Feb. 24, 1931.

A. D. LOMAN, JR

1,794,190

MUSICAL INSTRUMENT

Filed Sept. 10, 1929

*Fig:1.*

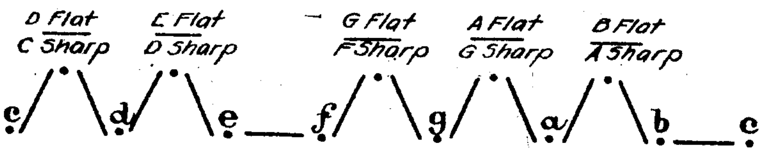



*Fig:2.*

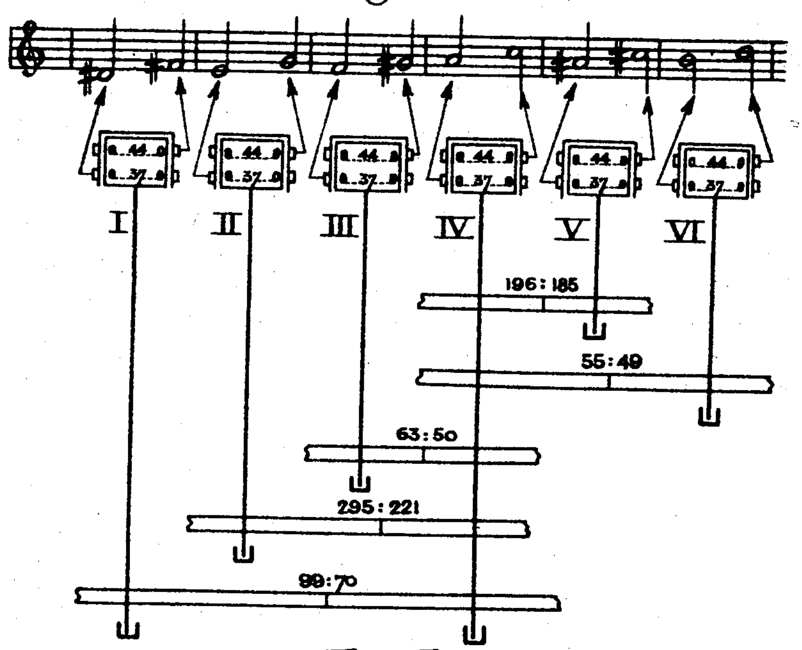
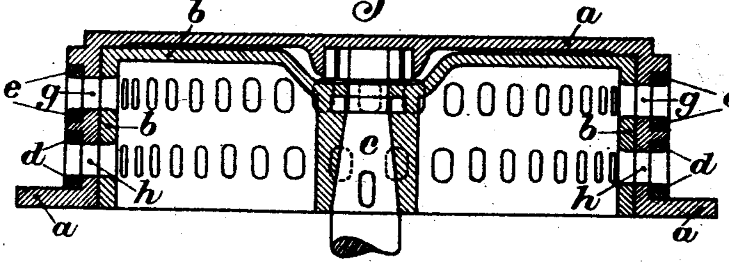



*Fig:3.*

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**Patented Feb. 24, 1931** **1,794,190**

# UNITED STATES PATENT OFFICE

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## MUSICAL INSTRUMENT

Application filed September 10, 1929, Serial No. 391,583, and in Germany September 12, 1928.

The present invention relates to a novel musical instrument.

In order to obtain a perfect comprehension of the device it will be necessary to state a few of the laws and rules of the production and propagation of sound.

The pitch of a tone depends on the frequency of vibrations producing said tone.

The difference in pitch of two tones depends on the proportion (not the arithmetical difference) that the frequency of vibration producing one tone bears to that producing the other tone; and, as far as such proportion has a musical meaning, it is called "the interval between the two tones".

The usual succession of notes between two tones which are distant from one another by a whole octave, is called "a scale". The most usual scales are those of major and minor, every one of which comprises eight tones between which there are accordingly seven intervals. These intervals are not alike; there are five so-called "major seconds" and two so-called "minor seconds". When dealing with keyboard instruments, the first named are also called whole tones, the latter being called half-tones. Now, in the case of key-board instruments, the octave is divided into 12 equal intervals which thus correspond nearly to the half-tones mentioned ($2\times5$ plus $2=12$). This tuning which is called "equal temperament" is adapted to organs, and piano-fortes. The differences in height of tone originated by this practical rule, compared with actual musical performances, are so trifling as not to hurt a musically trained ear.

In the drawing accompanying this specification,

Fig. 1 is a diagrammatic view illustrating the notes of an octave;

Fig. 2 is a diagrammatic view illustrating a musical scale to which the features of the present invention are applied; and

Fig. 3 is a central vertical section of one of the sirens employed in carrying out the invention.

As is well known, the ratio of vibrations between any two tones one of which is one octave higher or lower than two others, is equal to 2. That distance being divided into twelve equal intervals (proportion numbers), each interval, namely that of a half tone, is equal to $\sqrt[12]{2}$. For the sake of facility let us represent it by W, so that $\sqrt[12]{2}=W$. Then, if the frequency of vibrations of the first tone of an octave be called 1, the frequencies coming next will be respectively represented by

$$1\ W\ W^2\ W^3\ W^4\ \ldots\ W^{11} \text{ and } W^{12}=2$$

It is obvious that all of these frequencies of vibrations, except the first and the last, are surd numbers, i. e. roots which cannot be represented in the shape of integral numbers nor as vulgar or decimal fractions. Therefore, they cannot be practically utilized, as only rational quantities can be dealt with.

When tuning an organ or a piano-forte one must necessarily rely on the skill of the tuner who has to provide for introduction of such ascending gradation into the organ reeds or into the strings.

A second drawback resides in the fact that in course of time, in a pianoforte, one or more of the strings may sink lower than the others, for instance, as a result of having been subjected to harder duty, and this causes the entire system of equal temperament to become unfit for service. On the other hand, tuning of an organ can be very easily disturbed through temperature changes (warm or cold) or as a result of the hygrometrical condition of the air.

These drawbacks which are indeed very serious ones, will be avoided, as will be explained hereinafter, by the use of the novel instrument described herein. It is based upon the same principle as a siren, whereby any volume of sound can be developed and music can be emitted so as to be heard a number of kilometres away.

As is known, the height of pitch of a siren depends on two factors, namely, the number of revolutions per unit of time imparted to it, and the number of openings provided upon a peripheral circle (or a cover circle) of the siren, which corresponds with a like number of openings in a stationary wall; the product of these two numbers is equal to the amount of thrusts of air originated.

Now, when trying to build up a musical instrument whose tones are to be obtained by means of sirens to be tuned with respect to one another in accordance with equal temperament, a difficulty arises in that irrational numbers of the equal temperament cannot possibly be expressed in the shape of rational values of the siren namely, the number of revolutions and the number of orifices.

A second drawback lies in the necessity of adapting twelve sirens for a single octave, whereby a very complicated construction is required, especially in the case of instruments comprising several octaves.

Now, these drawbacks are eliminated in the following manner by this present invention:

A. By an accurate calculation the irrational numbers are replaced by rational fractions which have these features:

(1) they are so little different from the irrational values that nobody's ear can detect the difference even if highly trained, and

(2) the numerators and denominators are such that they can be realized as a number of orifices provided in a siren or as the number of teeth of a gearwheel or a chain-wheel adapted for transmitting motion between shafts.

B. Every siren is so constructed as to emit, at will, two tones, and, as a result, a whole octave can be emitted by means of six sirens only.

To this effect, the interval of the minor third has been started from, say, the distance of two notes between which there are three half-tones; this interval is equal to $W^3$, i. e. to 1.18921 . . . . Now, this irrational number is capable of being replaced by the rational fraction 44/37 which is equal to 1.18919 . . . .

As the difference between 1.18921 and 1.18919 is less than 0.002 per cent, it can never be detected even by a highly trained ear.

This interval of 44:37 has been taken as a basis for building up all the sirens each of these having two rows which have respectively 37 and 44 orifices those in each row to be opened or closed at the operator's will.

Every siren will thus bring out a minor third. The remaining irrational values are also made to correspond to rational values, namely, in respect of the number of revolutions of the various siren shafts.

In the embodiment chosen as an example and shown in Fig. 2, the main shaft of the musical instrument is the shaft of the fourth siren to which the necessary velocity is imparted to cause it to emit the notes A and C. Whenever this shaft is caused to revolve at the rate of 12 revolutions per second, the lowest tone of the siren is given a frequency of vibration equal to 37×12, or 444, which is little more than the normal A for which the international number has been stated as 435. And, by slightly reducing the velocity of the main shaft (for which purpose one can, for example, insert a determined resistance in the electrical circuit of the motor whereby the sirens are caused to rotate), the practically permanent pitch of a normal A will be obtained. Moreover, it should be observed that the musical instrument emits pure music for any other number of revolutions of the main shaft provided such number be kept constant, for the other sirens will rotate always at a certain ratio dependent on the number of their revolutions with respect to those of the siren located upon the main shaft.

In the embodiment shown in Fig. 2, the octave has been assumed to start from middle D sharp and to run on to the next D above, each of the six sirens emitting both tones indicated by the notes in Fig. 2.

The velocity of rotation of the shafts of the five remaining sirens is obtained in the following manner, assuming (for easy comprehension) that the shaft of the fourth siren (tone A) is rotating one turn.

*First siren.*—This siren emits the two tones D sharp and F sharp. As there are six half-tones between D sharp and A, the interval D sharp:A can be represented by $1:W^6$. Calculation will show that this interval becomes equal to 0.707107 . . . . This irrational ratio can be replaced by the rational fraction 70/99 which corresponds to the decimal fraction 0.707071 . . . . So slight a difference cannot be detected even by the most highly trained ear. One must accordingly obtain the velocity desired for the first shaft by using a toothed wheel having 99 teeth and meshing with a toothed wheel having 70 teeth to be placed upon the main shaft. It will be explained hereinafter how this transmission and those following can be rendered still easier.

*The second siren.*—This siren emits the two tones E and G. As there are 5 half-tones between E and A, the interval E:A can be represented by $1:W^5$. It has been calculated that this interval becomes equal to 0.749154 . . . . It seems that this irrational ratio can be replaced by the fraction 221/295 which corresponds to the decimal fraction 0.749153 . . . .

It will be more thoroughly explained hereinafter how the ratio 221:295 can be easily arrived at, without the necessity of using gears with a large number of teeth.

*The third siren.*—This siren emits the two tones F and G sharp. Since there are 4 half-tones between F and A the interval F:A can be represented by $1:W^4$. It has been calculated that the decimal fraction for it becomes equal to 0.793701 . . . . This irrational ratio can be replaced by the fraction 50/63 the decimal value of which is 0.793651.

*The fifth siren.*—This siren emits the two tones A sharp and C sharp. As there is a half-tone between A sharp and A, the interval A sharp : A can be represented by W : 1. It has been calculated that this interval becomes equal to 1.059463 . . . . This irrational ratio can, in its turn, be replaced without giving rise to any trouble, by the fraction 196/185, the decimal value of which is 1.059460.

*The sixth siren.*—This siren emits the two tones B and D. As there are two half-tones between B and A, the interval B : A can be represented by $W^2$ : 1. It has been calculated that this interval becomes 1.12246 . . . . This irrational ratio can, without difficulty, be replaced by the fraction 59/49, the decimal value of which is 1.12245.

The ratios for the number of revolutions of the six shafts can be represented respectively by:

70/99 221/295 50/63 1 196/185 and 55/49

This result is diagrammatically shown in Fig. 2.

It has been experienced that, when dealing with such great speeds as must be applied here, the teeth of the chain-wheels should, preferably, not number less than 12 and not more than 24; and, in the case of gear-wheels, no wheel should have less than 50 teeth or so; if they have a substantially greater number of teeth, some of them become unfit for service owing to the considerable mass of those wheels. Furthermore, experience teaches us that, in the case of great speed, chain-wheels are better than gear-wheels as their operation is more resilient, on account of which it requires less power; therefore, it is advisable to use chain-wheels whenever possible.

All of the above named transmissions can be obtained without difficulty by resorting to double transmission consisting either of two pairs of chain-wheels or of one such pair and a gear-wheel-pair; all of these chain-wheels and gear-wheels will be in compliance with the requirements as above stated.

This is obvious from the following statement wherein the pairs of chain-wheels are designated by C and the pairs of gear-wheels by G:

$$\frac{70}{99}=\frac{14}{18}\ (C)\times\frac{20}{22}\ (C)$$

$$\frac{221}{295}=\frac{13}{15}\ (C)\times\frac{51}{59}\ (G)$$

$$\frac{50}{63}=\frac{15}{21}\ (C)\times\frac{20}{18}\ (C)$$

$$\frac{196}{185}=\frac{21}{15}\ (C)\times\frac{56}{74}\ (G)$$

$$\frac{55}{49}=\frac{15}{21}\ (C)\times\frac{22}{14}\ (C)$$

The sirens can be constructed in various ways. A feature of an embodiment consists in a drum which is rotatably mounted inside a stationary drum, these two drums fitting snugly one within the other and each having a pair of rows of openings containing respectively 37 and 44 orifices so placed as to permit coincidence of the like rows in both drums. Externally, round each of the rows of openings in the stationary drum there is a ring bored with a number of orifices equal to those of the drum it surrounds; each ring is connected with a key whereby rotary motion round the stationary drum in the plane of the orifices may be imparted to the ring, with the result that both rows of orifices provided in the stationary drum can be, opened or closed at will.

This is shown in Fig. 3, where *a* is the stationary drum provided with two rows of openings designated by *h* and *g* and having respectively 37 and 44 orifices. Another drum *b* fits inside the first one, and is capable of rotation therein, this second drum *b* having rows containing the same number of openings placed at the same height. The drum *b* is secured to a shaft *c* for rotation therewith. Round the other drum *a* and in front of the rows of openings there are rings *e* and *d* which are, to some extent, let into the drum *a* so that they can move in a fixed path. These rings are provided with the same number of orifices as the rows they surround; it is therefore, possible, by shifting the rings, to open or close to any extent and simultaneously all of the orifices pertaining to either row. Each ring is connected through an intermediate gearing with a key; the instrument can accordingly be played upon by means of a simple key-board.

What has been stated above in relation to an octave also applies with equal force to further octaves which it might be desired to give the instrument. It is quite easy to provide for an upper octave combined with the main octave in such a manner that all of the siren will be caused to rotate at a speed double that of the main octave.

One could, likewise, provide for a lower octave the cells of which could rotate at a speed half of that of the main octave adjacent to it. One could, finally have a bass octave the sirens of which would be rotated at a speed half of that of the middle octave, i. e. four times slower than the speed of the main octave.

Having thus particularly described and ascertained the subject-matter of this present invention and in what manner the same is to be performed, I declare that what I claim as new and desire to secure by Letters Patent, is:—

1. In a musical instrument having a plurality of octaves, the combination of six rotatable members for each octave, each member having two rows of openings containing respectively thirty-seven and forty-four orifices, and means for opening and closing the

orifices of either row independently of those of the other row, the individual members being intergeared with each other so that the ratio of rotation of the first, second, third, fifth and sixth members with relation to the rotation of the fourth member will be respectively 70:99, 221:295, 50:63, 196:185 and 55:49.

2. In a musical instrument having a plurality of octaves, the combination of six tone-emitting members for each octave, each of said members comprising a stationary drum and a drum mounted for rotation within said stationary drum, both of said drums having a pair of rows of openings containing respectively thirty-seven and forty-four orifices, the orifices of one drum being adapted to register with those of the other drum, rings shiftably mounted on said stationary drum in encircling relation to each of said rows of openings, each of said rings having orifices adapted to register with those of the drum, said rings being shiftable to close the drum orifices, said tone-emitting members being intergeared with each other so that the ratio of rotation of the first, second, third, fifth and sixth members with relation to the rotation of the fourth member will be respectively 70:99, 221:295, 50:63, 196:185, and 55:49.

In testimony whereof, I have signed my name to this specification at the Hague, the Netherlands, this 28th day of August, 1929.

ABRAHAM DIRK LOMAN, Junior.