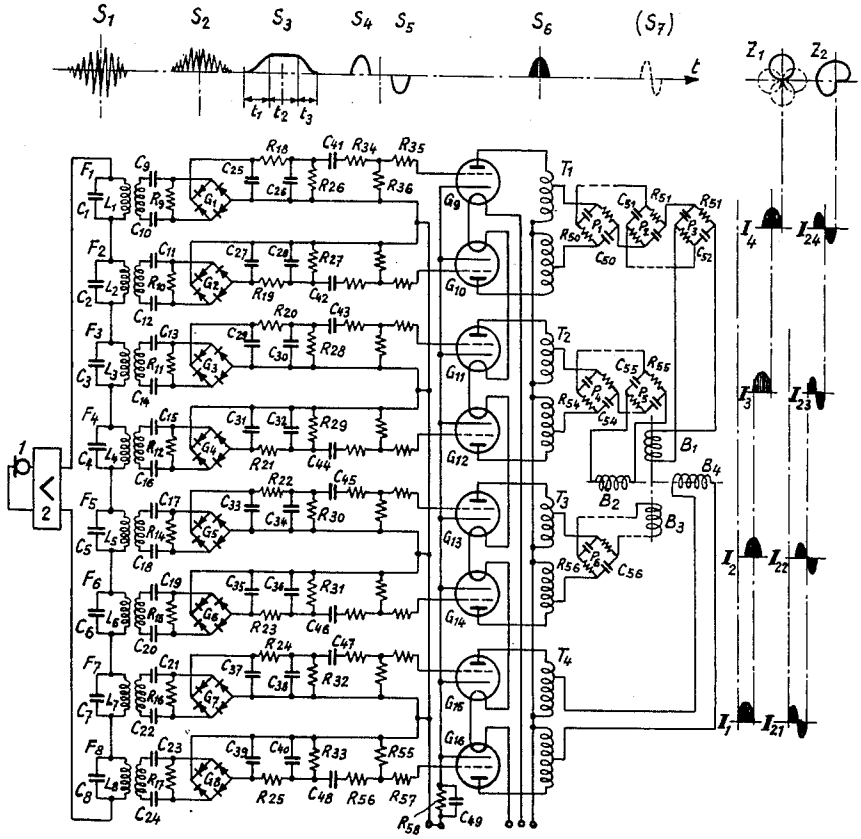
June 27, 1950 J. A. DREYFUS 2,512,889

ELECTROACOUSTIC APPARATUS

Filed March 20, 1945 2 Sheets-Sheet 1

Fig. 1



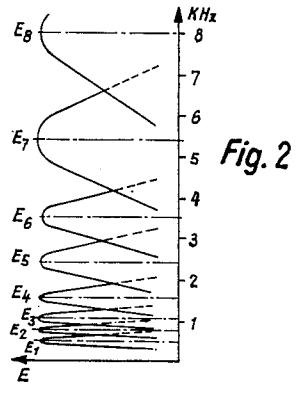


Fig. 2

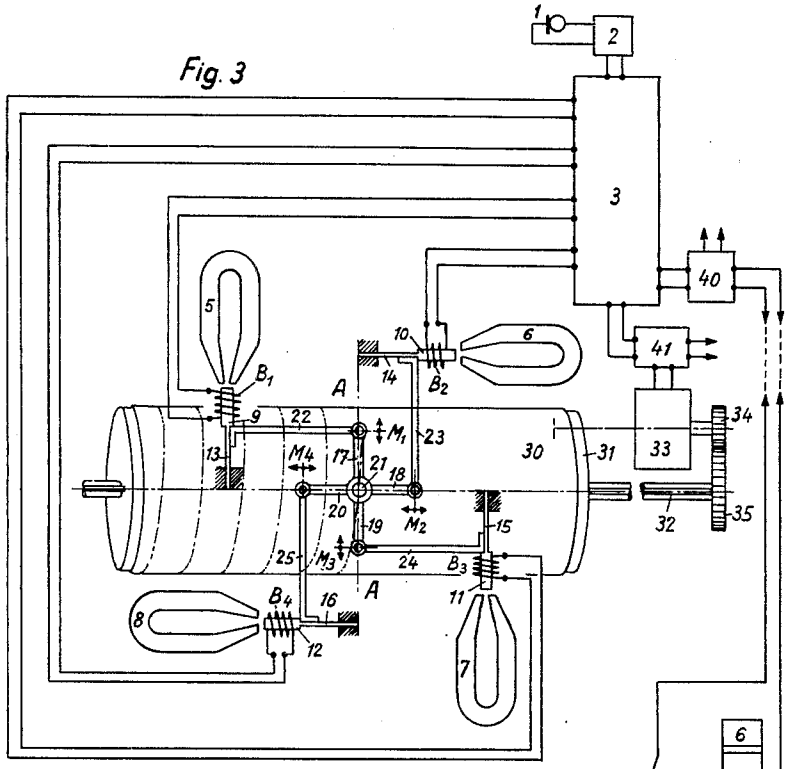
INVENTOR:
Jean Albert Dreyfus
BY
Richards & Geier
ATTORNEYS

June 27, 1950 J. A. DREYFUS 2,512,889

ELECTROACOUSTIC APPARATUS

Filed March 20, 1945 2 Sheets-Sheet 2

Fig. 3



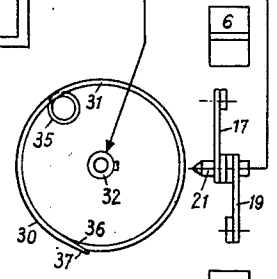
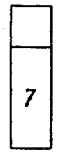


Fig. 4



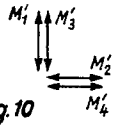


Fig. 10

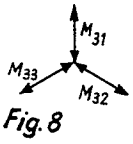


Fig. 8

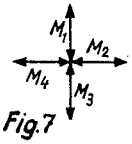


Fig. 7

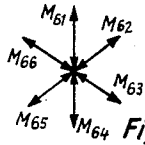
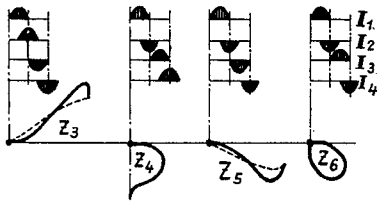


Fig. 9

Fig. 5



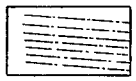
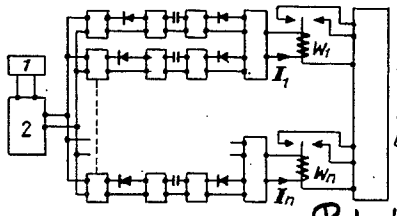


Fig. 6

Fig. 11



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ELECTROACOUSTIC APPARATUS

Jean Albert Dreyfus, Geneva, Switzerland

Application March 20, 1945, Serial No. 583,745
In Switzerland December 17, 1943

Section 1, Public Law 690, August 8, 1946
Patent expires December 17, 1963

17 Claims. (Cl. 179—1)

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The present invention relates to an electro-acoustic apparatus for transforming groups of sound-waves into electrical current impulses flowing through the coils of magneto-motor aggregates. The groups of sound-waves may be the phonetic elements of speech or any succession of sounds produced in like manner but occupying different zones of the frequency spectrum such as heart-beats, the explosions of an internal combustion engine, etc.

Wave groups of this type consist in general of two transitory portions corresponding to initial and final oscillation periods and of a stationary portion situated between them. Each of these has a different frequency spectrum.

The essential feature of this invention is the rectification and smoothing of certain oscillations of a frequency spectrum sorted by resonators or filters, thus eliminating in advance the effect of relative phase differences. A certain number, or all, of the rectified and smoothed oscillations are transmitted over a coupling member reacting to amplitude differences through a second rectifier, thereby causing impulses corresponding to a transient time of the acoustical wave groups. Differences of the xth order or sums of these impulses drive the magneto-motor service. In the process phase alterations may be imparted to these impulses.

This aggregate may, for example, be equipped with polarised relays for actioning a writing device, the levers of a typewriter, or switches of any kind. In this way the following types of apparatus can, among others, be produced:

(*a*) Apparatus for transforming the phonetic elements of language into graphical codifiable signs: a kind of electro-acoustic stenography. An apparatus of this type might be given the general name of "Sonograph," the method "Sonography," and the products "Sonograms."

(*b*) Apparatus for transforming phonetic speech-elements into codifiable typewritten signs, with the help of a kind of Teletype machine ("Sonotypography").

(*c*) Apparatus for setting in motion switching processes of any kind by means of phonetic speech elements, words or phrases, with the help of selective devices ("Sonomotor").

The current impulses may be transmitted by conductors or on electro-magnetic waves. This enables telegrams to be delivered vocally at the transmitting station and to reach their destination in the shape of "telesonograms" or "radio-sonograms." Spoken orders pronounced in one

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place can set in motion electrical or mechanical processes at a distance.

Figs. 1–7 are diagrams illustrating by way of example the arrangement of a "sonograph" and its product.

Fig. 1 is a diagram of an electro-acoustic apparatus in accordance with the present invention.

Fig. 2 illustrates the characteristic frequency and damping curves of the resonators.

Fig. 3 illustrates the mechanical construction of the apparatus shown in Fig. 1.

Fig. 4 illustrates the use of a paper sheet in the apparatus of Fig. 3.

Fig. 5 represents diagrams showing the return lines of the signs.

Fig. 6 shows a sheet carrying slanting lines.

Figs. 7 to 10 are diagrams illustrating mechanical impulses components.

Fig. 11 is a box diagram of the apparatus shown in Figure 1.

In Fig. 1 the variations produced in an electric current by means of microphone 1 are transmitted through compensated amplifiers 2 to a system of resonators, or filters in general, $F_1 \ldots F_8$, consisting, for example, in the condensers $C_1 \ldots C_8$ and reactances $L_1 \ldots L_8$. The wave groups may also be transmitted to a system of acoustic resonators, in the shape of membranes or of hollow vessels filled with a gas or liquid, which in turn excite an equal number of microphones. A single wave-series corresponds, for example, to the oscillation S_1 of one resonator. This is carried over the weak coupling condensers C_9, C_{10} to a two-way rectifier G_1 and produces an oscillation S_2, whose sound-frequency components are sifted out through the low pass filter C_{25}, R_{18}, C_{26}. The remaining current variation S_3 is composed of three parts t_1, t_2, t_3, corresponding to the transient and steady intervals of the wave groups, in so far as the time-constants of the circuit are suitably determined. The coupling member, which comprises a condenser C_{41}, or a transformer, and an adjustable damping member R_{34}—R_{36}, transmits only the relatively slow differences of amplitude corresponding to the transient times of the wave groups. At the grid of the rectifier-amplifier G_9 two tension impulses S_4, S_5 of opposite sign make their appearance. As an example, let only the positive impulse corresponding to the starting-up period of the wave-groups be amplified, and we obtain S_6. The number of resonators $F_1 \ldots F_8$ depends on the desired definition or differentiation of the signs. If the two rectifier-amplifiers G_9, G_{10} are connected in push-pull circuit, the

difference between two impulses appears at the exit terminals of adaption-coils T_1. The impulse differences $I_1 \ldots I_4$ flow through coils $B_1 \ldots B_4$, after being shifted in respect to time by the retarding member $P_1 \ldots P_6$. These can be, for example, fade-free phase slides, like the bridges formed by the pairs of coils $R_{50} \ldots R_{56}$ and the pairs of condensers $C_{50} \ldots C_{56}$. Acoustic of electrical period slides might also be used; these might in particular be combined with the above-mentioned acoustic resonators. The characteristic frequency and damping curves of the resonators, whether electric or acoustic, might correspond, for example, to Fig. 2.

For the graphical reproduction of speech elements it is advantageous to locate the resonator frequencies in characteristic zones, such as the "formants" for discrete vocal spectra or the peaks of the continuous spectra for consonants. The spectra of the transient portions of vocal wave groups are apparently not yet perfectly ascertained. One can, for example, utilise the following resonance ranges: 600, 800, 1100, 1800, 2300, 3700, 4700, 7000, and possibly 9,000 and 12,000 cycles. According to the required differentiation 2, 4, 6, . . . members of this series may be used. The smallest characteristic frequency of the resonator range should be greater than 600 cycles in order to avoid deformations of the speaker's basic tone or a band-pass filter for about 100 to 500 cycles may be additionally used. By excluding the action of the stationary portion of a phonetic wave series the impulses become practically independent of the velocity of speech and whispers can be likewise reproduced. Examples of resonator combinations: $F_8=600$; $F_7=7000$; $F_6=800$; $F_5=4700$; $F_3=5700$; $F_2=1800$; $F_1=2300$ cycles.

Fig. 3 is a diagram illustrating the mechanical design of a "sonograph," in which microphone **1** and impulse circuit arrangements **3** are approximately the same as in Fig. 1. Fig. 4 is a partial section of Fig. 3 along the line A—A. The impulse differences $I_1 \ldots I_4$ in Fig. 1 flow through the coils $B_1 \ldots B_4$ in Fig. 2. The magneto-motor aggregate comprises four polarised relays, or free-oscillating motors like those of a loud-speaker, with the permanent magnets **5—8** and armatures **9—12** which are reconducted to their position of equilibrium by four leaf springs **13—16**. Connecting rods **17—20** arranged in the form of a cross transmit to writer **21** the mechanical impulse differences $M_1 \ldots M_4$ which they receive over connecting levers **22—25**. The duration of an impulse difference may amount to about ten-thousandths of a second; as the interval between two successive wave-groups may be about twenty-thousandths of a second, the mechanical time-constant of the writing system must not exceed five-thousandths of a second. When all the impulse differences $I_1 \ldots I_4$ have the same positive value, writer **21** describes a trajectory approximating to a circle, like Z_1 in Fig. 1. If the impulse differences are alternately positive and negative, as in Fig. 5, the resulting trajectories resemble approximately $Z_3 \ldots Z_6$. This results in the condition that the relative lag within any one impulse group should amount to half the duration of an impulse.

In Figs. 3 and 4 a sheet of paper is wound round a cylinder **31** to which is given a spiral motion by a grooved shaft **32** driven by motor **33** and gear-wheels **34, 35** or by a roller **35** rotating in a helicoidal groove. The overlapping edges of the paper are coated with a non-drying adhesive. The normal peripheric speed of the paper is about

20 millimetres per second. It is well to strengthen the components of the mechanical impulses that are perpendicular to the displacement of the paper at the expense of those that are parallel to it, in order to obtain a satisfactory utilisation of the surface of the paper itself. When the signs have been registered and the paper unrolled, the axes of the series of signs are seen to be disposed like the lines of an ordinary manuscript, only slightly slanting (see Fig. 6). An automatic paper-feed would be an advantage and may be achieved by fitting up a second cylinder as a paper magazine. This could be arranged inside the first cylinder, which would, in this case, have a longitudinal slot with overlapping edges for the passage of the paper. To avoid the necessity of interrupting registration, a change-over system of two cylinders may be provided, or the paper-cylinder may rotate directly between oblique guide rollers.

Writer **21** may be fitted with pen or pencil, or with a stylus for writing in paraffin-coated paper, or any other device of a like nature. An electric generator **40** might also be provided to produce a difference of potential between writer **21** and metal cylinder **31**, which would then function as electrodes. Registration would in this case be effected by discharge flashes through the paper, if the generator were to deliver a high-frequency, high-tension current; or electrolytically, if it produced low-tension direct current and the paper was impregnated with an electrolyte.

The impulses can regulate the operation of motor **33** with the help of relays **41**. The tension period of the generator **40** can also be synchronised by means of the impulse differences. These can be used in particular for synchronising the impulseless return periods of writer **21** with the tensionless states of generator **40**. In this way definition or differentiation is improved and the return lines of the signs, represented by dotted lines in $Z_3 \ldots Z_6$ (Fig. 5), are avoided.

Systems with m relays may be employed, with $m=3, 4, 5 \ldots$. Their magnetic axes or mechanical impulse components form angles equal to $(360:m)°$ (see Figs. 7–9).

In order to reduce the number of relays in a system, cascade push-pull or bridge circuits may be used. If, for example, the two push-pull resistances T_1, T_2 in Fig. 1 are connected over their retarding members and two other amplifiers to a common push-pull resistance, the impulse definition remains invaried, while the number of coils is halved. The axes $M_1 \ldots M_4$ of the components in Fig. 7 then become $M'_1 \ldots M'_4$ in Fig. 10. In general, a p-stage cascade circuit reduces the number of relays $(p.n)$ of a system to the pth part—both p and n being $= 2, 3, 4 \ldots$. Combinatory calculus gives the variations V of 2_n positive and negative relatively retarded impulse differences as:

$$V_n=\frac{(2_n)!}{n!}$$

$V_2=12$; $V_3=120$; $V_4=1680$; $V_5=30{,}240$; . . .

On the definitions V depends the sign definition and to this is subordinated the variations of amplitude. According to the choice of resonators, transmitters, attenuation members, amplification factors, retarding members and impulse combinations, different series of signs are obtained. These may be combined in codes for the reproduction of speech or for analysing sounds in general. It is also possible to vary the impulse combination as desired by means of

a switch, an arrangement presenting great advantages for secrecy of communication and for multiple analyses. For general speech transmission a combination should be chosen with a view to obtaining the cheapest possible apparatus and the simplest possible code reproducing the most essential phonetic elements of the principal languages. It is possible to produce signs based in part on known letters of the alphabet. This would, however, demand an outlay hardly justified by the unorthographic result. It seems sufficient that the signs are such as can be easily learnt by heart and copied by hand or printed, like those used in stenography. The impulse differences can be transmitted by wire or wireless. In this way the "Speech-Sonograph" enables the spoken word to be translated automatically into coded letters, protocols or telegrams.

In Fig. 1 the impulse S_6 corresponds to the initial oscillations of the wave series. By switching the poles of rectifiers G_1, G_9, the final oscillations could be sorted out instead. By means of bridge-arrangements of impedances or resistances it is also possible to sort impulse-differences which correspond either to the initial or to the final transient time of a wave, according to amplitude-differences. By substituting transformers for adjustment resistances $T_1 \ldots T_4$ alternating impulses like (S_7) would result. The impulse differences would then be of the type $I_{21} \ldots I_{24}$ and would combine to form signs like Z_2, if the movement of the paper is not taken into account. The time constant of writer 21 (Figs. 3 and 4) would, however, have to be greatly reduced.

Fig. 11 is the diagram of a "Sonotypograph." Microphone 1, amplifier 2 and the electric impulse circuits are similar to those in Fig. 1. The positive or negative impulse differences $I_1 \ldots I_n$, which must be determined in order to avoid lability are, in this case, transmitted to a magneto-motor aggregate containing the polarised relays $W_1 \ldots W_n$. The contact elements are then combined in arrangements approximately corresponding to rapid Teletypes. The cost of such an apparatus would, however, hardly be economically justified for popular purposes as compared with the "Sonograph."

The impulse differences $I_1 \ldots I_n$ can also be combined in impulse selector devices enabling mechanical or electrical processes to be set in motion orally. Impulse adders and blocking devices can be used to make this result dependent on certain words or phrases. In theory there is no limit to the number of ways of translating sound into mechanical energy and only economic considerations can be taken as a criterion of their practical utility.

I claim:

1. An electro-acoustic apparatus for transforming sound wave groups into mechanical actions, said apparatus comprising, in combination, means including a microphone for transforming each sound wave group into an electric oscillation, a plurality of band filters of acoustic frequencies means connecting said band filters with said microphone and separating said electric oscillation into a plurality of partial electric oscillations, a plurality of rectifying devices comprising low pass filters, means connecting said band filters with said rectifying devices for transforming said partial electric oscillations into rectified current variations, each low pass filter being connected with a separate band filter, and

means connected with said rectifying devices and comprising an electro-mechanical device for combining differential effects of said rectified current variations into mechanical actions.

2. An electro-acoustic apparatus for transforming sound wave groups into mechanical actions, said apparatus comprising, in combination, means including a microphone for transforming each sound wave group into an electric oscillation, a plurality of band filters of acoustic frequencies, means connecting said band filters with said microphone and separating said electric oscillation into a plurality of partial electric oscillations, a plurality of rectifying devices comprising low pass filters, means connecting said band filters with said rectifying devices for transforming said partial electric oscillations into rectified current variations, each low pass filter being connected with a separate band filter, a plurality of coupling circuits comprising separate condensers and resistances, means connecting said condensers and resistances in series with each of said rectifying devices for transforming the rising and decreasing portions of said rectified current into waves of opposite signs, a plurality of rectifying circuits comprising separate condensers and resistances, means connecting the last-mentioned condensers and resistances in series with each coupling circuit for selecting waves corresponding to said rising current portions, and means connected with said rectifying circuits and comprising an electro-mechanical device for combining differential effects of said selected waves into mechanical actions.

3. An electro-acoustic apparatus for transforming sound wave groups into mechanical actions, said apparatus comprising, in combination means including a microphone for transforming each sound wave group into an electric oscillation, a plurality of band filters of acoustic frequencies, means connecting said band filters with said microphone and separating said electric oscillation into a plurality of partial electric oscillations, a plurality of rectifying devices comprising low pass filters means connecting said band filters with said rectifying devices for transforming said partial electric oscillations into rectified current variations, each low pass filter being connected with a separate band filter, a plurality of coupling circuits comprising separate condensers and resistances, means connecting said condensers and resistances in series with each of said rectifying devices for transforming the rising and decreasing portions of said rectified current into waves of opposite signs, a plurality of rectifying circuits for selecting waves corresponding to said rising current portions, a plurality of other rectifying circuits for selecting waves corresponding to said decreasing current portions, means connecting said rectifying circuits with said coupling circuits, and means connected with said rectifying circuits and comprising an electro-mechanical device for combining differential effects of said selected waves into mechanical actions.

4. An electro-acoustic apparatus for transforming sound wave groups into mechanical action, said apparatus comprising, in combination, means comprising a plurality of band filters of acoustic frequencies for separating an electric complex oscillation into a plurality of partial oscillations, a plurality of rectifying devices comprising low pass filters, means connecting said low pass filters with said band filters for transforming said partial electric oscillations into

impulse variations, coils, means connecting said coils with said rectifying devices for transforming differential effects of said impulse variations into dynamic impulses directed in different directions, and a device connected with said coils for combining the resultants of said impulses to produce mechanical effects.

5. An electro-acoustic apparatus for transforming sound wave groups into mechanical actions, said apparatus comprising, in combination, means comprising a plurality of filters of acoustic frequencies separating an electric complex oscillation into a plurality of partial oscillations, a plurality of rectifying devices comprising low pass filters, means connecting said low pass filters with the first-mentioned filters for transforming said partial electric oscillations into impulse variations, coils, means connecting said coils with said rectifying devices for transforming differential effects of said impulse variations into dynamic impulses directed radially in relation to the same center, and a recording device connected with said coils and actuated by the resultant of said impulses.

6. An electro-acoustic apparatus for transforming sound wave groups into mechanical actions, said apparatus comprising, in combination, means comprising a plurality of filters of acoustic frequencies for separating an electric complex oscillation into a plurality of partial oscillations, a plurality of rectifying devices comprising low pass filters, means connecting said low pass filters with the first-mentioned filters for transforming said partial electric oscillations into impulse variations, a plurality of coupling devices having rectifiers and, means connecting said coupling devices with said rectifying devices for transforming rising portions of said impulse variations into electric impulses, a plurality of retarding devices, means connecting said retarding devices with said coupling devices for shifting the phase of said impulses, and a device connected with said retarding devices and actuated by combinations of differential effects of said phase-shifted impulses.

7. An electro-acoustic apparatus for transforming sound wave groups into mechanical actions, said apparatus comprising, in combination, means comprising a plurality of filters of acoustic frequencies for separating an electric complex oscillation into a plurality of partial oscillations, a plurality of rectifying devices comprising low pass filters, means connecting said low pass filters with the first-mentioned filters for transforming said partial electric oscillations into impulse variations, and a plurality of relays, means connecting said relays with said rectifying devices for actuating said relays by differential effects of said impulse variations.

8. An electro-acoustic apparatus for transforming sound wave groups into mechanical actions, said apparatus comprising, in combination, means comprising a plurality of filters of acoustic frequencies for separating an electric complex oscillation into a plurality of partial oscillations, a plurality of rectifying devices comprising low pass filters, means connecting said low pass filters with the first-mentioned filters for transforming said partial electric oscillations into impulse variations, a plurality of coupling devices having rectifiers, means connecting said coupling devices with said rectifying devices for transforming rising portions of said impulse variations into electric impulses, and a plurality of relays, and means connecting said relays with said coupling devices for actuating said relays by differential effects of said impulses.

9. An electro-acoustic apparatus for transforming sound wave groups into mechanical actions, said apparatus comprising, in combination, means comprising a plurality of band filters of acoustic frequencies, one of said band filters being limited by frequencies of 100 and 500 cycles, the other band filters having average frequencies selected among 600, 1100, 1600, 2300 and 3500 cycles, said means separating an electric complex oscillation into a plurality of partial oscillations, a plurality of rectifying devices comprising low pass filters, means connecting said low pass filters with said band filters for transforming said partial electric oscillations into impulse variations, and a device connected with said rectifying devices for transforming said impulse variations into dynamic actions.

10. An electro-acoustic apparatus for transforming sound wave groups into mechanical actions, said apparatus comprising, in combination, means comprising a plurality of filters of acoustic frequencies for separating an electric complex oscillation into a plurality of partial oscillations, a plurality of rectifying devices comprising low pass filters, means connecting said low pass filters with the first-mentioned filters for transforming said partial electric oscillations into impulse variations, a plurality of coupling devices having rectifiers, means connecting said coupling devices with said rectifying devices for transforming rising portions of said impulse variations into electric impulses, and a two-dimensional oscillograph comprising coils, means connecting said coils with said coupling devices for exciting said coils by said impulses, directional rods connected with said coils and forming angles of $360°:m$, wherein m is equal to 3, 4, 5 . . . , a stylus connected with said rods, and means for moving a sheet of paper in contact with said stylus, whereby said stylus inscribes graphic symbols upon said sheet of paper.

11. An electro-acoustic apparatus for transforming sound wave groups into mechanical actions, said apparatus comprising, in combination, means including a microphone for transforming each sound wave group into an electric oscillation, a plurality of band filters of acoustic frequencies, means connecting said band filters with said microphone and separating said electric oscillation into a plurality of partial electric oscillations, a plurality of rectifying devices comprising low pass filters, means connecting said low pass filters with said band filters for transforming said partial electric oscillations into impulse variations, a plurality of coupling devices having rectifiers, means connecting said coupling devices with said rectifying devices for transforming rising portions of said impulse variations into electric impulses, and a device connected with said coupling devices for transforming combinations of said impulses into a graphic symbol representing a codifiable sign of a phonetic language element received by said microphone.

12. An electro-acoustic apparatus for transforming sound wave groups into mechanical actions, said apparatus comprising, in combination, means including a plurality of band filters of acoustic frequencies for separating an electric complex oscillation into a plurality of partial oscillations, a plurality of rectifying devices comprising low pass filters, means connecting said

low pass filters with said band filters for transforming said partial oscillations into impulse variations, a two-dimensional oscillograph having m components, wherein m is equal to 2, 3, 4, 5 . . . , and means connecting said oscillograph with said rectifying devices and causing said oscillograph to transform combinations of differential effects of said impulse variations into graphic symbols.

13. An electro-acoustic apparatus for transforming sound wave groups into mechanical actions, said apparatus comprising, in combination, means including a plurality of band filters of acoustic frequencies separating an electric complex oscillation into a plurality of partial oscillations, a plurality of rectifying devices comprising low pass filters, means connecting said low pass filters with said band filters for transforming said partial oscillations into impulse variations, a two-dimensional oscillograph comprising a metallic stylus, a recording sheet, and electrodes on opposite sides of said recording sheet, and means connecting said oscillograph with said rectifying devices and passing an electric current through said sheet to transform combinations of differential effects of said impulse variations into graphic symbols recorded by said stylus upon said recording sheet.

14. An electro-acoustic apparatus for transforming sound wave groups into mechanical actions, said apparatus comprising, in combination, means including a plurality of band filters of acoustic frequencies for separating an electric complex oscillation into a plurality of partial oscillations, a plurality of rectifying devices comprising low pass filters, means connecting said low pass filters with said band filters for transforming said partial oscillations into impulse variations, a two-dimensional oscillograph comprising a metallic stylus, a recording sheet, and electrodes on opposite sides of said recording sheet, and means connected with said rectifying devices and said oscillograph for passing an electric current controlled by said impulse variations through said sheet to record differential effects of said impulse variations as graphic symbols by said stylus upon said recording sheet.

15. An electro-acoustic apparatus for transforming sound wave groups into mechanical actions, said apparatus comprising, in combination, means including a plurality of band filters of acoustic frequencies for separating an electric complex oscillation into a plurality of partial oscillations, a plurality of rectifying devices comprising low pass filters, means connecting

said low pass filters with said band filters for transforming said partial electric oscillations into impulse variations, a plurality of type-actuating relays and means connecting said relays with said rectifying devices for actuating said relays by combinations of differential effects of said impulse variations.

16. An electro-acoustic apparatus for transforming sound wave groups into mechanical actions, said apparatus comprising, in combination, means including a plurality of band filters of acoustic frequencies for separating an electric complex oscillation into a plurality of partial oscillations, a plurality of rectifying devices comprising low pass filters, means connecting said low pass filters with said band filters for transforming said partial electric oscillations into impulse variations, and means connected with said rectifying devices for combining in space differential time effects of said impulse variations and transforming them into dynamic impulses.

17. An electro-acoustic apparatus for transforming sound wave groups into mechanical actions, said apparatus comprising, in combination, means including a plurality of band filters of acoustic frequencies for separating an electric complex oscillation into a plurality of partial oscillations, a plurality of rectifying devices comprising low pass filters, means connecting said low pass filters with said band filters for transforming said partial electric oscillations into impulse variations, and means connected with said rectifying devices for combining in space differential time and space effects of said impulse variations and transforming them into dynamic impulses.

JEAN ALBERT DREYFUS.

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