source of money, except, perhaps, at the time, cosmetic surgery, whose reputation, in the 50's, was then very bad (so much so that, when, ten years later, I directed my efforts in this discipline, I had to overcome the worried reprobation of my uncle, by explaining to him that there was also serious work to be done there!)

A doctor-general mechanic: he is the one who finds it interesting to understand human mechanics, to know and to be able to repair it, to develop perhaps new repairs, or even to invent spare parts and, in any case, to prolong as much as possible the so extraordinarily complex functioning of this machine, whose cogs sometimes dazzled me when I was learning its functioning

The doctor-good-sister, on the contrary, derives pleasure from the pleasure of others, from their joy of healing, of no longer being afraid, of no longer being in pain, from that warm recognition that, as a young intern, I already received at the bedside of my first patients, only by listening to them talk, telling me about their miseries that I had to relate precisely in technical terms, to deserve the compliments of my intern or boss.

But how to be a "good sister", without being a "garage mechanic"? How to do good without knowing, unless you are a healer? I didn't have enough confidence in my natural gifts; I didn't feel the charismatic charm of these extraordinary beings. To be able to do good, to receive the gratification that was for me the recognition of a reassured patient, I had to be strong in technique, very strong, to know everything that existed, that is to say to pass the internship, whose program included almost all of medicine. I tried to do this, to be sure to succeed with my patients. But the details of anatomy, pathology, physiology, gradually gave me the desire to invent in my turn: "Why, with regard to the treatment of such and such an affection, don't we try this, don't we do that?" I often proposed to the four or five friends with whom, during long cramming sessions, we prepared the exams of the competitive examination? Little by little, my true motivations were taking shape: research and care. But, in order to research in complete freedom while maintaining this precious relationship with the patient, being appointed to the hospitals seemed to me to be the indispensable work instrument, thanks to the technical means and the material independence that it entailed. That is why I did what was necessary to obtain a position in a hospital-university, and that, with the help of luck, I succeeded.

Some doctors are satisfied only with the pleasure of healing; they apply the recipes that others have discovered for them. All their pleasure is in the gratifying relationship they have with their patients; for this reason, they strive to maintain their reputation by treating them as well as possible. For others, on the contrary, the interview with the patient is of lesser interest, or even worries them; they take refuge in their laboratories and devote themselves to pure research, fleeing from the clinic, i.e. medicine at the patient's bedside, finding their way in research, whose results they entrust to the clinician, so that the latter can pass them on to the patients.

With many others, I am in between these two tendencies. I like, at the end of a consultation, after the anxiety, to read in the eyes of my patients the recovered calm. But I also like the enigma to be solved with the means at hand, the trick to be invented, even the pure research without immediate practical application, the one whose fruits do not allow to act better right away, but simply to understand better. My God, how far money problems are from all these motivations!

This reproach of trying to increase my private clientele by publicizing our work is all the more unfair since all our operations have always been carried out in the public sector: I did not want there to be any financial relationship between my patients and myself, so delicate was the road we had to travel together. So, people still ask me from time to time, why did you involve the general press in these efforts, instead of just informing the medical community?

At first, it was involuntary. Then, very quickly, I felt the interest and the necessity. Because the application of our technique implied such a change in people's conceptions of deafness, and such a financial investment, that it was necessary to warn the public, so that they would help us to achieve this. People are so made that they easily get enthusiastic at the magic words of discovery, science, hope; the offices of the administrations, whatever the heads of service say, open more easily to the person in charge of a novelty which has just been talked about in the newspapers or on television, than to the reserved and obscure researcher. This need to be efficient made me decide, in January '77, to call a journalist to give him our first results, with the pretext of the International Congress of Buenos Aires.

In doing so, I was defying the anger of many. I was taking professional risks and, as I suspected, the jealousy of some was not without consequences for me. However, to give our technique the audience it needed to obtain the right to be quoted, I deserved to suffer a little from the criticisms or exclusivities of some colleagues.

Initially, my first contacts with television were fortuitous, born of the public's right to be informed, which provides each medical congress with a press service. That year, 1974, Professor Pialoux was the president of the International Audiology Congress held in Paris, at the Palais de la Porte Maillot.

Professor Pialoux who, since the beginning, has been patronizing our efforts, is a discreet man, and all the more modest because he knows that, by his experience and his knowledge, he is the tacitly uncontested leader of the whole French school of ENT. In this brilliant concrete and glass cylinder which now guards the entrance to the Bois de Boulogne, we had just explained how we had been able to make deaf and deaf-mute people hear sounds and recognize words thanks to our electrodes. Depending on the state of mind of each participant, this publication seemed extraordinary, rich in teaching and hope, or of little interest. However, when it was necessary, as is customary, to summarize the activities of the congress to the press, this work, whatever the criticisms, stood out as one of the most important. But Professor Pialoux, who had sponsored the presentation of our results, instead of reporting it himself in front of the microphones and cameras, as others would probably have done, emphasized its importance to the assembled journalists by advising them to come and interview me personally.

As a specialist in medical problems on television, only one of them came. It is to him, to this approach made of curiosity and professional conscience, that we owe all that, thereafter, the general public could know about our rehabilitation of deafness. I was surprised by his call and I hesitated to answer it, so much so that I remembered all that had been reproached to me by my Parisian colleagues for having, a few years earlier, accepted an interview in a weekly magazine, precisely on this surgery of the inner ear to which I already traced a promising future. But this journalist had an official mandate. I therefore accepted to receive him at the hospital and explained things to him as well as possible.

Understanding quickly, he was seduced and wanted to see some surgeries. Again I hesitated, anticipating that he would ask me to film them. However, intuitively, I felt that this was an opportunity that should not be missed, and this swept away my hesitations, born of the classic obligation of reserve. I promised him, for the sake of form, to show him only patients who volunteered for this exhibition. But I knew they would all be if I asked them. I chose three of them. They were proud, a little moved and, deep down, delighted to have aroused such interest. Their "performances", of which I often saw only the imperfections, were such that the journalist decided, as I sensed, to show them in his program.

This one had a certain resounding effect. The rest of the press followed, and for a few days I was pestered with requests for interviews, which I fearfully refused, now sensing the danger of all this noise. Still, articles appeared, flattering - and often inaccurate.

Immediately, from the medical world, criticism and reproaches began to fall, invoking medical ethics and launching the classic accusation of "personal publicity". This discordant concert of accusations and undeserved grievances struck me in a deep and sensitive area, in spite of the cheerful, if not mocking, indifference that I displayed. It made me feel guilty in spite of myself, forced me to question myself in detail about the motives that had pushed me to accept this television interview which, little by little, in spite of the brevity of its five minutes, had become for my colleagues a sensational program, with its surgical views, its patients and the three sequences where, naked under my open gown, I paraded around the operating room, explaining the technique and its problems.

Because there was all that. I had, it is true, done everything to make the program beautiful, acceding to most of the director's desires. He had seen the operation with the eye of an artist, of a poet, sensitive to the "effects", to the beauty of certain sequences, which I was far from suspecting until then, rather than to the difficulty or the surgical detail. He drew, from these eight hours of intervention, backlighting on the shaping of the electrodes, views of my work read in close-up on my forehead, flash-backs of the insertion of the silastic, copied in zoom and in close-up on the monitor of the black television connected to my microscope. He made me see the operation as I myself had never seen it, and I realized, thanks to him, that it was beautiful.

But why had I helped him in this way, encouraging my deaf-mutes, intimidated by all these gentlemen from the TV, to answer properly? The cameramen, the perchmen crowded my office, all astonished in front of the electronic bricolage spread out on the table, the wires which went up to get lost in a worrying bandage, the patients, similar to remote-controlled toys, held in leash to our diodes, to our filters, to this apparatus of junk, and which however heard, answered the questions.

Of course, I had let myself be filmed in white, nonchalantly leaning on the edge of the empty operating table, now that the operation had just ended; a falsely relaxed star who, in reality, had to repeat his text twice before the sequence was good. In the tired relaxation that followed these long hours of surgery, barely recovered by a quick snack, swallowed in the office with the director and the three technicians of his team, I saw in these shots, for myself, only a game. But for my patients, I sensed its significance. I tried to give explanations and warnings, instead of speaking in voice-over or anonymously, to give the thing weight. I tried to do my best, to draw attention to clearly expose our first results and our hopes. Because I instinctively felt that in order to flesh them out and get something going, we had to talk about them. I anticipated that these 30-second set plays would be blamed on me, probably more than anything else in the program, and for a long time. But, again, I had to.

In fact, all of this earned us an outpouring of criticism. The motivations are complex and a bit murky; I don't want to dwell on them. But I was very sensitive to it.

As I thought, in other medical circles, in the world of public health administration or scientific research, those few minutes of airtime showing our results were very useful. They helped me to convince: it was worth a few enmities.

Three years later, I agreed to show the same journalist the equipment that we had finally developed and the performances that it allowed. The pretext was precisely the news of the publication that we made at the International Congress of Buenos Aires. This second program presented one of our first deaf-mutes who had been operated on, allowing us to see him speak, to hear him answer, to repeat the words that Dr. Fugain pronounced while hiding his face. Thanks to these scenes taken on the spot, I could eliminate the unspoken ulterior motives of some people; after all, who could prove to them that our results were as good as we told them? How could I be sure that it was all true? Television, which reached every house, even those of doctors and administration officials, removed these reservations, because it showed the "performances" of our patients and meant that these had been sufficiently remarkable to seduce a medical journalist, whose competence, prudence and seriousness were recognized by all. A medical film would not have had the same authenticating value. A recording can be faked; the chagrins would not have failed to imply it. But you can't lead a competent journalist and his team astray.

The ear, nose and throat specialists were for a long time the most sceptical. We had difficulty persuading them of the validity of our attempts, of the results obtained and of the effective improvement thus brought to our patients. In this narrow field of total deafness, too many classical notions were questioned; the intervention seemed too complex; the equipment, too cumbersome. It was necessary to convince and explain. The medical congresses were there for that purpose, with their original communications, their round tables where each one exposed his experience.

THE BUENOS AIRES CONGRESS

In this almost full "747", I am however alone. Since Rio de Janeiro, I haven't had time to recognize anyone. Only the name of the Rio de la Plata, whose brown immensity suddenly appears behind a few clouds, then that of Buenos Aires, in the distance, surrounded by its suburbs, come to my mind. Immediately after, green, immense, a solitude without town, sometimes crossed by a straight road going I don't know where, punctuated by some clumps of trees and the first herds. While continuing to descend, the plane, undoubtedly rather low, turns largely on itself. The pampa, green and very close, unfolds under the wing. Then it starts again towards the north, gliding almost in slow motion, losing altitude again, towards the airport now very close.

As soon as we arrived at the airport in the Argentine capital, all the alarmist fantasies of the last few weeks took shape: insecurity in the city, attacks, disappearances, disturbing reports in the weeklies, disturbing comparisons with Chile, protests by intellectuals, accounts of torture, kidnappings, assassinations. For several months, one had been wondering whether this XIth International Congress of the LRO, four years after the one in Venice, would really take place. Professor T..., a dark-haired Argentinean with silver temples, worried about the lack of eagerness of the future congressmen, had made, a few months before, a tour through the world with the different tenors of the international R.L.O., giving reassuring words. He had made a tour around the world a few months before to the various leaders of the international R.L.O., giving reassuring words, explaining that, after the agitated period that had followed the taking of power by the new regime, everything was going to be all right, that now everything was calm in Buenos Aires; it was possible to move around freely, without any danger, and the capital was ready to welcome without any problem the two thousand or so doctors who had been invited, in the hope that they would be as numerous as in Venice.

But in vain. Anxiety, often disguised under political or humanitarian pretexts, had decimated the ranks of Americans and many Europeans. In France, in Paris, many had recused themselves, invoking the distance, the cost of the trip. I myself, distrustful and cautious by nature in such cases, fearing stray bullets, coincidences, arbitrariness or hostage-taking, had hesitated: should I, in the interest of exposing our first results, however astonishing they might be in relation to the path we had travelled since Venice, take the risk of coming back dead or maimed? Impalpable risk, but real. In ordinary times, I would surely have renounced this trip on principle. However, this time, the somewhat vain pleasure of showing that, in four years, we had overtaken the Californian teams, but also a certain sense of duty, overcame my reservations. The Ministry of Foreign Affairs was paying for my trip, and our last requests for credit had been satisfied very quickly because of the imminence of this International Congress. I could not see myself, at the last moment, joining the camp of the fearful, cancelling my departure, especially since we had received unofficially from the Quai d'Orsay this theoretically reassuring advice: if it was not recommended to businessmen to go to Argentina at the moment, because they risked kidnapping and ransom demands, there was nothing to prevent doctors and tourists from going there, as long as they did not deviate from the official places and the organized circuits...

As we got off the plane parked two hundred meters from the terminal, we walked in single file, a coarse, motley caterpillar unwinding from the doors of the Boeing, then stretching towards the international buildings. A young woman, her hair blowing in the wind, wearing a navy blue skirt and a light blouse, cheerfully photographed the arrivals, regularly shooting our stream in packs of six or eight, like a friend happy to see distant cousins arrive. A soldier in battle-dress stayed behind her, two meters away. Then we were made to wait in the hall, at least fifteen minutes, for the arrival of the luggage, we were told, before the police control. I knew why much later, without having guessed it at the time. During these twenty minutes, the films had been developed, shot, and each face inspected, detailed at leisure, compared with the photos of such and such a suspicious face, inventing a beard, a wig, to better spot under a disguise the possible undesirables.

Outside, around the airfield, armed soldiers were patrolling everywhere; on the road, three police controls, immediately abbreviated at the sight of our congress titles. Then, Buenos Aires, a European city, dusty and damaged suburbs, luxurious and old-fashioned neighborhoods like Haussmann Boulevard, half-tracks or armored police cars parked at certain crossroads. In six days, I didn't see the violence; I was told about it, I guessed it in a thousand details; but maybe it was just my imagination. I felt incapable of understanding everything to make a judgment, to form an opinion: I was not there for that.

I was there, on official business, to stir up the oto-rhinos, to disseminate our technique, to present our results. I had to make specialists all over the world want to do the same, to show them that it was now ready, that we had to go ahead. It was the only way to bring our discovery to life.

But it is important to be clear. Speaking well in public helps to make what you present known and accepted. It is important to offer a quality performance, if necessary to wake up a drowsy audience for a few moments.

In the room of the pink hotel, style 1930, I walk, turn and stop. The dampness of the street stirs behind the windows with the waves of cars, buses, sirens. Of the two twin beds, for thirty-six hours one has been mine, the other a workbench where I have arranged my slides, neatly arranged in their order of passage, and laid out the plan for the four-hour lecture I must give tomorrow to some fifty doctors from all over the world.

Four hours is a long time, and yet you will have to speak quickly, because there are so many things to say; you must not forget anything; you must time your presentation so as not to finish too early or risk, on the contrary, rushing through the last passages. Four hours is difficult because it is unusual, far from the ten minutes of classical scientific presentations, or the normal time of lectures in university. So, in order to be sure of myself, in order to serve well what I am going to explain, I rehearse. I rehearse like an actor, laboriously, repeating certain delicate points to be understood, coming back several times on the difficult passages, because I know that there will be no prompter and I do not want to use my notes, not to read especially; I want to speak without paper to give to my listeners the impression that this problem whose details I expose to them is not any more one, since I speak easily about it.

Of one of our old masters, still alive and still looking good, many students laughed because one of them, a few days before a symposium, had caught him in the library of his department rehearsing his paper, in front of the secretary playing a possible difficult audience. I never laughed at that anecdote: do you make fun of an artist who reviews his score before a concert? My old boss was right: to get an idea across, to make people understand a hypothesis, to explain an invention and its results, it is essential to present it well, and to make its revelation a completion, built with rigor, almost a work of art.

And there, in this cloudy and rustling Buenos Aires that I ignore on purpose for a few hours, in this den of work that has become room 235 of the Commodore Hotel, I talk, talk; I remind the hangings of the physiology of hearing; to the two chairs, I give the history of our efforts; to the half-open door on the bathroom, I explain from afar how to go about discovering the structures of the ear and placing our indispensable electrodes one by one. The commode already knows it well, why, now that I have twice made him understand it in English.

Because I had to speak in English. From this came a certain apprehension and this application to repeat a sketch whose detours I knew well... in French. Because speaking for four hours in a row without paper and in English, I had never done it! I wasn't so much afraid of having a bad pronunciation: for a long time I had been told that the French accent is very much appreciated in the U.S.A. and, in spite of the poor quality of my syntax, I knew that I could make myself understood by my interlocutors, as long as they really wanted to hear my message, even if it meant expressing it with my hands, and with the help of a French term or a drawing, which was better than my speech. But, in front of a whole audience and speaking *ex cathedra,* I was afraid to get stuck on a word or to get lost in the transitions or in considerations far from the technical problems of which I had a good vocabulary. So, I repeated turns of phrase, I almost repeated by heart entire explanations, with the dictionary in my hand and the Carpentier and Fialip grammar book on the edge of the table.

This course, organized on the eve of the congress, humorously proved to me that my linguistic efforts in the room had, in this case, been quite useless. Because my audience was almost entirely South American, my fifty listeners quickly made it clear that they preferred to hear me in good French, rather than in bad English. I complied with a smile, not really knowing if my accent was so horrible, or if, whatever they say in those countries, the French language still prevails over the *Yankee.*

The congress opened in the classic hubbub of cosmopolitan crowds, duly equipped with briefcases and ties. The specialists from Bolivia and Paraguay had, by their number, replaced the Americans and the Europeans who had failed. In the undulation of the unknown heads navigating in all directions, in the staircases, the stands, agglutinated at the doors of the amphitheatres, one often met a face, a known physiognomy, or, a warmer stop and full of connivance, a French friend.

There was a lot of talk about the round table on cochlear implants that Professor Pialoux was to chair and in which I was participating. The three American celebrities who had been invited had preferred the safety of their California; the C.I.A. had pointed out to them that they represented an ideal target for kidnapping, the University of San Francisco, where two of them worked, being one of the richest in the world.

The Argentine organizers hesitated: out of seven speakers, we were only three, two French and one Australian. The latter was only a substitute for the tenor expected from Melbourne, who had been excused, and his mission was only to read a paper relating the work that was not his own. The general secretary of the congress feared that he would have to cancel the session; he told me so in his undulating French with an operetta accent. I jumped with indignation: we could well do without the absentees! We knew the problem better than anyone else, to explain the twists and turns and answer all the questions, especially since I had brought all the necessary iconography.

By refusing to give up and by agreeing to fill the empty seats, we responded to the hopes of our hosts. We thus took the responsibility of organizing in twenty-four hours this round table, of which we made, Professor Pialoux and I, a public demonstration of the progress brought in four years by the French school in this field. We divided up the seven chapters of the program; we rehearsed the delicate passages, the details of the photographs, the important points to be highlighted, while reserving, with false deference, the time necessary for the Australian to read his lifeless text, in the middle of our duettists' act. We wanted to show the world that the French were now at the head of the problem, and not the Americans, as everyone had been saying since Venice; because we were bringing tangible results, we were presenting a well-codified technique, a well-developed and available apparatus, and convincing results.

I still think sometimes of the details of that session, of the wake, of that evening when the two of us, like conspirators, exchanged our slides over the senseless squares of meat that are served in Argentine restaurants. I relived my emotion at seeing the room fill up, whose seats I had previously counted to measure our audience: seven or eight hundred people, half the congress, came to hear our discoveries, our certainties, our hopes, as if at a show. I feel the immense joy that I felt, in the darkness where the image of our apparatus or of our patients shone on the screen, to hear our voices that the microphone hammered out my faith and our efforts, flowing to the back of the room and convincing the most remote of the listeners, without any of them thinking of chatting or sleeping... And then, the restful swell of applause, then the joust of questions, the hand-to-hand answers to each speaker, the orchestrated discussion. And the end of the mass, the exit where, suddenly, the slightest acquaintance became a friend who wanted to congratulate us. To finish, in three words exchanged with Pialoux, the joyful connivance of having succeeded in a beautiful coup.

I was very happy that day, I remember it with great pleasure, even if I know the relative vanity and fatuity of it all.

Presentations of our research in scientific circles, publications of our work in medical congresses, reports of results intended for the press, information of the general public, abusive publicity... Where is the limit between what is legal and what can be criticized? Did I have to hide my name from the journalists who came to the news, refuse to say where I was working so that my references would not be published and that I could not be accused of having sought to make myself known, of having used this work to increase my reputation?

I don't believe it. We had to trumpet our success to show that we believed in it, that it was certain, definitive. It was in Buenos Aires that I understood how vain and damaging it is to refuse to be in the limelight, as long as you bring a real innovation. I felt the contradiction that there would have been to preserve anonymity, while seeking to make known what was becoming possible.

Because to give life to this discovery and to make it develop quickly, it was necessary to overcome the skepticism and the incredulity, by exposing *urbi and orbi* our results, by showing well that we did not fear the contradiction, and this, in particular for our deaf people themselves or their entourage, who could thus verify what we said about their improvement, their performances, what our detractors refused to believe.

In the cloud of incredulity, astonishment, and reserve that our first publications raised, the only proof that everything we had told was true, were these few scenes reported by the small screen, around 8 p.m., one Sunday evening in March 1978. But the big press was not mistaken, which immediately took up the description of this novelty, whose images guaranteed the authenticity. Especially as, simultaneously, a dispatch of the France-Presse agency, come from Buenos Aires, reported what had been communicated by the service of press of the congress, and confirmed the interest and the actuality of it.

The wonder of others, the awakening of the public and its anonymous admiration, often fleeting, fleeting but burning, were precious to me when the cold of doubt, the fear of failure, the wind of worry made the desert in my head. The mass media gave us, in the eyes of non-physicians, an aura that served to convince.

AN ESSENTIAL RECYCLING

A small colourful cylinder with paperclip handles, a sort of dwarf washing machine turned upside down on its three legs, the tablet of a capacitor or the chocolate of an integrated circuit, these are the pieces of the electronic game.

Blue, with a smell of old varnish, the solder smokes and babbles under the iron. On the copper-printed beach, like misplaced cars, the plump, yellow and red bellies of the capacitors are lined up in a row. Winter descends through the windows. The tall trees of the Collège de France are disguised as black grids enclosing knowledge and experience. At the back of the narrow lab, leaning over his workbench, Mac Leod pinches, cuts, bends, welds and measures. The square dinosaur of the oscilloscope seems to nod, explaining the sound in beautiful sinusoids. In this assembly that he is putting together, a primitive piece of junk that could be sold on a sidewalk of the boulevard Saint-Michel, I can hardly follow the path of each channel that guides the frequencies, taming them, translating them so that they can finally be understood by each of the electrodes, and so that my implanted patients stop jumping at the slightest noise, which has become a frightening din for them.

The nerve is more sensitive, much more sensitive than the eardrum and the ossicles: there is very little difference between the level at which it starts to hear and the level at which the sound is so violent that it becomes unbearable. It is therefore necessary to multiply the sounds, to compress the information, so that my old music lover, my electrician, my deaf-mutes can hear me speak without panicking as soon as I raise my voice. So we looked for several systems. It worked more or less well.

Then, one day, Mac Leod had the idea of transforming the amplitude of the waves of each wave into sticks of constant energy, always lower than the threshold of the intolerable, whose frequency varied with the height of these waves. It seems to be a classical process, but it was a brilliant one, since our patients were now protected from this serious initial inconvenience. And it was Mac Leod who, after having had the idea, tinkered with the device himself. At that time, in January '74, we were doing everything ourselves. We had no official help. It was all up to him: I had never held a soldering iron and these electronic toys did not exist when I was a kid.

In the shadow near the lamp, the meticulous curve of his neck bent over the editing betrays the attention, the calculation, the invention deployed by Mac Leod for months to dare, to find. What amazes and seduces him in this quest, in which he puts his hands to work and spends his evenings, spending the few pennies of his very poor lab, is the inappreciable, read on the faces of these beings who are suddenly made to hear. And no doubt the exciting idea of being the first to achieve this also moves him.

What are the reasons for living of the researcher, whose most difficult virtues Mac Leod has always embodied for me: the disinterested asceticism, the inattentive rigor to the passing of time, the cold objectivity refusing to affix affectivity or passion to the facts? What matters is the detail of his deep motivations, about which I have never dared to question him. What is essential, for our deaf people, is that these motivations, whatever they may be, made him accept to help us, throughout these five years. Because I knew nothing about electronics and, despite my disparate efforts during those sessions when I was watching him do it, it took me a long time to understand something about it. This world of components, of circuits, for weeks I saw it only through the distorting magnifying glass of my ignorance; and only the unusualness of the forms, the beauty of the colors, the heterogeneity of the words, of the functions, of the structures reached my understanding.

Electricity is difficult to understand because you can't see it. We have to invent the flow of electrons in one direction or the current in the other. To better explain the action of a choke, the play of a diode, we are often told: "Everything happens as if. But this action, this game, are only interpretations, currently rendering, at best, the observed facts, without being sure that, in reality, electrons are thus pressing at the doors of the circuits, charging the plates of a capacitor as one fills an amphitheater or a sluice.

What is the personality of an electron? Are they really all the same? Some of our breakdowns, some of these strange impressions sometimes described by our first operated were not due to the head of noggin of one of them, rebel and individualist, refusing for a moment to do as the others? Surely not, say the scientists. And yet, I am not really convinced. My imagination likes to run wild, but is reluctant to work on command. To conceive electricity is often, as for many other sciences, to imagine on order invisible facts. I cannot hold an electron in my hand or at the end of an instrument. A procession of electrons hurts me if I take it with my fingers; it titillates the resistance or makes the spot of the oscilloscope move; but I do not see them passing, these electrons, nor do I see them running to warm up in my conductors, or on the contrary, well aligned in picofarads, waiting wisely in a small capacitor.

It's like microbes: I have to believe in them, but I don't like them, because I've never seen them. Hear me out: I've never seen them alive, all enzymes out and pseudopods brandished, ready to fight fair with me. Their attack is always sneaky, several of them, from behind, when I can't see them. I am obliged to defend myself blindly, by disinfection, asepsis, antibiotics. The fight with them is not the same as the duel with the superfluous bone of a blocked stirrup, the fracture crushing a wounded nerve or even most cancers clinging to the organs from which they must be extracted. In these battles fought by surgery, we see the enemy without having to invent him. But in electronics, we must believe in what our fingers cannot touch.

So I had to learn to imagine the invisible; I was obliged to retrain, as they say, in two long years when I became a student again, incognito, dragging along the most active of my collaborators in this return to my roots. In order to free up those long afternoons spent at the Halle aux Vins, quai Saint-Bernard, or in the Saclay labs, our schedule was stretched, spreading out the rest of our work to the wee hours of the morning or the late hours. And, little by little, we were able to grasp the terms of the engineers, to follow the discussions, to bring back to our patients the volts and microwatts that were intended for them.

This abysmal return to the student world is a strange experience. The Halle aux Vins, where the sciences were taught at the University of Paris VI, is a sonorous and worn-out swimming pool, where, from the plane trees of the Seine, one dives to the depths of knowledge. The badly washed tiles of the halls and corridors, the wild posters, the passionate graffiti cover this noisy and dirty brick aquarium where the students swim, this temporary and shapeless grouping of beings so different, worried or busy, idle between two courses, picnicking in a staircase or begging for food in front of a two-franc machine.

The girls, neglecting to be beautiful, try to appear banal. The boys, depending on the time of day, are shy or persistent, modest or funny. The jeans and the velvet standardize the fortune of some, the poverty of others. Under the monotypical appearance of the distended sweater, of the features without make-up, the equality of the chances lives, happy effect of the democratization of the education. Here, in science, unlike law or Sciences-Po, the student whose family is rich does not dare to put on the garb of his fortune. In these subjects, where only intelligence and knowledge count, there is no need, as for the lawyer, the judge or the enarque that one wants to become, to explain one's future respectability to the professors one meets every day by means of a tie or a haircut.

To erase myself to the rank of what I wanted to be: a humble student able to aspire to as much knowledge as possible, I put on the same bure, those afternoons, bringing back from the countryside to this use, the turtleneck, the pants necessary to hide from the others, as a tare, my paradoxical origin, since I was at the same time student and professor in the same university - one day potache, examiner the next day.

In each of my companions, lecture hall neighbors or fellow students, instructors or assistants, I tried to guess the scientist, the gifted one, the future Nobel Prize winner. Having come to learn, I instinctively believed at the beginning that everyone knew, and I expected from each teacher the same revealing dazzle that I had experienced when listening to Mac Leod explain the physiology of the neuron or the analog-digital converter. Whether by chance or by circumstance, I have never found such clarity in anyone, and I remain convinced that he is one of the greatest neurophysiologists of his generation, but also one of the most modest and secret.

On rabbits, rats or frogs, we were shown how to work without asepsis, without gloves. We were taught - and it's hard to get used to it - to throw away our patients after the operation. We recorded, synchronized, "counted" dozens of animals, to better understand why our deaf people could hear and to try to give them back their new hearing for life.

Because all our electrophysiological research consisted, in fact, in giving them, easily and definitively, the sound information in all its complexity. It was therefore necessary to transcribe it into electrical signals. Then these had to be transmitted to the depths of the cochlea. And it was also necessary for this rehabilitation to be compatible with a normal life and to persist faithfully, with the years and time.

Little by little, I got used to juggling with the stimulators, the impedances, the mysteries of mass and earth interference. I was thus able to follow the slow gestation of this prosthesis, capable of responding to all imperatives.

This development often made me haunt the new and aseptic workshops of modern factories, populated by young heads and white coats, the offices of engineers, the conference rooms with too deep chairs. Frequently, in these long discussions, I intervened to remind the limits and weaknesses of surgery, whose gestures, in spite of our operating microscope, often appeared to me primitive and coarse, compared to those that our technical friends accomplished on their miniaturized components.

I have repeatedly seen our adventure dissected into figures, the word dismantled into a thousand and one formants, hasty drawings explaining our desires. On large white sheets of paper hung on a desk, I have seen, I don't know how many times, the sound wave arriving from the left, going to the right and the top of the paper, cutting itself into numbers, into impulses, coming back down in millionths of a second - scrutinized, multiplexed in this hypertrophied space of an imponderable time, immediate sound digestion, indispensable to its assimilation through the cutaneous barrier of the skull - then emerge, faithful, towards the bottom of the sheet, reconstituted within the receiver simply figured with its eight electrodes and which, there in the corner of the sketch, did not interest anybody any more but me alone, silent.

We have stirred up so many problems! Our certainty has so often collided with the submerged wrecks of unpredictable difficulties! Sometimes, my slightly passionate enthusiasm, suddenly dented by a delay or an imperfection, was comforted by the calm of Mac Leod, whose objective and disinterested serenity was for me the best proof of the legitimacy of our enterprise. The halls of Orly or Marignane, the buzzing atmosphere of our trips in airplane seats, remain full for me of these discussions, these sketches, these ideas, born moreover just as much during car journeys, or snacks in my lab.

The equipment, such as it is now, was made in this way, progressively defined by the chance of the daily life and the circumstances of these five long years, by slowly purifying all the insurmountable or underhanded obstacles which opposed its birth, then to its development. Some difficulties were particularly painful to assume. As long as they could not be solved, they all ploughed with anguish and tore our hopes.

The three most vivid, those that left me an indelible scar that success does not erase, were the invention of the transmission system, the slowness of the realizations, the reliability of the implanted material.

The invention of the transmission system conditioned the interest of all our efforts. If we could not manage to transmit conveniently, without wire and through the skin, the information and the energy necessary to our electrodes, all that we had proved, explained at the Congress of Audiology in Paris, in 1974, had finally no more practical interest than the tests of Eyries in 1957. Not to find, with tuned solenoids or multiplexing to the millionth of a second, the means to cross the skin barrier of the ear without seeing it, was to remain or to go back twenty years, it was to betray the reassuring promises that I made every day to my first implanted patients, bristling with wires and covered with bandages.

It took a long time to get there: a year and a half! From month to month, from waves of disappointed hopes to hollows of disinterest; swayed by a permanent swell of impatience contained so as not to offend or irritate the industrialist, the engineer and all the good wills working, among other things, on the invention and the development of our equipment.

For they did not have only that to do. The Bertin Company had a thousand other research contracts in progress. The engineers had other projects in mind. Ours was only occasionally the main focus of their concerns; I was only thinking about it. The rest of my activities were implicitly and entirely subordinated to it. Our researchers were also looking for other people. I could not do anything about it. Inwardly, I was angry at this dispersion, this scattering of their activities, this flitting of their efforts. It seemed to me that, if they had once sat down without respite in front of our problems, we would have saved months and months of bandages, of care, of waiting. However, with experience and hindsight, I am less sure now. When we often go from one problem to another, we have a new approach to each of them each time, surely favourable, perhaps even indispensable to the invention, to the discovery of the necessary solution.

And this time spent, this maturation in the choice of decisions, this experimentation of the various processes, pushed for weeks and months on the test benches, how much did they finally seem to us almost light, fragile, insufficient, when appeared the two unforeseeable breakdowns of our first implanted devices. However, all the precautions seemed to have been taken: accelerated ageing, particular selection of the material - whose "military" quality was supposed to guarantee longevity and robustness - prolonged operation of each receiver for weeks and weeks before being handed over to me, before I was allowed, despite my impatience, to sterilize it and then to put it in place.

Now, these electronic difficulties are resolved. But I will always keep in me, ineffaceable, the disgust of all the evil that I had to assume them. Even today, this memory is sometimes awakened by the similar disgust I feel, from time to time, when I try to solve this or that administrative problem that the management of our equipment continues to cause. The slowness of the decisions, the pretext of "studies at the highest level", the false encouragements, the unkept oral promises (which are, in fact, only intended to put my vigilance to sleep), the procrastination of the persons in charge of certain services who do not dare to take a position, their systematic and discretionary refusal to apply original and yet regulatory solutions, would perhaps lead me to sink into the same temporary discouragement that I experienced in the past, if, fortunately, the goodwill of some people, undoubtedly motivated by the quality and the seniority of our results, did not make things easier for us more and more often.

If, at times, I have appeared to be "triumphalist", it iI had to break down the sterilizing skepticism on all sides. These technical and administrative difficulties against which I have fought, and some of which will not be resolved for years, remind me of the discretion of my role as a surgeon. I have been above all the instigator of the work of others, following in the footsteps of Eyries twenty years ago, taking over from the Americans by changing the octave, but leaving it to all those who are going to take it up to bring this idea to its true development. The real practical problems will arise in the months and years to come, and they will be so important for the daily life of all future surgeons! I will, of course, continue to deal with them, but I will no longer be alone and, as far as I am concerned, the main thing is done.

Just as our electrodes make the sounds of our surgeries unfold in thousandths of a second, my memory unrolls the skein of memories tonight and adds them up. The only regret of these intense years are the guilt-inducing criticisms, the reproaches that hurt me. For my deaf patients who are beginning to hear, I have taken them on in silence, with a strength that comes from a desire whose distant image is finally beginning to appear. Perhaps the smell of the night will bring it back to me... bring back from the years that have passed the acrid need to heal the unbearable.

EPILOGUE

Our guests begin to withdraw. Beyond the large lit bays, the crowd is thinning out. Everything will soon be over; these four days have gone well. Great tenors from all over the world, surgeons or scientists, physiologists from San Francisco, anatomists from Stockholm, have spoken their truths about our technique. We have explained ours, detailing our procedure in all its detours, revealing all the recipes, the tricks, the thousand precautions. How many of our delegates will now embark on the adventure? Few, no doubt, in the coming months. America will copy us on its side; Japan will perhaps mark out our device, and probably, in a few years, will produce a simpler and less expensive machine. It's classic, but who cares! The main thing is that my deaf people hear, that, everywhere in the world, deaf-mutes now quickly cease to live as separate beings, inattentive strangers who are barely understood.

When I was seven years old, I met my first deaf-mutes. They were our neighbors. Beyond the garden wall, we could hear their inarticulate cries. The father and mother would call their son, taunting him with invectives that only he understood.

He often came to play with us, in the sandy alleys of the provincial house where my father's university career had, for a time, brought us to live. For me, as a child, the house was big, the park immense, the magnolias endless. In the climbing of the wall often undertaken to join us, over the rusty lean-to leaning against the frames, a stop at half-course made us inspect, from the top of the half-wall, the foreign garden, its unusual drawing, the hazel trees and the elder trees making the hedge around the tiled roof hemmed with shades and stretching, along stony mosses, up to the gate.

The head hidden in the foliage, we observed this strange couple, these two strange human animals, deaf-mute both, speaking by gestures of the fingers punctuated by strange cries and that we could not have redirected - he, tall, thin, rough, cap and old belt, she, badly round, in big stockings in dresses of attic.

And their son, normal and insolent, speaking and hearing very well, made fun of his parents, of their infirmity and explained to us complacently a thousand humiliating details. To surprise us and make us laugh, he would throw insults or forbidden words at them in front of us. He felt very strong; he measured that, with his eight or nine years, he knew much more than his father, illiterate hardly able to sign his name and who had never taught him anything. And we were astonished that he could shout such enormities with impunity. It was my first contact with the world of the deaf, the memory of which I was soon to forget for forty years. And we laughed at his exploits. But it hurt me to see his parents calling him from below, with gestures tracing their sentences on the ardour of the boxwoods, probably trying to order him to come down from our wall and from the trees where we were hiding. The acrid leaves caressed our necks and knees, our hands clutched the rough bark. Sometimes, by breaking a hollow and sonorous branch, the cottony pith extracted with a stick, we obtained a blowpipe or a whistle.

The bitter smell of these elder trees, whose wall was masked, filled our vision. And, always as strong and captivating, it floats in my memory, as at the edge of the moat of this castle, this evening, as along the gates of the Venetian garden, as at the moment still felt...

Mirage of the unspeakable, banal and lukewarm. Could it be that a childhood memory - the suffering of others projected onto the unconscious - managed, five years ago, in that Venetian afternoon near the Accademia, to lead me to the key that would allow me to break the terrible silence? Chance of the things to live that have made me, for decades, "forget", but keep present in the secret of the spirit the scandal of this child insulting his parents, with the bruised image of a father to rehabilitate, a father impotent to hear, unable to speak?

The pungency of these painful scenes had imprinted itself on the sunshine of happy insouciance - dragonflies and cypresses, buttercups, bare knees - into a malaise punctuated by grand staircases, swings, buzzing grapes of light behind closed shutters. The discomfort would only dissipate the day when such great misery would be erased. From there, no doubt, came the impulse to overcome, the urgent desire to find, then the illumination and this faith to convince which possessed me during these five years.

Rebel-Oiseau, 1978.

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ÉDITIONS

Monsieur Claude Henri CHOUARD
10 Boulevard Flandrin
75116 PARIS

Paris, le 15 septembre 2017

Lettre recommandée avec AR

Cher Monsieur,

Faisant suite à votre demande, je vous confirme par la présente que les droits sur l'ouvrage suivant :

- *« Entendre sans oreille »* du Professeur Claude-Henri Chouard, Editions Robert Laffont, 1978.

vous sont rendus et que vous êtes désormais libre de les céder à tout autre éditeur de votre choix.

Je vous prie de croire, Cher Monsieur, à l'expression de mes sentiments les meilleurs.

Cécile BOYER RUNGE
Président

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Book title : Hearing without ears

Author of the book : Claude-Henri Chouard

Born in 1931, Claude-Henri Chouard is an associate professor at the Faculty of Medicine in Paris, head of the otorhinolaryngology department at St-Antoine Hospital, and director of the St-Antoine O.R.L. research laboratory.

Date of publication: 1978

Book Summary:

From now on, almost all the deaf and deaf-mute people in the world can hear, thanks to a French discovery. Claude-Henri Chouard, associate professor at the Faculty of Medicine in Paris, has found and developed, with his team at the Saint-Antoine Hospital and Dr. Mac Leod's laboratory, a process that finally allows deaf people to return to normal life.
To achieve this, the road, arduous, full of pitfalls and often lonely, was a long act of faith. It was necessary to organize research, to invent an entirely new electronic device, to study and practice a revolutionary surgical technique and, above all, to dare. And the miracle happened: the deaf people operated on heard.
To be deaf is still terrible for hundreds of thousands of people in the world. It means being excluded, a prisoner of silence. But soon, this silence will be definitively overcome: Professor Chouard is now teaching, in September 1978, the details of his technique to specialists all over the world.
This book is the story of the birth of a discovery and of the long research that follows, with its trials and tribulations, its doubts, its anxieties, its constant struggles against what, yesterday, still appeared to be the impossible: "hearing without an ear. It is also the moving testimony of a man entirely devoted to his patients and who dedicates his life to them.