Edouard-Léon Scott's French patent No. 31470

[Front page, official form, not translated]

Scott's patent description as filed in handwriting. [*Note 1*]

Descriptive note annexed to the request for a patent of fifteen years made by Mr. Scott (Léon-Edouard) of Paris for a process by means of which one may write and draw by means of sound (acoustic), graphically multiply the results obtained and make industrial uses of them.

The process that I have invented, completely unknown hitherto, and for which I request a patent, consists in fixing a simple or composite stylus close to the centre of a thin membrane placed at one extremity of an acoustical conduit of any kind. The stylus lightly touches a substance that is sensitive to the lightest rubbing, such as a layer of lamp-black, for instance, a substance deposited on glass, metal, or even a sheet of paper or fabric. The sensitive layer passes below the stylus with a regular and predetermined speed. The stylus traces, when one speaks, when one sings, or when one plays an instrument close to the acoustical conduit, figures or drawings in concordance with the sounds produced. I subsequently fix this novel graphic by an immersion in a liquid *carbure* [*Note 2*], followed by a bath of albumin in water. I then pull prints directly called negatives or indirectly positive prints, by photography or by transfer to stone, etc.

By means of this process and the components of the phonautograph (Figs. 2, 3, 4, 5 of the attached drawing), I collect the acoustic trace of speech from a distance, of the singing voice and the various instrument. I propose to use my process for the construction of a dividing instrument, such as for a mathematical tuner for all instruments, for a stenographer for the voice, for the study of the conditions of the sonority of various commercial substances and alloys and to produce industrial designs for embroidery, filigree, jewellery, shades, book illustrations of a completely novel type.

The first figure of the drawing clearly demonstrates my process in its most extreme simplicity, a process that in my mind is almost independent of the number of thin membranes, of the shape and dimensions of the conduit on which they have been applied, of the manner of the suspension of the phonoautograph and the nature of the motor that provides the speed of the sensitive layer.

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Explanatory legend of the attached drawing.

Observation. - The dimensions of my apparatus are not determined, which means that they extend in the limits of the vibration of the membranes. Nonetheless, in order to

fix the ideas, figure 1 may be considered to have a natural size, the figures 2, 3, 4, 5 to a scale of one sixth, figure 6 to a scale of one fifteenth.

The figures 2, 3, 4, 5 are variants of the same apparatus that I call phonoautograph; the same letters and abbreviations designate the same pieces in each figure.

[membr (fig. 1) tymp. (fig. 2, 3, 4, 5) - (in thin rubber, gold-beater's skin, bladder, or prepared paper) and which receives the impression of the vibrations and ondulations of the sonic stream brought to it by the acoustic tube. This membrane, which in certain applications of the phonautograph may be placed perpendicular to the axis of the conduit, is oblique in my figures in order to be influenced by the waves called inflections.

[ann. a gripping moveable ring, intended to be fitted to all membranes of the phonautograph and which serves to give them the desired degree of tension.

[dir. - stylus director. - A small cylinder in a very light meaterial, hollow along its axis and glued fixedly to the membrane. It is intended to receive the stylus and to hold it in a fixed and predetermined direction.

[sty. - stylus, simple or composite at its end and which writes the movements of the membrane on the moving sensitive layer.

[couch. - a sensitive layer created by lampblack or other colouring substance deposited by evaporation on a paper, a fabric or a metal or glass plate.

[infund^{1} (fig. 2), infund^{2}. (fig. 3 and 5), infund^{3}. (fig. 4) - various forms of funnel, a truncated conical, parabolic, elliptical surface of revolution, according to the special purposes that one may suggest in order collect the strong or weak sounds, close or a bit more remote, stenography of song or production of drawings.

The lower extremity of each funnel is provided with a membrane, perforated or unperforated as the case may be, and which is closer or further removed from the infundibulum by means of a slide [*Note 3*] shown in the figures 2, 3, 4, 5 and may or may not also be situated on an antinode or a node of vibration.

A- In the figures 2, 3, 4 there exists a combined piece, A, the same for the various funnels, a truncated conical or elliptically cylindrical piece that is formed by tubes covered by a second slide and a membrane with its ring and its stylus, the membrane be analogue to the oval window in the ear.

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The slide of this piece A that is regulated by a graduated screw is intended to compress the air between the membranes, it these are unperforated, and to control the lenght of tubing for deep or sharp sounds belonging to various instruments.

[B (fig. 5) Air box or box for the drum to augment the intensity of the sounds and the sensititiveness of the membranes for weak or remote sounds. In this figure, there are three slides, that work within the widest limits are made to vary according to the needs of the internal capacity of the instrument and its length

[tir., tirages (fig. 2, 3, 4, 5) - slides applied to cylindrical or weakly conical, and which as far as possible should be air-tight. They work by sliding of polished surfaces one upon the others and they are regulated by a gradual screw.

[fig. 0. - the sensitive layer that passes below the stylus, given a movement by the action of a remote trumpet, with a speed determined by the movement of a [pendulum] clock and made uniform by means of a motor as known from clockwork or an electromagnet, a motor that is not shown in the figure.

To increase the clarity I apend to the drawings of my apparatus two copies of a sample of the acoustic figures of the voice, of a cornet, drawings that I obtain before any construction of apparatus and by the sole use of the process of figure 1.

Edourd-Léon Scott
rue Taranne, 6
the 24th March 1857

Edouard-Léon Scott's Certificate of Addition to his French patent No. 31470

[Front page, official form, not translated]

Scott's description as filed partly in handwriting relating to his Certificate of Addition. [*Note 4*]

Specification annexed to my demand of 29 July 1859 for a certificate of addition to my patent of invention given 25 March 1857 with the number 31470 for a process for writing and drawing by means of sound (acoustic)

Phonautography is a novel art created by an invention of Mr. Eduard-Léon Scott, for which he has taken out a patent for fifteen years on 25 March 1857. This art presents itself with the purpose of simply obtaining a correct impression of fast movements and especially the vibratory movements that are present in the air and which are produced by any agent, mechanical, physical, or physiological, amongst which by acoustical instruments, musical instruments, or even voices.

The patent of invention was based essentially on three means, either seperately or joined, are the soul of various apparatus and manipulations that compose Phonoautography.

The three means are:

1. Joining of a stylus to a membrane placed at the end of a conduit, the shape of which may vary according to the special object in mind;
2. The use of an elastic stylus, of animal or vegetal origin, and consisting of one or more parts;
3. The fixing, by means of one or more chemical baths of the obtained traces on a paper or tissue covered by a layer of special lampblack.

I insist on this point that these means constitute three inventions or discoveries that may be applied to sciences and to arts in isolation or combined two and two. For example, the stylus may be adpated to be either on an object in movement, for inscribing on the sensitive layer its displacements or measure them, or on motors or on mechanisms of extensive variation. The fixing of the lampblack with impressions permits the conservation of the trace of the movements of the animate or non-animate agent into natural drawings in such a subtle way that one has never been able to hitherto.

These three means joined and used in different ways according to the nature of the phenomena that one desires to record are sufficient to obtain a trustworthy and detailled graphical image of a large number of phenomena produced in the air that surrounds us. One may without trouble understand how, strange as it may seem from the point-of-view of science, to conserve the exact representation of the phases through which a phenomenon passes, that one had thought simple, through an interval of time that is inaccessible to our senses due to its brevity, some thousandth of a second only. Phonautography, for example provides to physicists and physiologists a

natural diagram of the successive or simultaneous states of the bodies that are the basic cause of our sensations.

The majority of these movements are so delicate and so rapid that their inscription on a sensitive layer would present the greatest difficulties. The slightest rubbing of the brush completely masks the law [*sic*]. I have hence had to adopt in phonautography a stylus that is at the same time hard and supple
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without appreciable weight, completely different with respect to the metal stylus used by Mr. Wertheim to inscribe the vibrations of solids. The phonautographic stylus, with a very fine point, marks by a kind of sweeping its trace on a thin layer of lampblack produced by a special oil and deposited by means of sublimation. Being suspended in a semi-fluid condition, this black has almost no adherence to the paper or tissue that retains it during its rising. The phonautograhic image is fixed as soon as it is created by the procedure described in the patent and determined more especially below. It may afterwards be multiplied, if required, by ordinary means.

I will now describe the additions to the patent that are the object of the present certificate [- of addition, *GBN note*]. In the patent of 25 March 1857, while declaring that I considered the invention to be independent of the kind of motor that provides the speed of the sensitive layer, I had indicated the use of a motor with a uniform movement to provide a progressing and regular back-and-forth movement of this layer. I have later recognized that for a large number of uses one could make do with a continuous movement of a cylinder moved by a helical screw progressing in a fixed nut. It is this embodiment that is represented in the overall view of the apparatus constructed by Mr. Rudolph Koenig (plate 1). The experimenter may dispense with the uniformity of the movements of the sensitive layer: it is sufficent in order to count the time or measure the duration of a phenomenon, short as it may be, to simultaneously direct, at the moving cylinder, a chronometer with a seconds hand or a tuning fork supplied with a supple stylus, calibrated to a predetermined number of vibrations, such as 1000 or 500 per second.

I have since taking out the patent added to the tightening ring of the membrane a piece initially called the handle of the hammer, in analogy to the similar device in the hearing organ, but I now call it with greater precision the subdivider of the membrane. This piece, such as it appears in the manufactured apparatus is represented in detail in plate 1. It serves to determine in the membrane node lines so that it permits to write a sound, in regard of which, without the assistance of this device, the stylus would have found itself placed on a node of vibration of this membrane.

A serious difficulty had to be overcome to collect in a practical manner the sound waves on the membrane. Conduits are the more unsuitable for conducting voices the more they vibrate easily. In a such conduit a notable part of the vibration of the fluid is transformed by means of communication into vibrations of the solid and thereby loses much of its force, even if the conduit has little length, the membrane may remain almost insensible to a sound of mediocre intensity. I have hence had to stay with conduits made in a non-sonorous material (cast plaster of Paris or solidified paste) while giving them a certain thickness.

The mode to proceed to obtain phonautographic samples is very simple. Rotating the cylinder one wraps a strip of paper on it while keeping it tight. One loads

this paper, which rotates with an almost uniform speed, with an even, opaque and extremely thin layer of lamp black. Towards the centre of the membrane the stylus is placed; the end that traces is pulled from a feather of certain birds. This point obeys all the simple
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or complex movements of the membrane. In this condition one introduces the stylus to the cylinder in order that it touches it while resting unchangeable in the direction of its shaft. One makes the sounds heard at the opening of the vessel or conduit, the membrane starts to vibrate, the stylus follows its movements and its end traces on the cylinder that describes a continuous helix the figures of the vibration of the produced sound. They mark its number and its timbre. These figures are ample when the sound is intense, microscopic, if they are very weak, spread out when the sound is deep, contracted if it is sharp, of a regular and honest design if the timbre is pure, uneven and as if trembling, if it is bad or veiled.

Now we show the series of experiments that are interesting to physicists, physiologists, instrument manufacturers, science amateurs, that one may already perform with the apparatus constructed the way shown in the present certificate:

1. To write the vibrating movement of any solid body to make a comparison to the movement of a fluid, counting the number of vibrations performed by the solid in the unit of time by means of the marking chronometer.

2. A tuning fork that has been calibrated to a determined number of vibrations per time unit (500 or 1000, for instance) by means of the preceding experiment, to count by letting them write simultaneously, the number of vibrations accomplished by any agent able to vibrate (solid or fluid) in a time frame as short as one may wish (some thousandth of a second). An example: to count and measure the various phases of a noise and the time intervals passing between rapid and successive sound phenomena, check the relative sonority of metals, of alloys, of wood, etc.

3. To write the vibrations produced by a membrane by one or more simultaneously sounding tubes, to count their number, demonstrating their phases; obtain the acoustic drawing or diagram of any of the chords or dissonances; write equally the song [*sic*] of any wind instrument; show the timbre that these instruments have; write the composite movement resulting from two or more instruments played simultaneously.

4. To write the song of a voice, measuring its extent by the marking chronometer or the calibrated marking tuning fork; to demonstrate its purity or the isochronicity of the vibrations as well as the timbre; write a melody and transcribe it aided by the marking tuning fork; write the simultaneous song of two voices and to show their being in tune or dissonance.

5. To study acoustically the physiological or pathological movements of the vocal apparatus and of its parts during the different phonations, the shout, etc.; to mark the timbre of a given voice;

6. To study the articulated voice, the declamation (see the second plate annexed regarding a first application to ordinary writing); to show syllabic diagrams.

7. To register by the combination of the second means (the flexible stylus) and the third (the fixing) the movement of a pendulum, of a spinning top, of the magnetized needle, the mode of locomotion of an insect, etc.

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Finally, by means of the adjustments that will in the end be shown in the modifications to the below apparatus:

To write, by means of an acoustic conduit of several hundreds of meters length sounds or signals produced at more or less extended distances;

To write, without the aid of conduits, signals produced under still water from stations removed several kilometers.

Description of the phonautographic apparatus and the manipulations supported by the patent of 25 March 1857.

1˚ The cylinder and its movement. - The axis of the cylinder is made of iron. One of its extremities is a thread turned in steel. The nut and the bearing are in copper. A device at the nut enables the freedom of the cylinder during the operation of blackening. The construction that supports it is cast and is fixed by screws in the plate of oak that serves as the base for the whole apparatus. The gauge of the thread enables the writing of the chronometer or the tuning fork in the interstice. The cylinder is moved by hand by means of a handle, which provides the means to slow down or accelerate the movement according to the rapidity of the trace that one wishes.

2˚ The chronometre and its support. - The marking chronometer used in the apparatus is designed to calibrate a sound from a solid or a fluid is the one imagined by Mr. Redier. A point prepared for this purpose carries a supple stylus that is placed in contact with the cylinder in the interstice between the phonautographic traces. An escapement lets it function for 6 seconds. One obtains hence on each strip series of 6 seconds; the sixth of each is the number of vibrations carried out in a second of time (see plate 3). The support of the chronometer has all the necessary movements and slides freely in all directions on the plate that carries the apparatus.

It will be understood that any other marking chronometer or any other support might be used and that it is the marking itself of time on the cylinder by means of a chronometer that is the purpose of the present addition.

3˚ The marking tuning fork and its support. - This marking tuning fork, calibrated to a number of multiple vibrations of 500, 1000 for example, carries out the same duties as the chronometer. Only, instead of counting the seconds, these are thousandths of seconds that is indicated in the interstices on the cylinder. It also provides the means for counting noises, sounds, or signals of an extreme brevity. It should be held at a distance from the membrane sufficient that it is not influenced by its vibrations. This tuning fork is mounted in a support analogous to the one for the chronometer.

4˚ The membrane and the apparatus for its tensioning. - The material of the membrane may change with the purpose in mind. One may equally well use gold-beater's skin, blown rubber [*Note 5*], bladder, an animal vellum, or even collodion. It is often useful, to give them suppleness and to remedy the hygroscopicity, to treat the membranes with glycerine. The tensioning ring of the membrane that I today shall call the Tensioner, and the controller of the stylus that I call Subdivider of the membrane are in some respects different from the one shown in the patent of 25 March 1857.

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The membrane is held in a state of suitable tension by means of two rings, on one of which it is fixed. The two rings get closer or further apart by means of a thread, as in timpani. The subdivider of the membrane is fixed to the lower ring. It consists of a small mobile bracket with a groove that receives at one of its ends a screw that is designed to plunge mor or less into the membrane. This bracket and its support are fixed in the required position by screw means.

The ring that carries the membrane turns against friction on the short elbow pipe. This last adjustment designed to give the membrane a suitable inclination with respect to the axis of the short tube. This tube itself slides against friction in the opening of the vessel that faces the cylinder. By means of these devices one obtains all directions and and the various ways of getting the stylus closer without moving the vessel.

5˚ The supple stylus. - The stylus shown on the drawing is provided at its end with a barb of a feather, cemented to an inelastic stick taken in the middle part of a flexible organ that that may be found in certain crustaceans, for instance big shrimp. It will be understood that the use of these two particular substances is not required, in that I have had to patent substances of a vegetal or an animal origin, enjoying the same properties. The division of the stylus in two parts of a different nature seemed to me to be very important for the good success of the operation, and I insist on it in the present certificate.

6˚ The vessel and its support. - This vessel must, as I have explained, be in a material as non-sonorous as possible, and of a certain thickness. Its shapes, which I also said in the patent, may be varied in order to be suitable for the special purpose in mind. Hence it may be a simple bowl connected to the short tube of the membrane in order to study e.g. the timbre of the voice in speaking; a conduit modelled on the shape of the ear canal of the external ear for in particular physiological studies; a huge acoustic horn, a paraboloid of revolution, etc. The vessel shown in the drawing of the built apparatus is a part of an ellipsoid of revolution cast in plaster of Paris. The opening that communicates with membrane is placed in one of the foci of the ellipsoid and the sound producer is towards the other focus that is situated in front of the vessel in free space, which offers the advantage that it does not disturb the timbre, which would be the case if the sound were produced inside the vessel. This vessel has shown itself to be very practical in the sense that it is adaptable to a large number of experiments and permits to present several instruments in front of its opening. I would nevertheless remind [the reader] that I have patented all kinds of conduit, at the extreme end of which one may place a membrane furnished with a stylus.

The support of the vessel is cast; it is structured like a kind of slanting ratchet that allows one to lift the vessel or to lower it at will; the front branch of the support carries an adjusting screw by means of which one lifts the opening of the vessel that carries the membrane to the required height.

7˚ The smoking lamp and the special blackening. - I use a lamp without any draft of air; it carries a big and wide flat wick. The lampblack is obtained by a mixture of about two thirds unrefined lamp oil and one third oil of resin of the second distillation. It is necessary to watch the good state of the wick and to renew the mixture at each operation, because the oil of resin, heavier than the ordinary oil, precipitates. To blacken one

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turns the cylinder and one lets the lit lamp move 7 or 8 centimeters below the paper fitted.

8˚ Fixing of the samples. - This is obtained by a dipping performed with care into a first bath of pure alcohol; the sample having thus recived this first treatment is let to dry, and is subsequently coated with a solution of a resin in alcohol. Sandarac works well as a fixative and may advantageously replace the albumen solution described in the patent.

The second plate annexed to my request of 29 July 1859:
[*Note 6*]

Application of the phonautographic notation for transcription of declamation.

To write declamation down precisely it is not sufficient to mark above or below the line the long or short [sounds], the fortes and the pianos, the higher or lower pitch, the aspirations, the pauses for breath, and the pauses and explosions, it is necessary to represent clearly and simply the amount or mathematical value of each of these modifications.

The phonautographic trace from now on provides, without one having to be preoccupied with the articulation, a very simple means to draw objectively the diction of the artist. This trace is a kind of reptile, in which the rings follow all the modulations or inflexions of speech. It is sufficient in order to translate by sight apart from the articulation; to make the following remarks: the horizontal distance of the foot of the curve indicates the tone or tonality; the height of the same curves the intensity of the voice; the detail of the curves the timbre; the lack of curves the pauses or silences. The few natural expressions shown here are sufficient to understand this figure.

Brock-Nannestad's *Notes* to the translated documents.

Note 1: the formalized application document is accompanied by a description that forms the basis for the right claimed. The patent is registered SGDG (Sans Garantie de Gouvernement), i.e. un-examined. This means that the extent of the patent has to be settled in court along with any dispute. The handwritten text is the authoritative one; for information purposes an edited extract was published in a collection of printed publications.

Note 2: the original word *carbure* has both the meaning of a (hydro)carbon and that of a carbide. The only liquid "carbide" that might be relevant in the present context is carbondisulphide, called *carbure de soufre*. We can hence only conclude that an unspecified organic solvent was used for first dipping, which was replaced in the patent of addition with the more specific "alcohol".

Note 3: the original has *tirage* rather than *coulisse*, which is the term usually associated with slides in musical instruments. However, mechanically they appear to perform the same.

Note 4: the formalized application document for a *certificate of a patent of addition* is accompanied by a description that forms the basis for the right claimed. A patent of addition or improvement must have a basis in the original invention.

Note 5: this appears to refer to blowing a bubble and cutting the membrane from the thin sheet obtained.

Note 6: this plate describes the performance of an analysis of elocution recorded by the Phonautograph. The plate contains the text translated above as well as 7 examples, in each of which a phrase is given, followed by a copy of the corresponding phonautographic trace above a phonetic transcription of the text, in which the character height indicates the volume that the utterance was spoken at.

End Note: copyright clearance is in the process of being obtained for the plates to be reproduced along with the above translation.