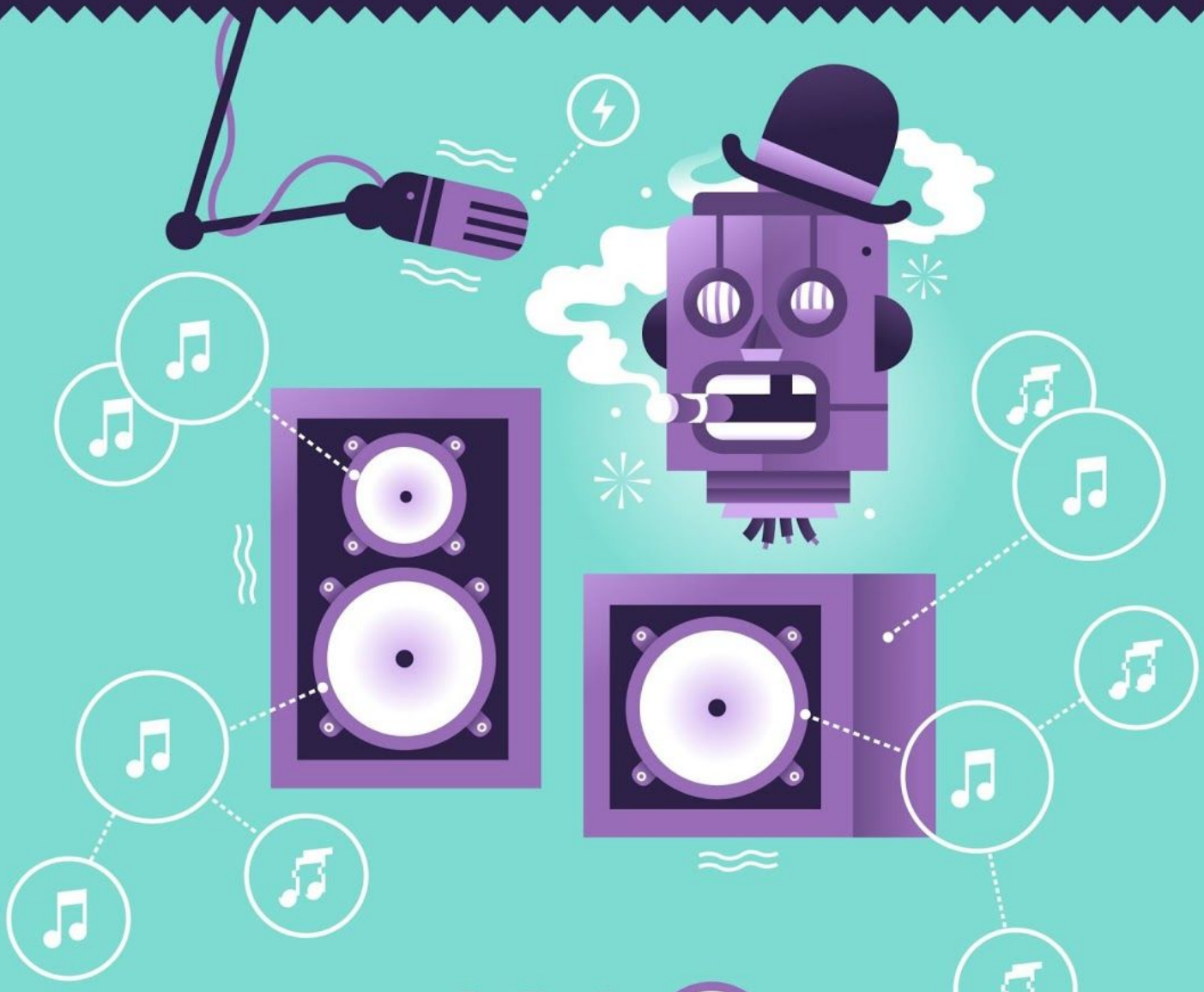
# WHAT IS VODER



Specialty Answering Service

# Contents

# 1 Introduction

The Voder (Voice Operation DEmonstratoR) was a manually operated speech synthesizer invented by Homer Dudley in 1937. The technical details of the product are described in the 1937 US Patent 2121142.

The Voder was a natural progression from Dudley's earlier work on the vocoder. The Voder, an initiative by Bell Telephone Laboratory, was the first time that electronic speech synthesis was attempted by breaking up human speech into its acoustic components and then reproducing the sound patterns electronically.

The Voder was first unveiled and demonstrated in 1939 at the New York World Fair (where it was demonstrated at hourly intervals) and later in 1940 in San Francisco. The World Fair of 1939 had the most famous robot of the day, and the Voder, which could give every robot a voice! There were twenty trained operators known as the 'girls'. Mrs. Helen Harper was particularly skilled with the machine and her performance was applauded. The trained operators handled the machine much like a musical instrument such as a piano or an organ, and they managed to successfully produce human speech during the demos. In the New York Fair demonstration, which was repeated frequently, the announcer gave a simple running discussion of the circuit to which the operator replied through the Voder. This was done by manipulating fourteen keys with the fingers, a bar with the left wrist and a foot pedal with the right foot.

***Figure 1: Mrs. Harper Operating the Voder Machine***

*Source: Journal of the Franklin Institute, Volume 227, Issue 6, June 1939, Pages 739–764 'A Synthetic Speaker' (Homer Dudley, R.R. Riesz, S.S.A. Watkins)*

The quality of speech produced by the Voder was not great. However, it holds a key space in the history of telecommunications. It demonstrated the synthesis of the human voice, which then found applications in a lot of voice communication scenarios including contact centers where it could be used for either security purposes (for example, to avoid human intervention when handling sensitive tasks like repeating a punched-in credit card number) or to save bandwidth.

## 2 History

Early efforts towards speech synthesis included research in both spectral and physical sound modeling methods. The Voder was the first major attempt to encode speech electronically and work on the Voder started as early as October 1928 at the AT&T Bell Laboratories. The Voder is based on a source-filter model for speech, which includes a non-parametric spectral model of the vocal tract produced by the output of a fixed bandpass-filter bank. In 1948, Werner Meyer-Eppler recognized the capability of the Voder machine to generate electronic music, as described in Dudley's patent. In the 1950s, Munson and Montgomery attempted a parametric spectral model for speech synthesis.

The field of speech processing includes various sub domains such as speech modeling, speech synthesis and speech recognition. Bell Labs was focused on a lot of research surrounding the physical nature of speech, in order to improve its most famous invention – the telephone. Once the physical nature of speech was studied and researched, the next fundamental challenge was to attempt the construction of speech from suitably chosen elements. The Voder was an attempt to answer this challenge.

The earliest attempts towards speech synthesis using mechanical means can be traced back to 1779 when a Russian, Professor C.G. Kratzenstein, managed to produce the five vowel sounds 'a, e, i, o, u' using various shaped tubes. A few years later, W. R. von Kempelen of Vienna, managed to improve upon this and produced a number of consonant sounds as well as vowel sounds.

One of the earliest manually operated electrical apparatuses for speech synthesis was constructed by J.Q. Stewart in 1922. A similar machine was also demonstrated by Dr. Harvey Fletcher of Bell Labs in 1924 when he managed to produce a limited vocabulary of sounds, including vowels and words such as 'mamma' and 'papa'.

Over the years, an ever-increasing understanding of the mechanism of voice has led to significant developments in the field of speech synthesis.

# 3 Technology

The Voder was the result of research into compression schemes for transmission of voice on copper wires and for voice encryption. The Voder was essentially a spectrum based voice synthesis device, which was operated using a keyboard. The Voder was the first successful attempt at recreating an important physiological characteristic of the human voice – the ability to create voiced and unvoiced sounds.

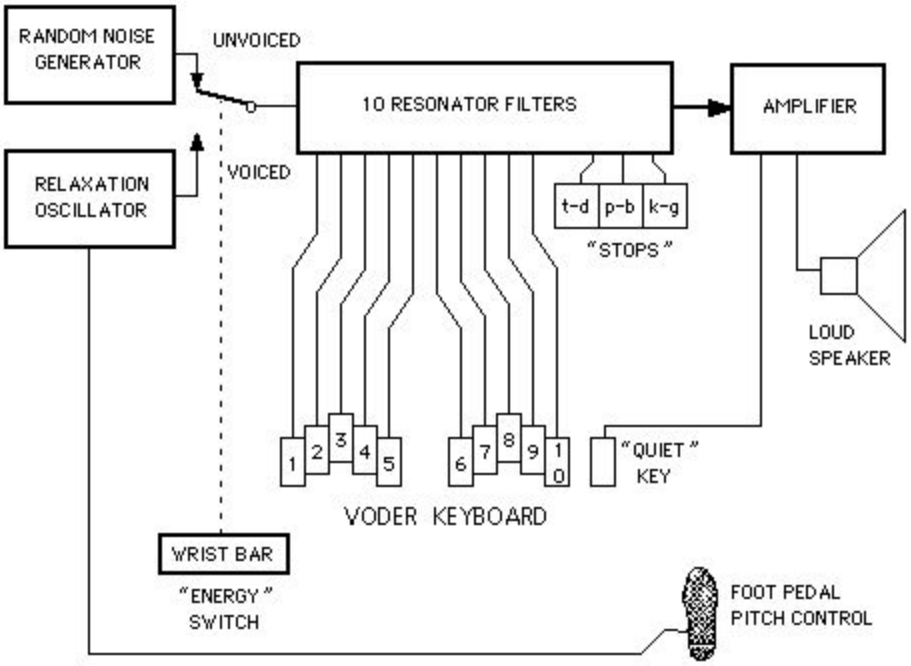



***Figure 2: Schematic Diagram of the Voder***

*Source: http://www.haskins.yale.edu/featured/heads/SIMULACRA/voder.html*

The Voder performed speech synthesis by imitating the behavior of the human vocal tract. It was a complex piece of equipment to operate and it required an operator to have several months of training (almost a year) before recognizable speech could be produced by the machine. The operator manipulated a set of analog controls to produce speech-like sounds from the Voder. A wrist bar allowed the operator to select one of the two basic sounds – a buzz tone or a hissing noise produced by a relaxation oscillator and a gas discharge tube respectively. The buzz tone was used for creating voiced vowels and nasal sounds while the sibilants (voiceless fricative sounds) were produced by the hissing noise. The pitch control was achieved by a foot pedal, which also converted the tones and hissing sounds to vowels, consonants, and inflections.

The ‘resonance control’ box of the Voder consisted of ten contiguous band pass filters. These covered the entire speech frequency range and were connected in parallel. The initial sounds produced by either the oscillator or the gas discharge tube were passed through ten band pass filters and their outputs were passed through an amplifier that mixed and modulated them and passed it on to a loudspeaker in order to produce an electronic human speech. Ten finger keys were used to operate the potentiometers through which the band-pass filter outputs were passed through. Three additional keys were used to generate transient excitation of selected filters to produce plosive sounds (such as ‘p’ or ‘d’) and affricative sounds (such as ‘j’ or ‘ch’).

The Voder was ergonomic, designed to work within the limitations of a human operator. The diagram below shows how the foot pedal, the wrist bar, and the ten spectrum keys were manipulated by a single human operator. A normal human operator would only be able to control a maximum of ten keys at a time, and hence the spectrum keys were limited to ten. These were used to control the ten band-pass filters so as to determine the spectral element of the speech. The wrist bar was used to switch between a periodic and white noise excitation to create a buzz tone or a hissing sound respectively. The periodic excitation produced voiced sounds such as ‘aaa’ while the white-noise excitation produced hissing sounds or unvoiced sounds such as ‘sss’. The foot pedal was used to manipulate the voice inflections by controlling the frequency of the periodic excitation.

A wrist bar switched between a periodic excitation ("buzz-type energy") and a white-noise excitation ("hiss-type energy"). Periodic excitation was used to produce voiced sounds (like "aaaaa") while white-noise excitation was used to produce unvoiced sounds (like "sssss"). A foot pedal controlled the frequency of the periodic excitation, which would thereby control inflection.

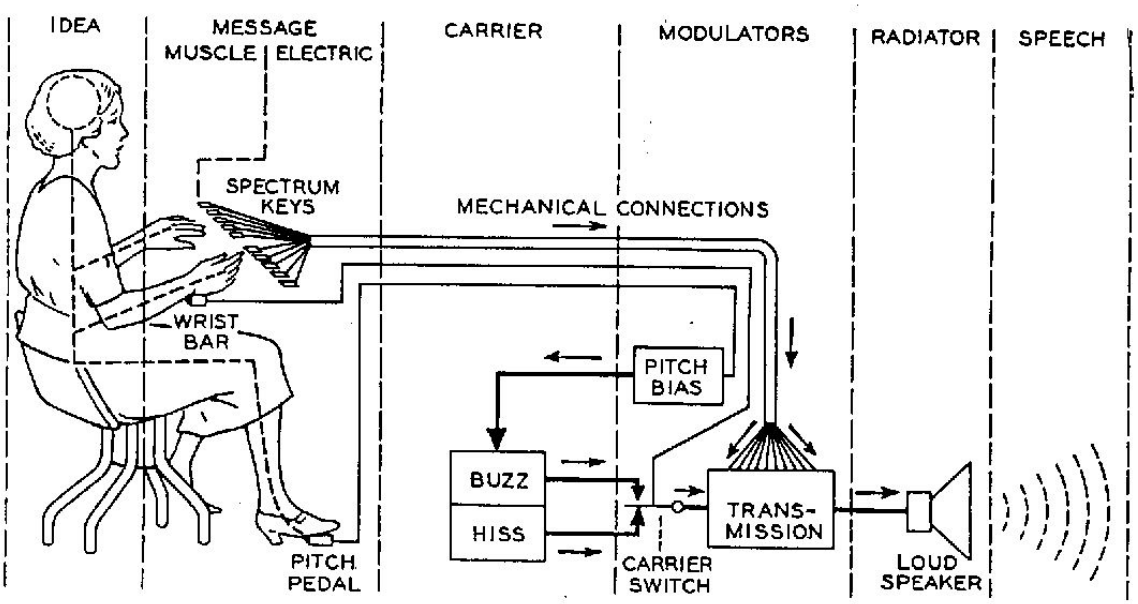



***Figure 3: Ergonomic Design of the Voder***

The theory behind the Voder was simple and it actually produced only two basic sounds – the buzz (for vocal sounds) and the hiss (for sibilants). However, in practice it was not an easy machine to operate. The operator needed to manipulate ten keys, a wrist bar, and a foot pedal simultaneously to create speech. Even after close to a year's practice, an operator could only recreate a pre-programmed pattern. Future research focused on how to make a machine hold a proper conversation and how to create voice from text, without the intervention of an operator. Still, the Voder was an impressive success and Bell Labs continued its research in this field, and nearly two decades later in the 1960s, they created a robot voice that could sing,

## 3.1 The Principle Behind the Voder

The Voder was based on parametric techniques introduced by Homer Dudley in the late thirties. A parameter-based model of the acoustic properties of the human vocal tract was created and human speech was analyzed by determining the values of the parameters in the model. Hence, these techniques were known as parametric models. The figure below shows a basic vocal tract model from 'The Carrier nature of Speech', a paper published in 1940 by Dudley in the Bell System Technical Journal.

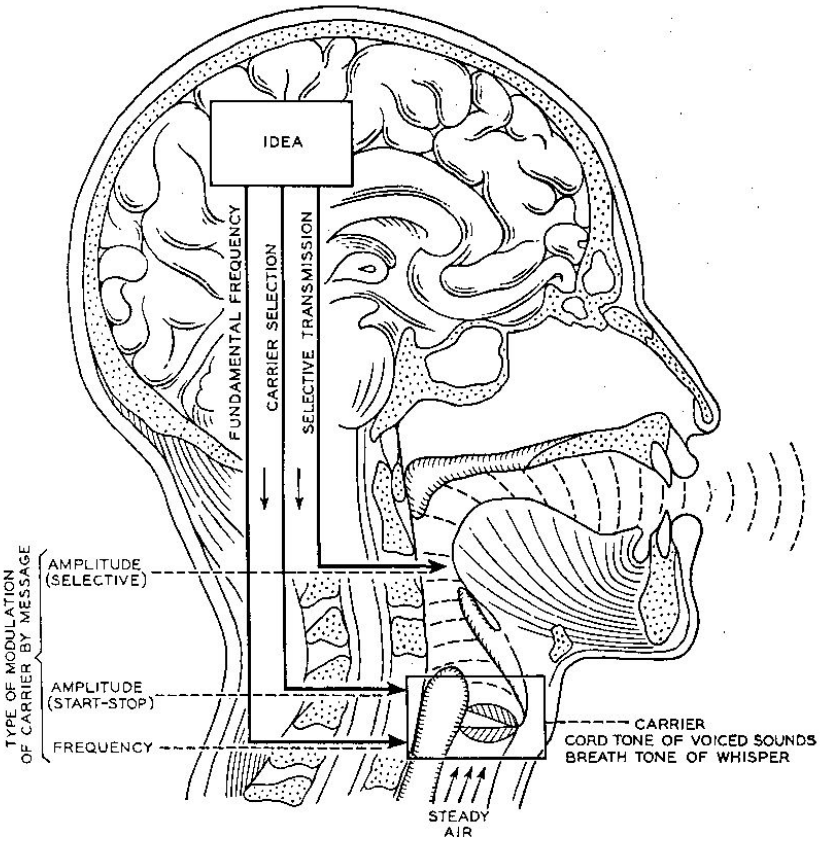



***Figure 4: Dudley's Vocal Tract Model***

*Source:*
*http://www.iro.umontreal.ca/~mignotte/IFT3205/APPLETS/ParametricSpeechSynthesis/ParametricSpeechSynthesis.html*

Human speech production could be modeled in a similar manner as that of an electrical carrier circuit. There was a switching of voice carrier energy, frequency modulation, and amplitude modulation, just as in an electric carrier. However, the voice mechanism was far more complex than an electric circuit due to the presence of two types of carriers (voiced and unvoiced sounds) each with a multiplicity of partial carrier components. There were also multiple modulations of both types – frequency and amplitude, which produced a wide range of voice phenomena.

The Voder was designed on the principle that any electrical speech synthesizer must be a functional copy of the human speech synthesizer in that it should provide all the essential speech characteristics. Human speech production consisted of three main steps:

1) *Having a steady energy source:* this is achieved by the compressed air in the lungs. Correspondingly, the Voder had an electric supply for its steady energy source.

2) *Converting the energy into audible vibrations, which may be regular or irregular. This is achieved by two distinct methods:* Voiced sounds were produced by the vibration of the vocal cords in the larynx, which produced a buzz tone. Unvoiced sounds and whispers were produced by forcing a stream of air through a constriction in the vocal tract, which produced a hissing sound. These methods were also used in combination to produce voiced fricative consonants (such as 'z' in 'zoo'). The electrical oscillator in the Voder produced the buzz tone and the 'random noise' source produced the hissing sound.

3) *Creating various speech sounds:* This involved selecting from several vibration rates produced, the ones that were needed to form the spectrum of the phonetic element. This was achieved in humans by adjusting the resonances and couplings of air cavities through the movements of organs such as jaws, lips, tongue, etc. Sound waves produced by the energy sources in step 2 would not be recognized as speech if the resonant effects produced by the cavities and apertures of other organs such as the mouth, lips, throat, and nose were absent. The air in these cavities resonated in a specific fashion to make certain overtones produced by the larynx to be radiated more efficiently to the atmosphere than others. Thus, the spectrum of the speech sound was determined by the other voice organs in order to generate the tone quality of the specific speech sound. In the Voder, this was achieved with the help of simple electrical filters. Hand controlled potentiometers controlled the output of these filters.

In addition, the pitch changes were achieved by a foot pedal and the wrist bar helped to switch between voiced and unvoiced energy sources, as described earlier in the Technology section of this article.

Thus, the Voder can be thought of as an assembly of equipment that enabled a human operator to build speech sounds similar to those produced by the human vocal tract by manipulating them with fingers, wrist, and foot.

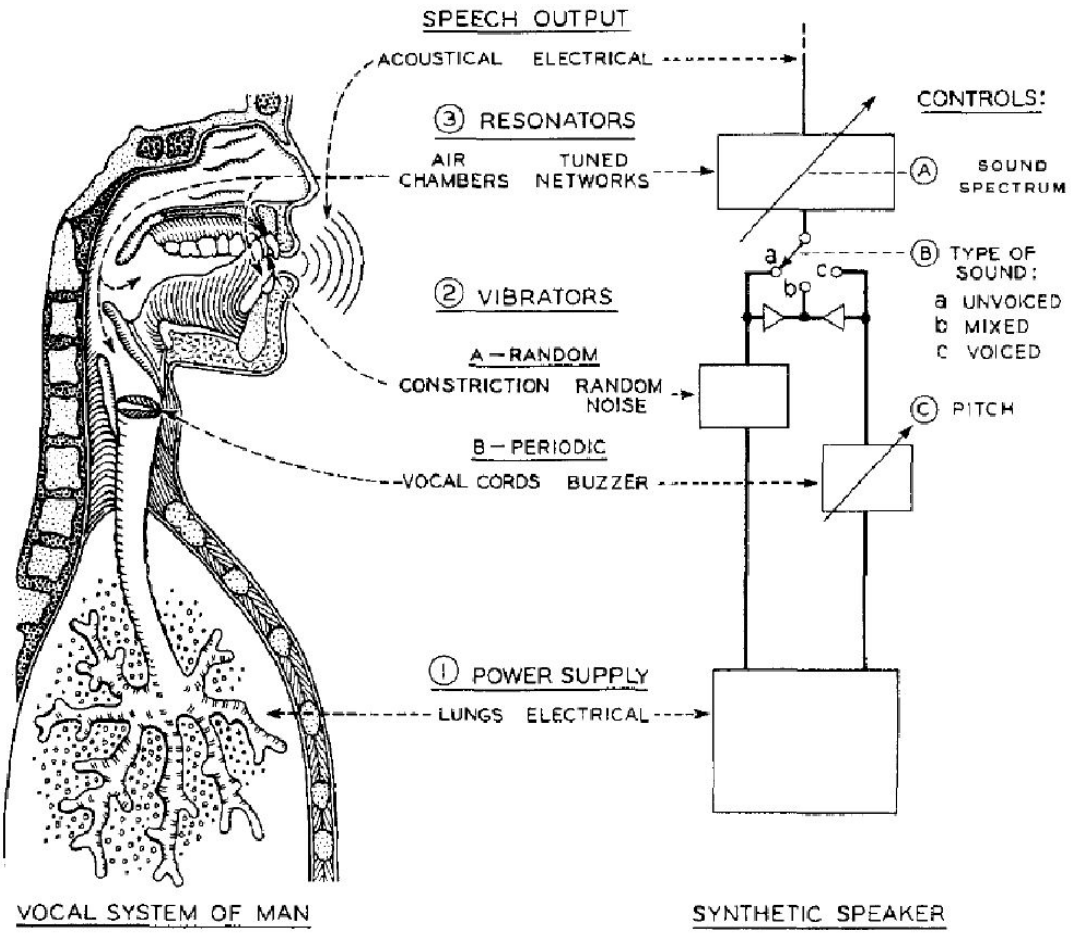



***Figure 5: Functional Comparison of a Synthetic Speaker with the Human Vocal System***

*Source: Journal of the Franklin Institute, Volume 227, Issue 6, June 1939, Pages 739–764 'A Synthetic Speaker' (Homer Dudley, R.R. Riesz, S.S.A. Watkins)*

# 4 The Components of the Voder

The key components of a Voder and their functions are described below:

## 4.1 Vibratory Energy Sources

### 4.1.1 Hissing Sound

The hissing noise (similar to that produced by the steam from a radiator) was used for creating whispered speech and unvoiced consonants. The source of vibratory energy needed for this was a random fluctuation noise, which has a uniform energy distribution over the frequency band. In the initial design, an amplified thermal or resistance noise was used as the electrical source for these vibrations. Later the design was modified to achieve better stability at the cost of lower amplification, by the use of the random fluctuations in ionic current in a gas-filled triode. The random characteristic of the output produced by this circuit closely matched that of the hissing sounds produced by the constrictions in the human vocal tract.

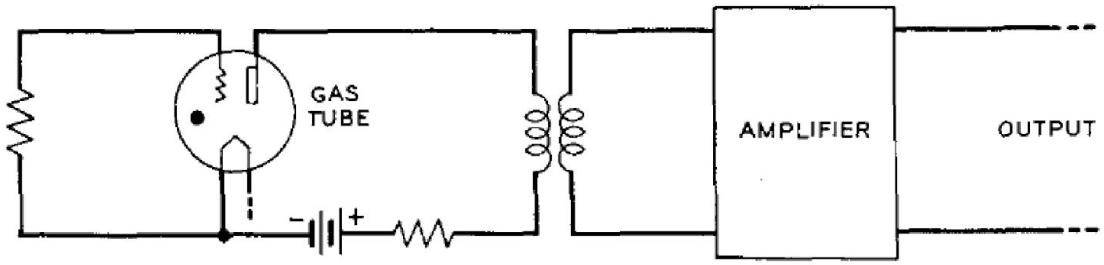



***Figure 6: Circuit for Random Noise***

*Source: Journal of the Franklin Institute, Volume 227, Issue 6, June 1939, Pages 739–764 'A Synthetic Speaker' (Homer Dudley, R.R. Riesz, S.S.A. Watkins)*

### 4.1.2 Buzz Tone

A relaxation oscillator was used as the energy source for the buzz tone necessary for voiced sounds. The output was a repeated damped pulse with a fundamental frequency of 100 cycles per second and several upper harmonics.

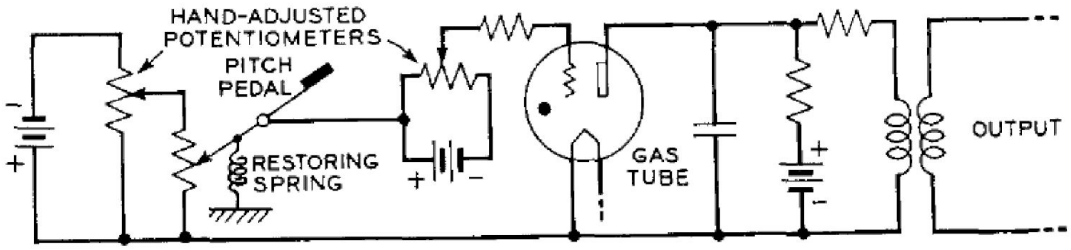



***Figure 7: Circuit for the Relaxation Oscillator***

*Source: Journal of the Franklin Institute, Volume 227, Issue 6, June 1939, Pages 739–764 'A Synthetic Speaker' (Homer Dudley, R.R. Riesz, S.S.A. Watkins)*

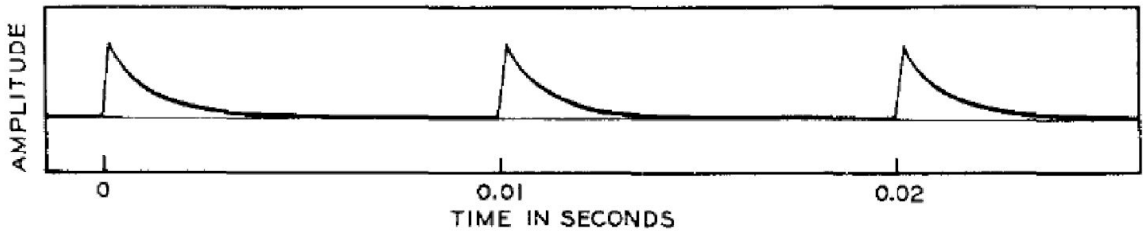



***Figure 8: Output Wave for the Relaxation Oscillator***

*Source: Journal of the Franklin Institute, Volume 227, Issue 6, June 1939, Pages 739–764 'A Synthetic Speaker' (Homer Dudley, R.R. Riesz, S.S.A. Watkins)*

### 4.1.3 Pitch

The Voder was capable of synthesizing the entire range of human voices with their pitch variations and inflections. This was achieved with the help of three potentiometers, which varied the grid potential on the gas tube. Two of these were used for initial adjustments and were operated by hand, whereas the third one was a pedal control used to instantly achieve the desired pitch value or the inflections, giving life and expression to the voice. The two hand controlled potentiometers were used to set the base frequency and the octave range above the base that was available for the voice produced. This essentially determined the vocal range, and whether the synthetic voice would be bass, soprano, or intermediate in nature. Leaving the pitch pedal in its fixed position would create a monotone chanting voice without any life. The spring-controlled pedal could be deflected by the toe of the operator's right foot to create pitch variations. When the toe was lowered, the pitch of the Voder's synthetic voice was lowered; and when the toe was raised, the pitch was correspondingly raised. In order to make the pitch change correspond to the way in which the human ear interprets the change, the Voder was designed in such a way that the logarithm of the fundamental frequency was approximately proportional to the depression of the operator's toe. This ensured that equal changes in the depression of the toe produced equal fractional changes of an octave in the pitch of the Voder.

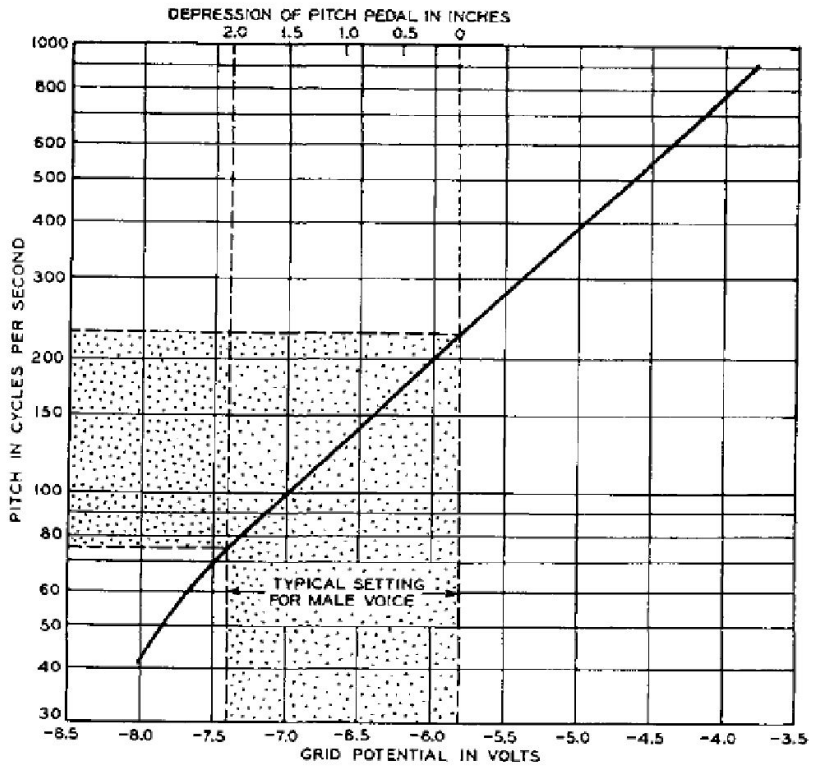



***Figure 9: Pitch Characteristic of the Relaxation Oscillator***

*Source: Journal of the Franklin Institute, Volume 227, Issue 6, June 1939, Pages 739–764 'A Synthetic Speaker' (Homer Dudley, R.R. Riesz, S.S.A. Watkins)*

### 4.1.4 Selection Using the Wrist Bar

The operator had a switch in the form of a horizontal bar to select between the voiced and unvoiced energy sources. The switch was operated by the left wrist of the operator – depressing the switch selected the voiced energy source, while restoring the switch caused the unvoiced energy source to be selected. For some speech sounds such as 'zh', which required both voiced and unvoiced energy to be produced simultaneously, both sources would be selected.

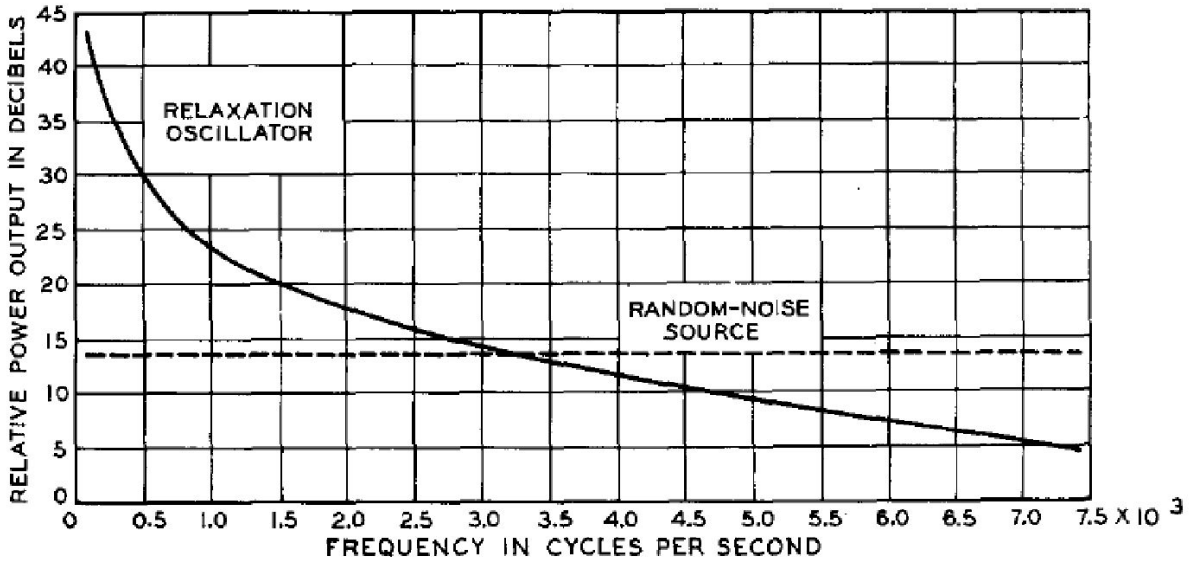



***Figure 10: Output Characteristics of Energy Sources in the Voder***

*Source: Journal of the Franklin Institute, Volume 227, Issue 6, June 1939, Pages 739–764 'A Synthetic Speaker' (Homer Dudley, R.R. Riesz, S.S.A. Watkins)*

## 4.2 Resonance Controls for Speech Sounds

Converting the electric waves produced by the vibratory energy sources into acoustic waves alone would not produce recognizable speech sounds. The electric waves from the energy sources were only the raw material, and in order to convert them into speech sounds, the spectrum of the wave had to be appropriately created using necessary adjustments in the electric circuit through which the electric wave passed. The resonance control circuit must offer enough flexibility to the operator so that the spectrum characteristics of each phonetic element could be simulated with an acceptable precision. In the Voder, this was achieved by ten finger-operated keys located on the keyboard. The frequency range of the Voder (from 0 to 7500 cycles per second) was divided into 10 sub-bands that were represented by band-pass filters. Each filter would allow waves whose frequencies lie within its pass band to pass through it while attenuating the waves of other frequencies. During the design of the Voder, the pass bands of the filters were chosen after a careful analysis of how the human ear interprets speech sounds. The amplitude of the electric wave that was passed to the filters is determined by the position of its potentiometer. The potentiometers were placed before the filters in order to filter out any non-linear distortions. Each potentiometer was controlled by pressing the corresponding control key in the Voder keyboard which applied a small voltage to the electric wave which could increase logarithmically over a range of 55 dB depending on the extent of the key displacement. The key was released to its default 'up' position by a spring. In its default position, no voltage was applied to the electric wave that passes through the filter. The operator thus mimicked the action of the mouth and throat to control the spectrum of the wave generated by the energy sources in the Voder by operating the finger keys. The resonance keys were designed to produce a

logarithmic increase in amplitude for equal increase in the key depression to correspond with the way in which the ear interprets a logarithmic increase in amplitude as an equal increment of loudness. The operator needed the ability to deftly operate the control keys so as to make the necessary key depressions for producing a succession of phonetic elements. After passing through the resonance control circuit, the electric waves were then amplified to a reasonably high level to radiate them through a loudspeaker for a large audience.

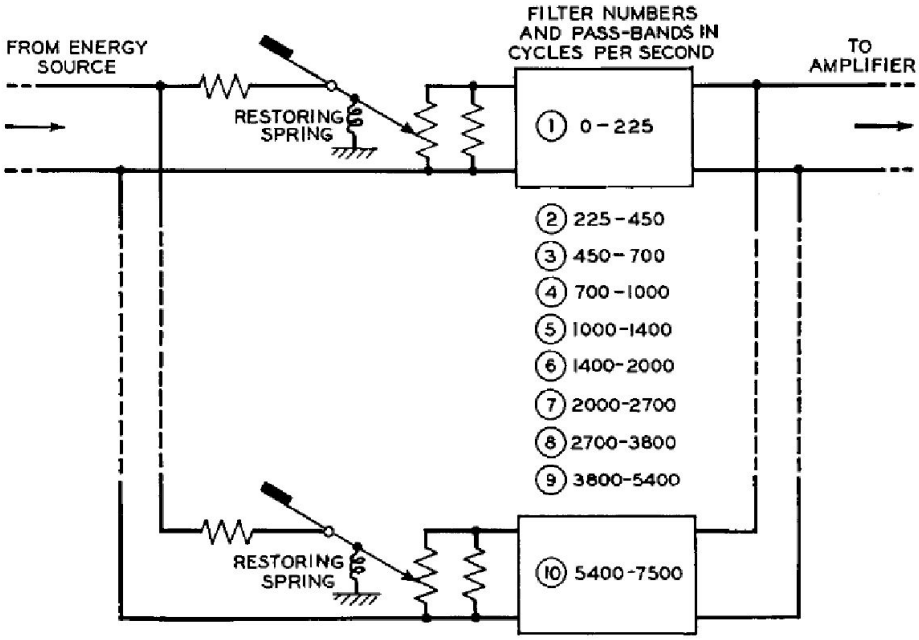



***Figure 11: Resonance Control Circuit***

*Source: Journal of the Franklin Institute, Volume 227, Issue 6, June 1939, Pages 739–764 'A Synthetic Speaker' (Homer Dudley, R.R. Riesz, S.S.A. Watkins)*

## 4.3 Operational Technique

Designing a machine like a Voder involved two phases – an electromechanical design and the design of the operational technique. Once the electromechanical design reached a certain stage of maturity, then a decision was made on the operational technique so that the electromechanical design could be fine-tuned to suit the operational technique and vice versa. In the case of the Voder, questions such as how to design the spatial arrangement for the finger keys, what is the level of movement that the keys should have, how should sound sources be switched, what is the pitch range required, and how to vary the pitch etc., could not be answered until some decisions about the operational technique were made. The design objective was to enable as simple an operating technique as possible, without compromising on the versatility or the features of the machine.

While deciding on the operating technique, a study was made on all the information that was then available around speech sounds. Oscillographic measurements were made to identify how speech

sounds would divide themselves among the ten filter channels in the Voder. However, the information thus obtained was highly complex and could not be adopted in its entirety while designing the Voder's operating technique. Thus, the operating technique was more guided by the ear than by the oscillographic data. Some sounds were more difficult to produce than others – especially vowels with low frequency resonances such as "oo" "aw" and "e". So, it was decided that a much lower resonance would be needed to produce these sounds in the Voder than was initially thought.

As the operating technique was developed, it became clear that some additional provisions that were not previously thought of would be desirable. These included a key to adjust the volume, the arrangement to mix voiced and unvoiced sounds, the special keys for producing stop consonants and the volume reduction corresponding to pitch reduction.

## 4.4 Simplifying Controls

In order to simplify the operating technique of the Voder, several special controls and interlocking operations were added to the initial Voder design.

One interlock type that was applied to some of the resonance control keys in order to increase the naturalness of certain vowels such as 'a' in father, is described below:

The 'a' in father requires the depression of control keys 3 or 4. The naturalness of this could be improved if a small amount of the fundamental frequency of the voiced energy source, which usually passed through filter 1, is also used. In order to automatically pass on a small flow of energy at the fundamental frequency on to the loudspeaker every time a key 3 or 4 was pressed, a connection was made from keys 3 and 4 to key 2 through high resistance networks. This allowed the operator to avoid the hassle of having to further depress key 1.

Another interlock feature that was added helped to reduce the volume as the pitch is lowered, so as to more closely match human speech.

There was a control switch introduced to enable the operator to produce whispered speech, which uses only the unvoiced energy source. This switch was arranged in such a way that when it was in the whispering position, the energy source selected was always the unvoiced source, regardless of the position of the wrist bar. This enabled the operator to easily switch between normal and whispering speech using the same operating technique.

Yet, another control key was the 'quiet' key, which could be depressed using the right thumb to decrease the amplitude by about 20 dB. By using the quiet key along with the resonance keys, the four speech sounds f (fun), v (van), th (thin), and th (then) could be made less loud, thereby increasing their intelligibility.

Another automatic control was introduced to produce phonetic elements such as 'zh', which required energy waves from both voiced and unvoiced sources. For all such sounds, either the resonance control key 8 or the 'quiet' key was always depressed. An automatic control was provided on these

two keys so that if either were pressed with the wrist bar down, then the output from both energy sources would be used for creating the speech sound.

The phonetic elements known as stop consonants required sudden changes in amplitude, which could be achieved by having the operator move her fingers very rapidly across the resonance keys. In order to avoid this change in operating technique, three additional keys that could be operated with the right thumb of the operator were introduced. These were used to produce the stop consonants using the same gliding motion as was used with the other ten resonance control keys. Each of these keys was used to produce a pair of stop consonants – an unvoiced one and its voiced conjugate. One key was used for k and g, one for p and b and the third for t and d.

## 4.5 Abilities Beyond Human Voice

Although the Voder was fundamentally designed for human speech synthesis, it was a diverse machine with several other capabilities. For example, the device was able to cover the full pitch range from bass to soprano, a feat that most humans cannot achieve.

By adding an additional switch to the fundamental Voder design, an old person's wavering sound could be created. This is done by fluctuating the fundamental frequency of the voiced energy source 2-3% by introducing a tiny voltage that fluctuated at the rate of 6 cycles per second in series with the grid voltage of the relaxation oscillator.

In addition, it could also imitate animal sounds (such as those of a cow, pig, woodpecker, insects etc.) and even mechanical sounds (such as the sound of a steam engine or an airplane engine).

# 5 Operating a Voder

From an operational point of view, there were two key challenges for operating a Voder:

1. Make the Voder talk
2. Select and train the operators

## 5.1 Operator Selection and Training

Since trained operators were a critical part of the success of a Voder, there was a lot of thought on the ideal profile of an operator. Towards the end of 1937, it was decided that the Voder would be demonstrated in the World Fair and that operators would be selected from among telephone operators. It was assumed that they would have sufficient skill to master the instrument in the limited time available before the World Fair, which was a year and a half later. Dudley himself wondered in his paper 'A Synthetic Speaker' whether a different profile of operators such as musicians or sculptors or actors would have exhibited greater skill and faster learning.

There was no way to guess how easy or difficult it would be to train the operators or how long it would take them to master the skill to successfully operate the Voder. Therefore, the training was planned in such a way as to master a simple vocabulary and to avoid words that were inherently difficult to reproduce. However, in order to show the versatility of the machine, it was also necessary to cover all speech sounds and their combinations as much as possible. Finally, 2500 words were chosen from three published vocabularies for training – 1. "The Words and Sounds of Telephone Conversations," N. R. French, C. W. Carter and W. Koenig, Bell System Technical Journal, IX, 29o-324; 2. "Relative Frequency of English Speech Sounds", 1923; and 3. "The System of Basic English." C.K. Ogden, 1934. These were then classified based on their phonetic content and arranged in an order based on how they can be created in the Voder. Finally, twenty-four operators were selected for training from a set of three hundred and twenty switchboard operators, mainly from the New York Telephone Company and the Long Lines Department of the A. T. & T. Co. The candidates were selected based on their fingering ability, phonetic sense, and quickness of comprehension based on their ability to produce a short sentence after about half an hour of training.

Several training methods were considered including touch methods using templates to guide the fingers, visual methods using indicators and so on, but finally training the ear was chosen as the method of training, as it was considered the most effective. Twelve Voders were used to simultaneously train the twenty-four operators. The training included six half-hour training periods at the machine daily with a new lesson being introduced every alternate day. There were 40 lessons planned, which were completed in six months. The next six months were spent in improving the technique – the naturalness and intelligibility of the speech produced. Thus, the latter six months were focused on mastering the pitch pedal of the Voder. Sometimes, the operators also carried out conversations with each other using Voders. Recording machines (using magnetic tapes) were used

to record and play back the sounds produced by the operators so that they were able to objectively analyze their areas of improvement, much like in a modern day contact center.

# 6 The First Voder Demonstration

## 6.1 Planning the Program

The first Voder demonstration at New York World Fair was a well-planned event. The Voder was displayed in a large circular room about eighty feet in diameter, and was placed on a raised platform. Since the Voder was exhibited in a Fair where the audience would continuously change, the performance was planned to be repeated every five to six minutes to cater to a fresh set of visitors. It was planned to restrict the performance to simple sentences to enable even average skilled operators to do the job. It was also planned that the demo would be in the form of a dialogue between a man with a microphone and a Voder, which would be operated by one of the girls. There was a prepared script to assist the performance so that the Voder could be made to answer using the limited vocabulary for which the operators had received training. Although there was an initial idea to allow the audience to interact with the Voder, either by requesting it to repeat a word or by asking it a question, it was later dropped because of the impracticality of handling the large crowds who were expected to visit the Voder room. Similarly, it was decided that the other abilities of the Voder such as singing, producing animal or mechanical sounds etc. would not be demonstrated during the World Trade Fair.

# 7 Vocoder vs. Voder

A Vocoder and a Voder are both electrical speech synthesizers. However, there are some fundamental differences between both. The Vocoder handles speech in a coded form and derives its name from 'Voice Coder'. The Voder derives its name from 'Voice Operation DEmonstratoR'. The Vocoder was a predecessor to the Voder. While the Voder is a speech synthesizer, the Vocoder was a speech analysis/synthesis system. This means that while a Voder could create speech based on some manual controls, the Vocoder could only reproduce speech. The Vocoder however, was automatic in its operation and thus the elaborate training required for operating a Voder was not required in the case of a Vocoder. The Voder was derived from the Vocoder by replacing the automatic controls with manual controls and removing the first half of speech input into the system.

The Vocoder works on the principle of reconstructing speech by instantaneously analyzing spoken speech to arrive at the code currents for the control. The Vocoder consists of an encoder-decoder system. The input voice is passed through a multiband filter in the encoder, each band is passed through an envelope follower, and the control signals generated are passed to the decoder, which applies them to the corresponding filters in the synthesizer. Since the change in control signals is slower than the original speech, the Vocoder enables speech transmission using a lower bandwidth. Thus, more speech channels can share a radio circuit or submarine cable for telecommunication requirements. Since the control signals can be encoded, the Vocoder can also be used for situations that require the voice transmission to be secured against interception.

Today the Vocoder finds applications in the areas of VoiP systems, digital trunking, digital voice scrambling, and encryption and in digital WLL.

# 8 Conclusion

The Voder was a versatile instrument, which had multiple performance possibilities over above human voice synthesis. When Dudley retired from Bell Laboratories in 1961 after nearly forty years of speech research, one of the Voder machines was retrieved, refurbished, and replayed. One of the original operators was invited to perform on the occasion and she was successful in making the machine speak even after nearly twenty years. Today there have been several advancements in the field of speech synthesis based upon the underlying principles of the Voder machine. Thus, the Voder marked a significant milestone in the history of speech synthesis.

# 9 References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8 Journal of the Franklin Institute, Volume 227, Issue 6, June 1939, Pages 739–764 'A Synthetic Speaker' (Homer Dudley, R.R. Riesz, S.S.A. Watkins)