

Jan. 2, 1951

F. L. DODD
ELECTRONIC CARILLON

2,536,800

Filed Sept. 24, 1946

3 Sheets-Sheet 1

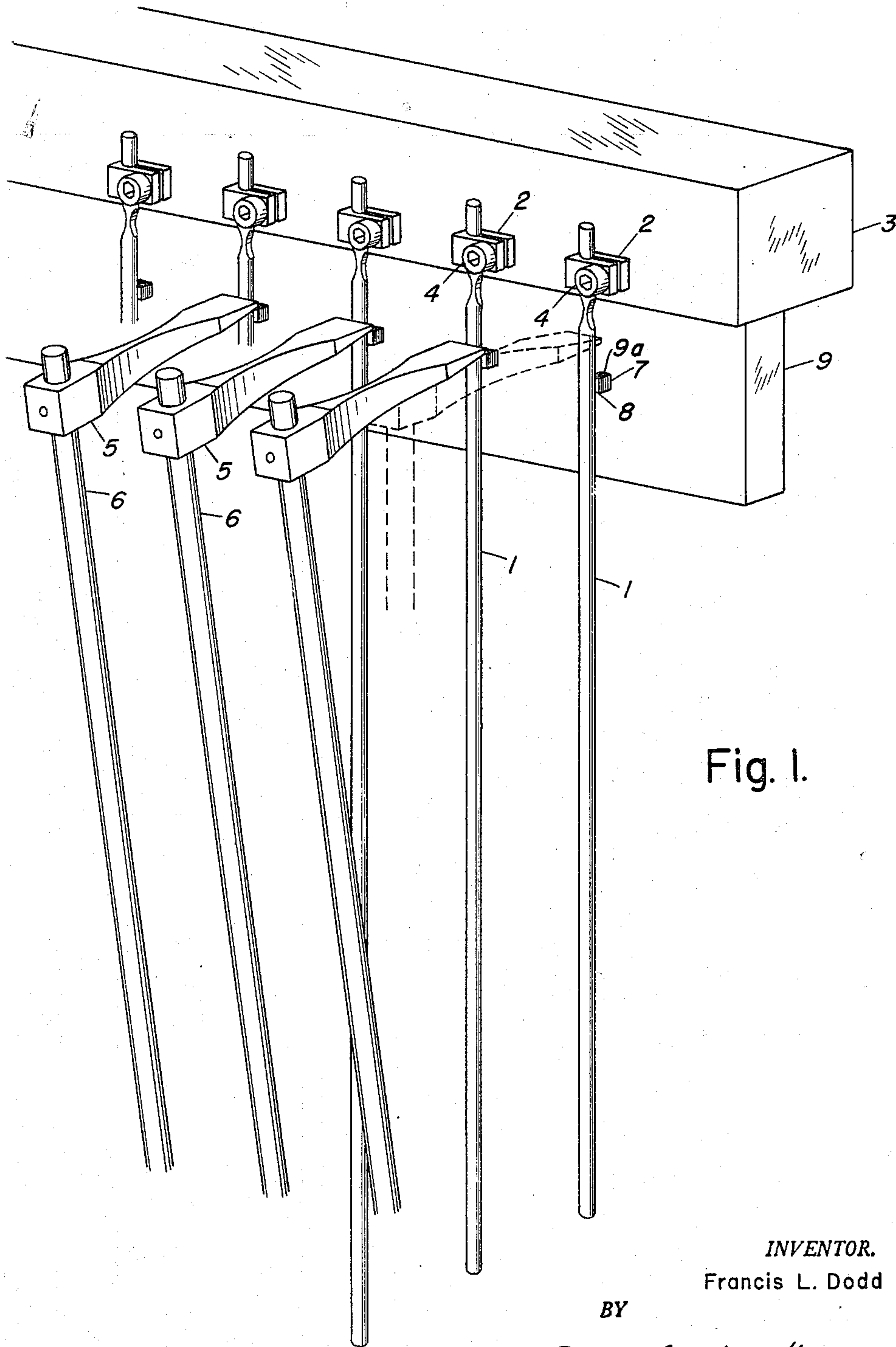


Fig. 1.

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3 Sheets-Sheet 2

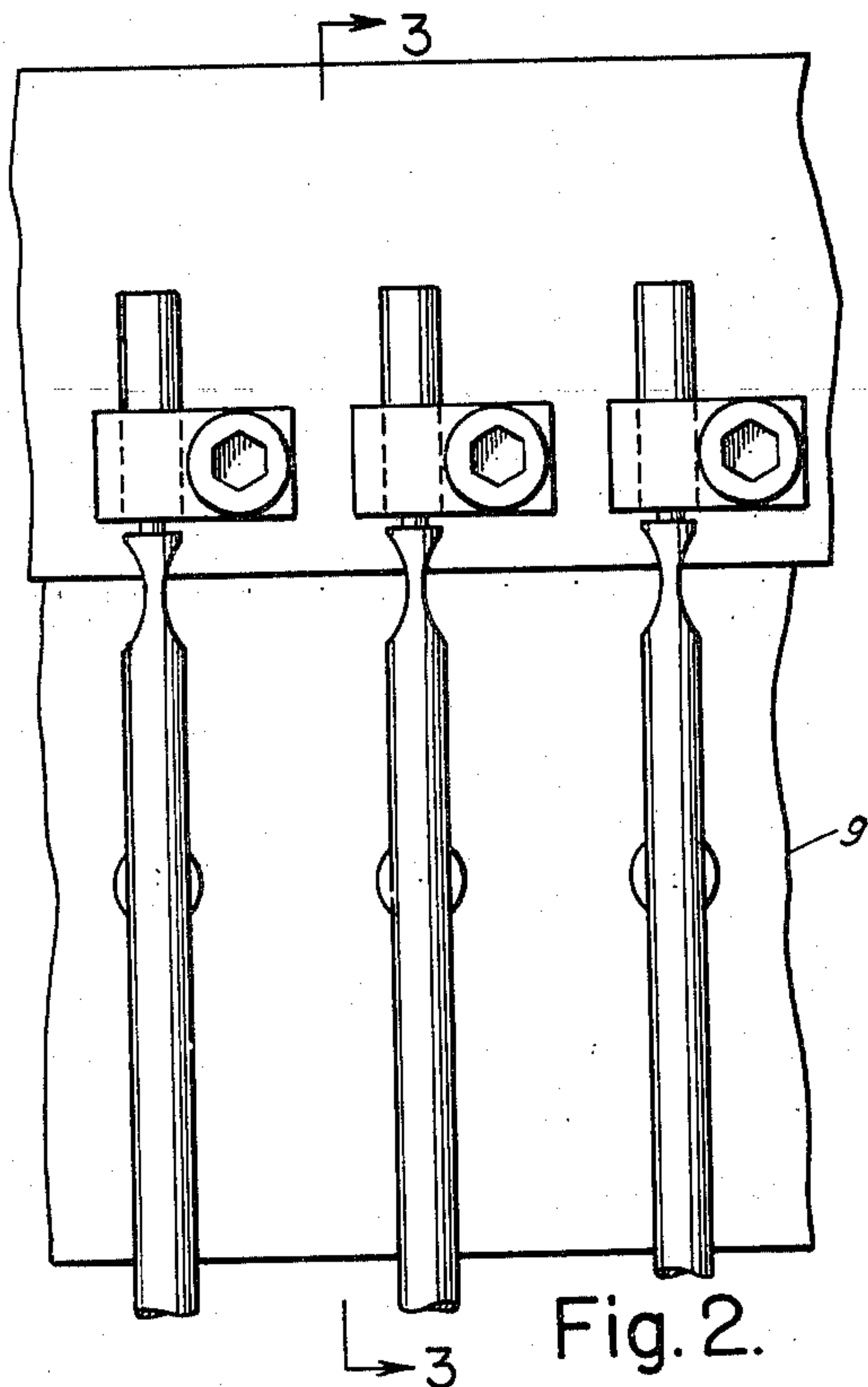


Fig. 2.

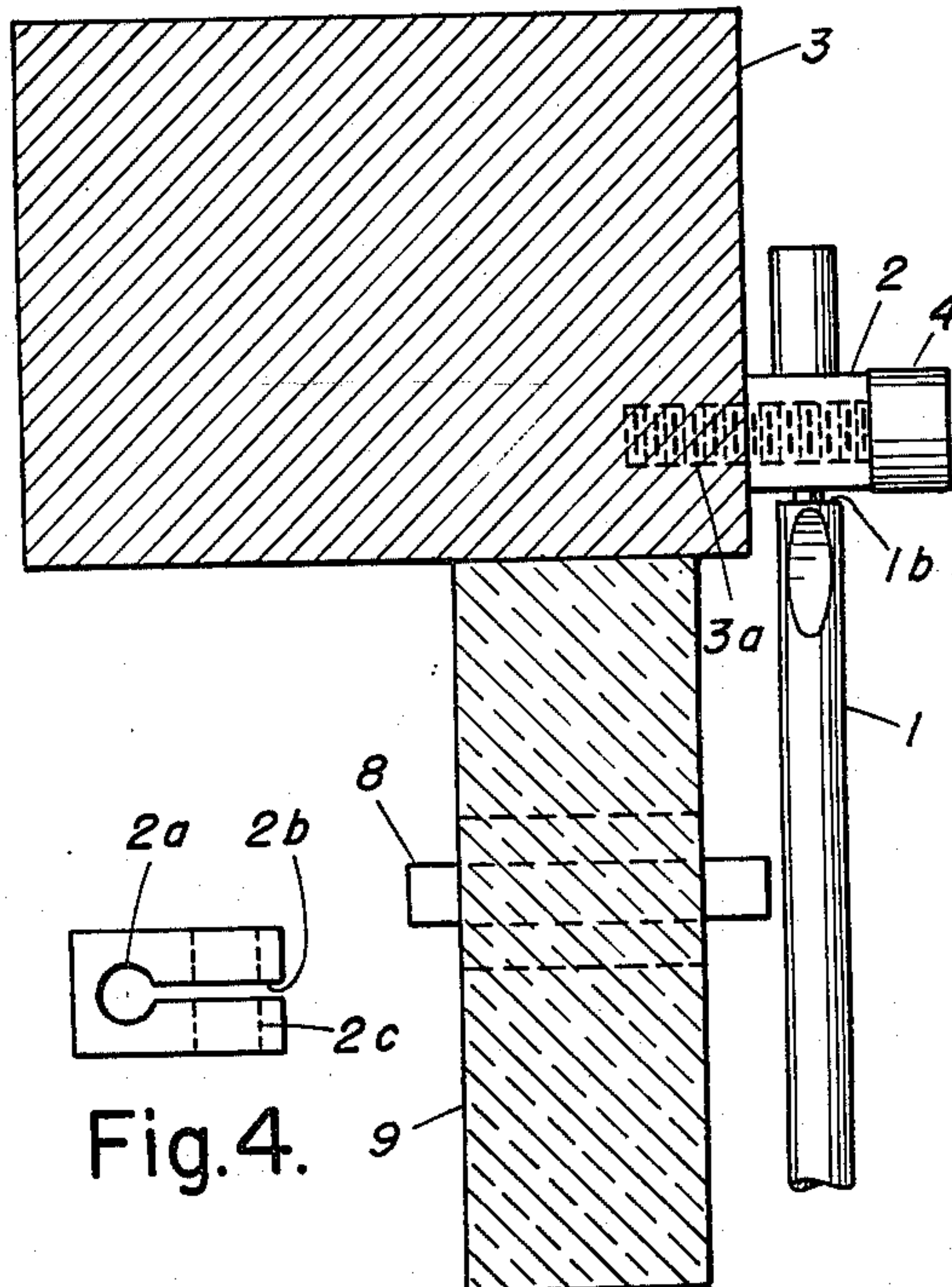


Fig. 3.

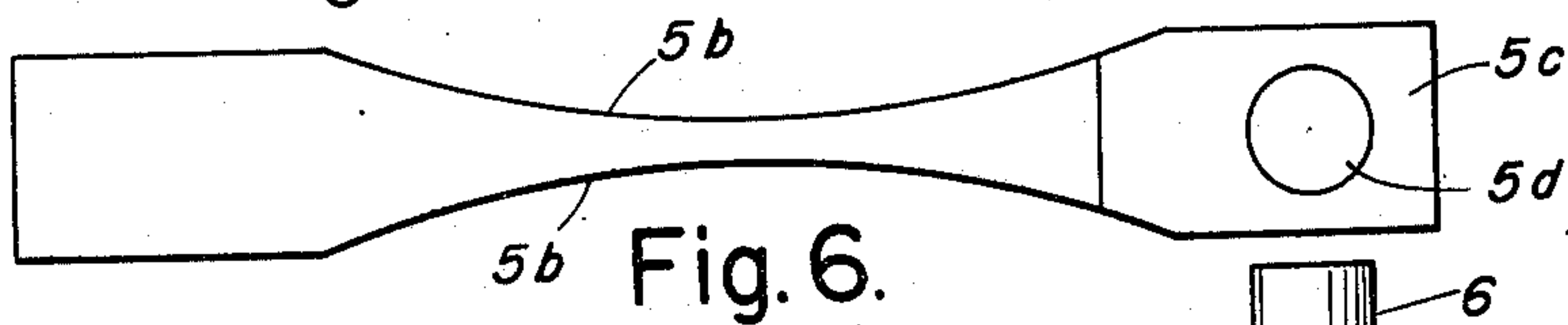


Fig. 6.

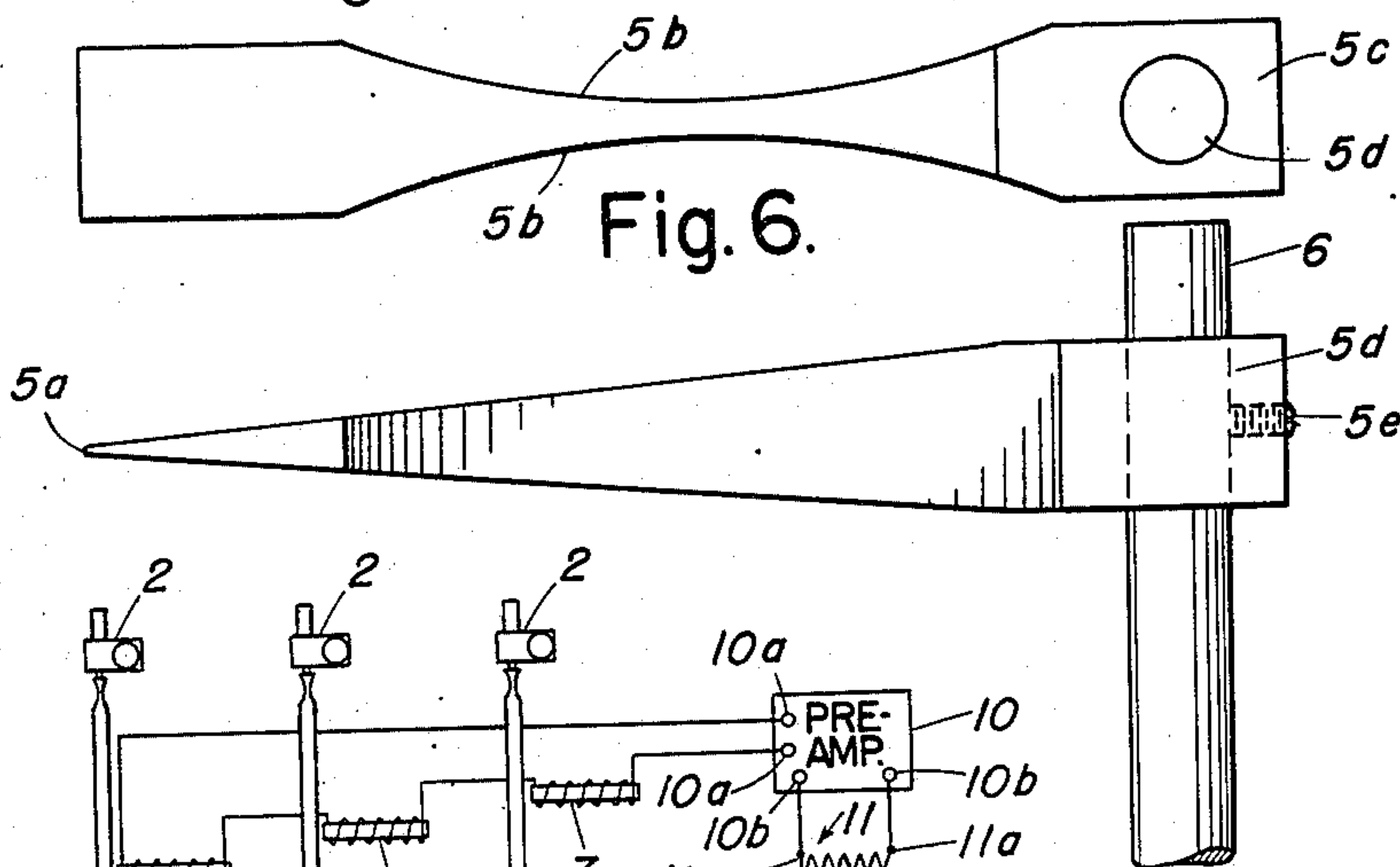


Fig. 7.

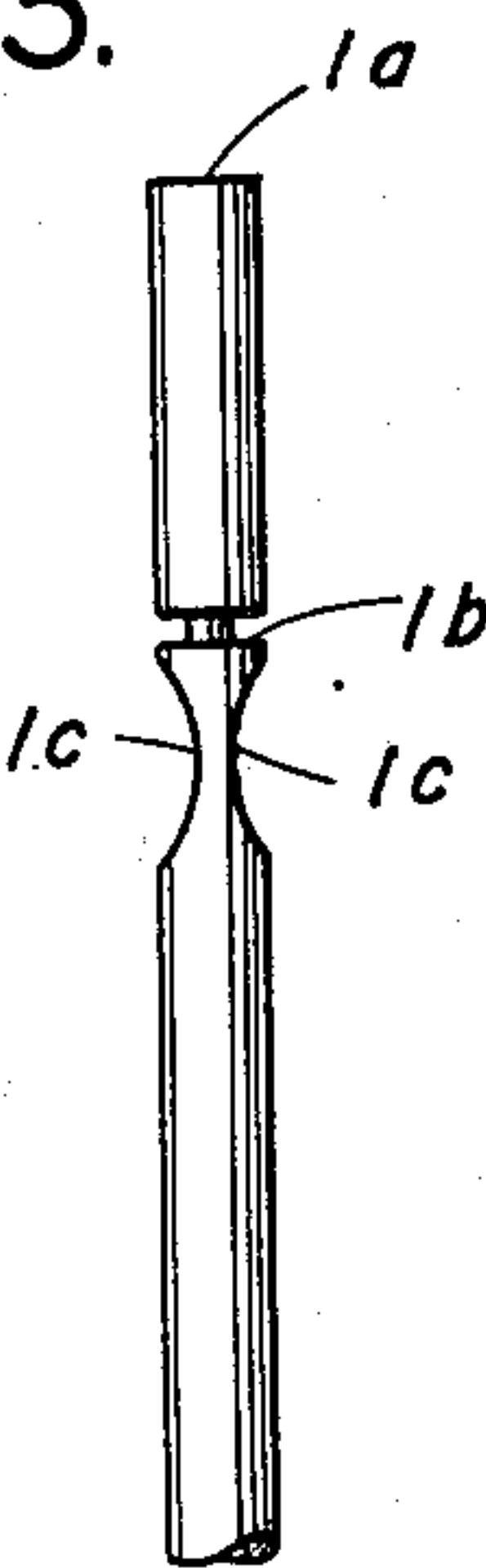


Fig. 5.

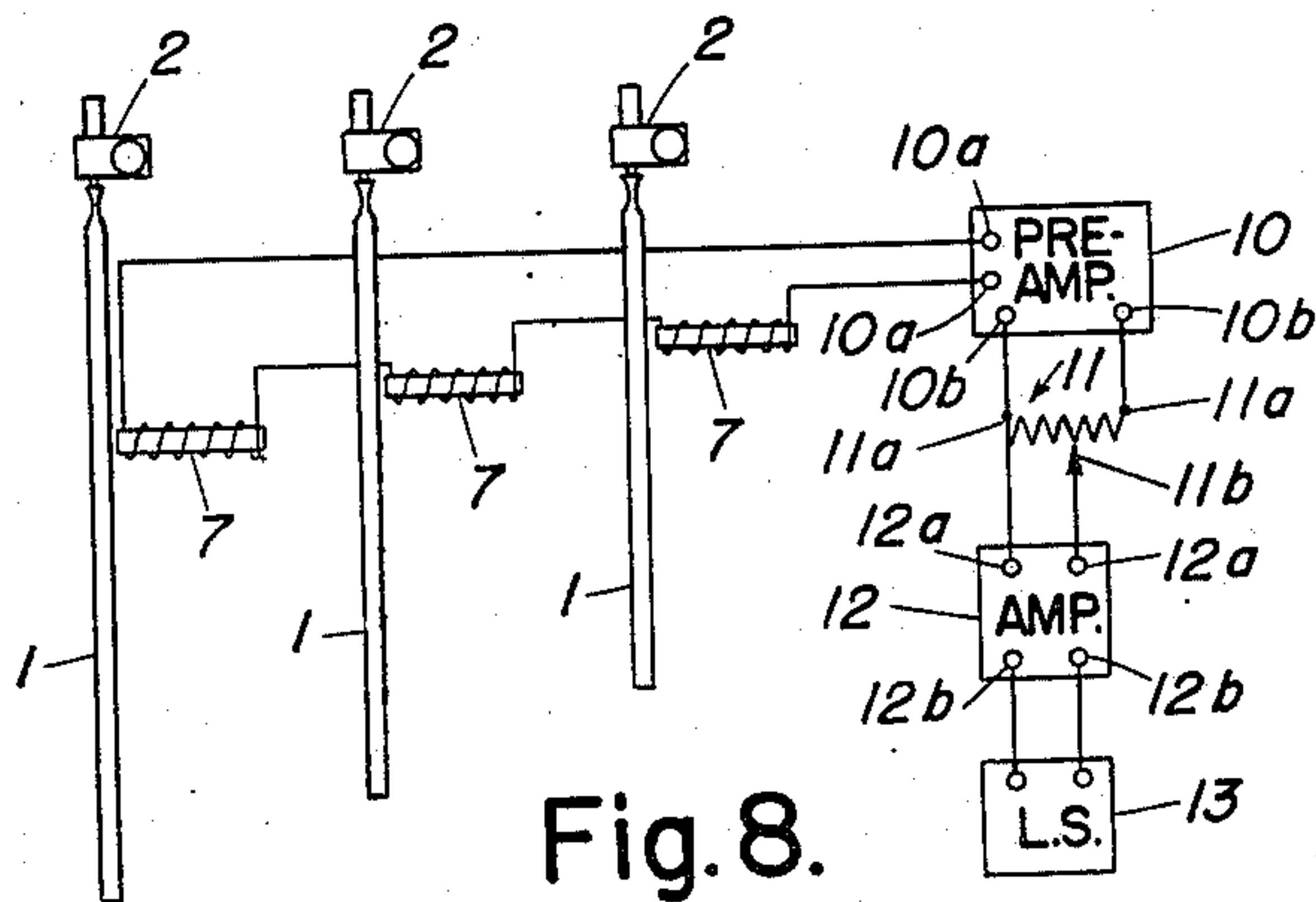


Fig. 8.

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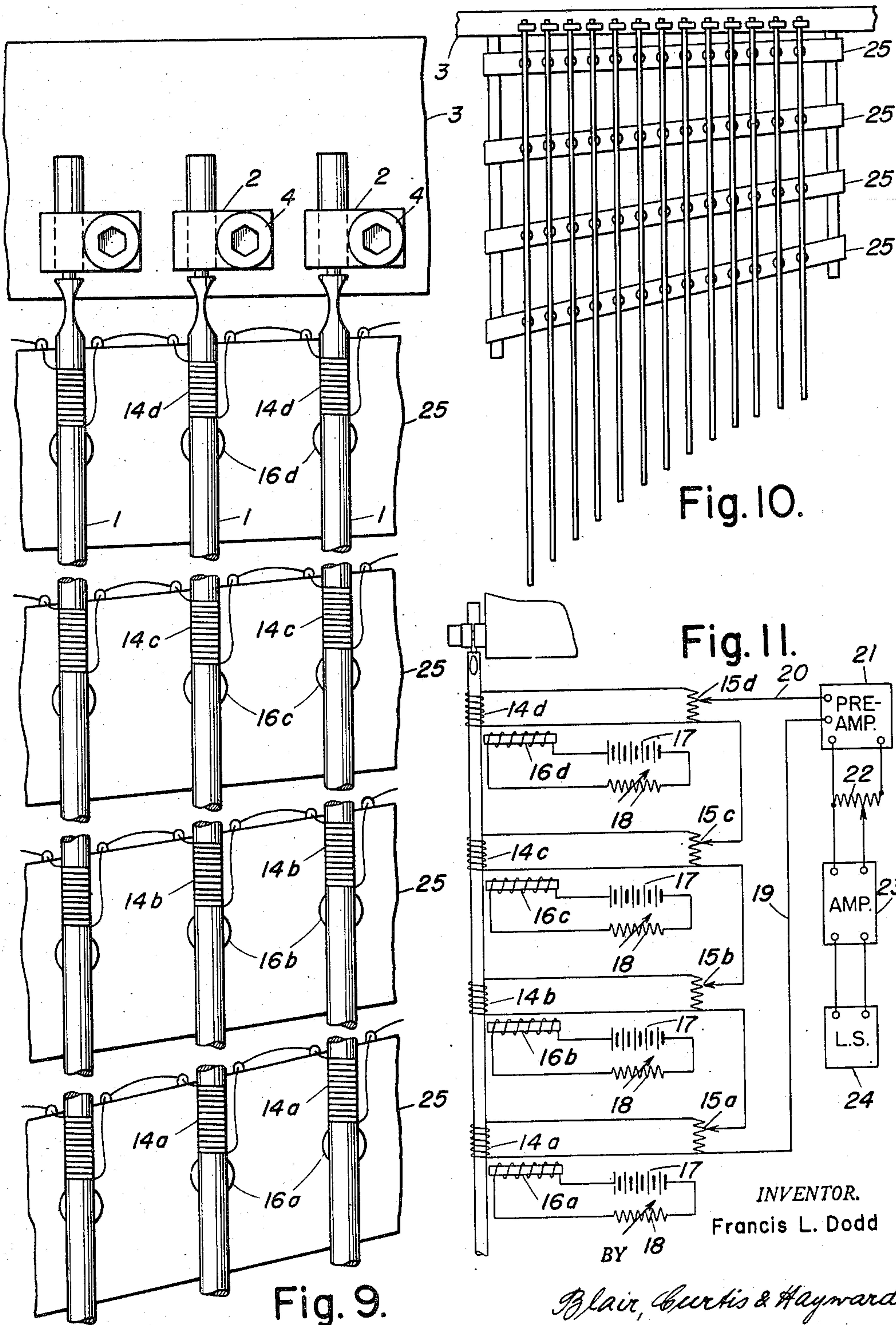


Fig. 10.

Fig. 11.

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2,536,800

ELECTRONIC CARILLON

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Company, a corporation of New York

Application September 24, 1946, Serial No. 698,941

13 Claims. (Cl. 84—1.15)

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This invention relates to electronic carillons, i. e. musical instruments in which the oscillations of tuned mechanical vibrating elements are translated into corresponding electrical signals, amplified and converted into sound waves.

It is among the objects of this invention to provide an electronic musical instrument capable of producing tones closely duplicating those of tuned bells. It is also an object of this invention to provide a musical instrument capable of producing tones of widely variable timbre. Another object is provision of a carillon which may be easily played. Another object is that of providing a musical instrument which is relatively small and which may be easily installed. A further object is provision of a carillon which may be economically constructed. Other objects will be in part obvious and in part pointed out hereinafter.

The invention accordingly consists in the features of construction, combinations of elements, and arrangements of parts, all as will be illustratively described herein, and the scope of the application of which will be indicated in the following claims.

Figure 1 is a fragmentary perspective view of a musical instrument embodying features of my invention;

Figure 2 is a fragmentary elevation showing the method of support of the vibrating elements;

Figure 3 is a transverse sectional view along line 3—3 of Figure 2;

Figure 4 is a plan view of one of the mounting lugs;

Figure 5 is a fragmentary elevation of one of the vibrating elements;

Figure 6 is a plan view of one of the hammers;

Figure 7 is an elevation view of the part shown in Figure 6;

Figure 8 is a combined elevational and schematic view showing diagrammatically the electrical apparatus employed for translation in this embodiment;

Figure 9 is a broken elevation of a portion of another embodiment of my invention;

Figure 10 is a full elevation of that portion of the instrument shown in Figure 9; and

Figure 11 is a combined plan and schematic view showing diagrammatically the electrical apparatus employed for translation in the instrument shown in Figures 9 and 10.

The conventional type of carillon, i. e. a system of tuned bells with clappers operable from a central position through a chain of mechanical linkages, has several disadvantages; it is inflexi-

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ble as to pitch and timbre; its great cost makes it unavailable to many churches, schools and public groups; its cumbersome bulk not only makes installation difficult, but limits the number of buildings capable of properly supporting and housing it; it also is restricted as to separation and relative placement of the console and bell loft; its operation requires considerable manual force; and finally, as is any mechanical system, it is vulnerable to rust, wear and similar disorders.

In order to duplicate the tones of bells, it is necessary to create sounds of identical wave form. The wave form of the sounds emitted by bells is complex and aperiodic (not cyclic), consisting of a fundamental (the lowest frequency present) and a finite number of non-harmonic overtones (higher frequencies not even multiples of the fundamental). The fundamental and the various overtones may each be termed a "partial" of the composite tone. The frequency of the fundamental principally determines the pitch of the bell and the frequencies and relative amplitudes of the overtones determine its timbre.

The fundamental frequency in the mode of vibration of a rod supported at one end depends principally upon its mass and its stiffness. A rod thus can be tuned to the proper fundamental by some simple expedient as cutting or grinding away portions of its free end (decreasing its mass) until the desired frequency of vibration is achieved. The timbre of the rod, however, is more unalterably inherent in the rod, being governed not only by its mass and stiffness but by such factors as its shape, its method of support, etc.

The novel conformation, arrangement and combination of elements in the embodiments shown contribute to a mode of oscillation similar to that of bells.

The embodiment shown in Figures 1, 2 and 3, comprises a plurality of metallic rods 1 of tuned lengths, the upper ends of which are clamped by metal lugs 2 which are secured along one side of a metal bar 3 by machine screws 4 passing through lugs 2 into tapped holes 3a in bar 3.

Positioned opposite rods 2 is a plurality of hammers 5 mounted on pivoted dowels 6; hammers 5 are arranged to be selectively actuated to strike rods 1 from a keyboard through a chain of mechanical linkages similar to that employed in conventional pianos. A plurality of coils 7 wound on magnetic cores 8 is supported adjacent rods 1 in such manner that each of the coils 7 registers with one of the rods 1. Vibration of rods 1

causes variation of the flux linking the turns of coils 7 which induces in coils 7 electrical oscillations according to the mode of vibration of rods 1. Coils 7 are electrically connected in series to the input terminals 10a of a pre-amplifier 10. The terminals 11a of a potentiometer 11 are connected across the output terminals 10b of pre-amplifier 10; one of the terminals 11a is also connected to one of the input terminals 12a of a second amplifier 2; the tap 11b of potentiometer 11 is connected to the other input terminal 12a of amplifier 12; the position of tap 11b thus determines the fraction of the total output of pre-amplifier 10 which is applied across the input of amplifier 12 and thereby controls their overall amplification. The output terminals 12b of amplifier 12 are connected to a loud-speaker 13 which transforms the amplified oscillations into sound waves.

Each of the rods 1, as shown in greater detail in Figure 5, is of round cross-section; a short distance below its upper end 1a is a circumferential groove 1b; the rod is normally mounted so that groove 1b is just below the point of suspension of the rod as shown in Figures 2 and 3; this reduction of the cross-sectional area of the rod allows use of thicker rods without increasing the effective elastic restoring force (stiffness) of the rods; the use of thicker rods allows them to be struck briskly, duplicating the audible impact of a bell clapper; this also affords a wide variation of impact force which enables more expressive playing.

Just below groove 1b are two opposed depressions 1c. These give rod 1 an oblong cross-sectional shape and lowers the partial frequencies with respect to the fundamental frequency without appreciably affecting the stiffness of rod 1. In other words, the depressions 1c enable correction of the vibrational response of the rods.

The lengths of the rods are tuned to a tempered chromatic scale.

Coils 7 and cores 8 are so positioned that each coil and core registers with one of the rods 1 a distance below the point of suspension of the rod which is roughly proportional to its length. Theoretically, the point of suspension of a rod is a nodal point—point of minimum vibration—for each of the partials in the mode of vibration of the rod. Actually, however, the first nodal point for each partial is slightly below the point of suspension, possibly due to the fact that the upper end of the rod cannot be clamped with perfect rigidity. The first nodal points of all the partials in the rod fall within a comparatively limited portion of the length of the rod near the point of suspension. Coils 7 register with the rods just below this common nodal area. In practice the position of the coils is adjusted while listening to the output of the instrument. Placement of the coil opposite a point too high on the rod will result in too low an output volume; placement too low will cause an audible rapid beating or pulsing of the output tone—a phenomenon which has been descriptively termed "wobulation." Coils 7 and cores 8 are mounted in holes 9a drilled through an insulating bar 9 which may be secured underneath bar 3 in any suitable manner.

Lugs 2, as shown in Figure 4, are metallic blocks, each having a vertical bore 2a to admit the upper end 1a of rod 1, a vertical slit 2b extending from one side of lug 2 and communicating with vertical bore 2a, and a horizontal bore 2c through the two legs formed in lug 2 by slit 2b. The shank of bolt 4 passes through horizontal bore 2c into bar 3; when bolt 4 is tight-

ened, it compresses the legs of lug 2 causing the upper end of rod 1 to be tightly clamped.

Hammers 5, shown in Figures 6 and 7, are of elongated shape, tapering in cross-section in the vertical plane to a thin striking face 5a; in the horizontal plane they are substantially rectangular with two opposed concave depressions 5b. The butt 5c of hammer 5 is traversed by a vertical bore 5d through which is admitted the upper end of dowel 6. Hammer 5 is secured in position on dowel 6 by a set screw 5e threaded through butt 5c and bearing on dowel 6.

The hammers are positioned so that they strike their respective rods just below depressions 1c, as shown in dotted lines in Figure 1.

Rather inexplicably, this method of supporting and striking the rods enables production of tones closely duplicating the tones of tuned bells.

The duration of the tones has been found to be affected by the mass of bar 3—a light bar causes rapid damping of the vibration of the rods (possibly due to dissipation of energy by vibration of the bar); a heavier bar results in more sustained vibration. The mass of bar 3 has been selected to maintain the tones of the instrument for the time optimum in playing of average rapidity.

In Figures 9, 10 and 11 is shown another embodiment of my invention. This instrument comprises rods 1, lugs 2 and bar 3 of the same construction and arrangement as the corresponding components of the embodiment hereinbefore described. It also includes like hammers mounted and actuated in similar manner as in the above embodiment.

The instrument shown in Figures 9, 10 and 11 comprises in addition to the elements mentioned, four coils 14a, 14b, 14c and 14d which are wound on each of the rods and spaced along the rod so that each coil is at a node of transverse vibration of one of the partials in the mode of vibration of the rod. In practice, these coils are positioned in the following manner: a rod 1 is mounted in a test jig and tuned to the proper frequency by cutting or grinding away portions of its lower end while "beating" (or comparing) its tone with a standard. Then the rod is excited by a solenoid placed in the region of the common nodal points (near the point of suspension), the solenoid being energized by the output of a variable-frequency audio oscillator. As the frequency of the oscillator is varied, the rod will be set into vigorous vibration at certain frequencies—the frequencies corresponding to partials in the natural mode of the rod. At the four lowest of these sensitive frequencies, the nodes of transverse vibration are located by some simple test such as running the finger up the rod—at other than nodal points, pressure of the finger against the rod will restrain the transverse vibration; when pressed at nodal points the rod will continue to vibrate despite the pressure against it. Coil 14a is placed adjacent a node of the lowest partial used in the rod, coil 14b is placed adjacent a node of the next higher partial in the rod, and so on. For the higher partials, several nodal points along the rod may be found. Generally, that node will be chosen for each partial which will allow convenient spacing from the chosen nodes of the other partials, being consistent in all rods of a given instrument to facilitate interconnection between the coils.

Only the four lowest partials in the mode of

vibration of the rods have been used. Any number of partials may be reproduced, of course. However, since the higher partials are of lesser amplitude, their use would give diminishing benefit. The coils 14a at nodes of the lowest partials in the rods are electrically connected in series, the coils 14b at the nodes of the next higher partials are likewise connected in series, and so on. The coils in a series are thus positioned adjacent nodes of partials which bear similar relations to the composite modes of their respective rods.

These coils being thus wound directly on rods 1 will not detect the transverse vibration of the rods—only longitudinal vibrations will induce signals in them.

The series of coils 14a is connected to the terminals of a potentiometer 15a and likewise the series of coils 14b are connected across the terminals of a potentiometer 15b and so on. One end of potentiometer 15a is connected to one of the input terminals of a pre-amplifier 21 by conductor 19; the tap of potentiometer 15a is connected to one end of potentiometer 15b, the tap of potentiometer 15b is connected to one end of potentiometer 15c, the tap of potentiometer 15c is connected to one end of potentiometer 15d; and the tap of potentiometer 15d is connected to the other input terminal of preamplifier 21 by conductor 20. Variable portions of potentiometers 15a, 15b, 15c and 15d are thus connected in cascade across the input of pre-amplifier 21, so that the signals induced in the various series of coils may be combined in variable ratio depending on the respective settings of the potentiometers 15a, 15b, 15c and 15d; the composite signal is impressed on the input of pre-amplifier 21. Variation of this ratio of combination varies the relative amplitude of the partials in the composite tone, which varies the timbre of the tone. An almost infinite number of ratios of combination is possible; thus a wide range of tonal quality can be achieved.

The output of pre-amplifier 21 is connected across a potentiometer volume control 22; the input of an amplifier 23 is tapped across a variable portion of potentiometer 22; and the output of amplifier 23 is connected to a loud-speaker 24, so that the signal will be amplified by pre-amplifier 21, controlled as to volume by potentiometer 22, further amplified by amplifier 23, and converted into audio tones by speaker 24, in like manner as in the embodiment previously described.

Adjacent each of the rods 1 are four electromagnets 16a, 16b, 16c, and 16d comprising coils wound on soft iron cores. They are so positioned that electromagnet 16a registers with the rod just below coil 14a, electromagnet 16b is just below coil 14b, and so on.

Electromagnets 16a (three of which are shown in Fig. 9) are electrically connected in series, electromagnets 16b are likewise connected in series, and so on. There are thus four series of electromagnets, the electromagnets of a series being positioned adjacent the coils of a series.

For clarity, only one of the rods 1 has been shown in Figure 11; it will be understood, however, that each coil 14a-d in Figure 11 represents a plurality of coils in series, each wound on one of the rods 1 and spaced along said rod at a node of transverse vibration of one of the partials in the mode of vibration of the rod, and each electromagnet 16a-d represents a plurality of electromagnets in series, each of the electro-

magnets in a series being positioned adjacent one of the coils in a series. Each of the four series of electromagnets are provided with a source of current, such as a battery 17, and a rheostat 18 for controlling the amplitude of the current flowing through the electromagnets of the series. As shown in Figure 10, the electromagnets of a series may be mounted in a bar of insulating material 25, the four bars 25 being arranged so that the electromagnets will be properly positioned in relation to their respective rods.

Energization of one of the electromagnets has the effect of increasing the intensity of magnetization of the rod 1 to which the electromagnet is adjacent, augmenting the intrinsic magnetization of the rod. Transverse vibration of the rod, which varies the spacing of the rod from the electromagnet, causes variation in this supplemental magnetization. Since the amplitude of the signals induced in coils 14a-d by longitudinal vibration of the rod is proportional to the effective magnetization of the rod, the signals induced in the coils are the product not only of the longitudinal vibration but of the transverse vibration as well. The signal thus induced in the coils constitutes the longitudinal mode of vibration of the rod modulated by its horizontal mode. The effect is to lower the apparent pitch of the partial adjacent whose node the electromagnet is positioned, and to cause this partial to be more sustained. Since there is an independently variable source of current for the electromagnet adjacent a node of each of the four lowest partials, the pitch of the partials may be selectively lowered and sustained. Thus not only can the relative amplitudes of the partials be altered but their frequency can be varied. This allows virtual "building" of any tone desired within wide limits.

There will thus be seen to be provided instruments capable of achieving the aforementioned objects.

Many possible embodiments may be made of the above invention, all without departing from the scope of the invention. For example, electromagnets 16a to 16d, inclusive, may be replaced by permanent magnets, or rods 1 may be permanently magnetized, and coils 14a to 14d, inclusive, may be placed adjacent rods 1 instead of in encircling relation thereto. It is to be understood that all matter hereinbefore set forth or shown in the accompanying drawings is to be interpreted as illustrative and not in a limiting sense.

I claim:

1. A musical instrument of the class described including: a metallic mass, a plurality of magnetized rods tuned to various frequencies of vibration and having one end secured to said mass, means for selectively actuating said rods, an electrical circuit magnetically coupled to said rods whereby electrical signals are induced in said circuit by the vibration of said rods, and means for converting said signals into audio tones, said magnetized rods being magnetized independently of said coupled circuit whereby the intrinsic magnetization of said rods is augmented independently of said electrical circuit and said vibration of said rods.

2. A musical instrument of the class described including: a metallic bar, a plurality of rods tuned to various frequencies of vibration and having one end secured to said bar, means for selectively actuating said rods, a coil with a magnetized core adjacent each of said rods whereby electrical signals are induced in said coils by the movement of said rods, means inde-

pendent of said coils for magnetizing said rods independently of said coils and said movement of said rods, means for amplifying said signals, and a loud-speaker for converting said signals into sound waves.

3. A musical instrument of the class described including: a metallic bar, a plurality of rods tuned to various frequencies of vibration and having one end secured to said bar, means for selectively actuating said rods, a coil with a magnetized core registering with each of said rods and spaced below the point of suspension of said rod a distance proportional to the length of said rod whereby electrical signals are induced in said coils by the movement of said rods, means independent of said coils for magnetizing said rods independently of said coils and said movement of said rods, an audio-frequency amplifier for amplifying said signals, means for controlling the output volume of said amplifier, and a loud-speaker for converting said signals into audio tones.

4. A musical instrument of the class described including: a metallic bar, a plurality of metallic lugs mounted on said bar, a plurality of magnetized rods tuned to various frequencies of vibration and clamped at one end by and depending from said lugs, each rod having a circumferential groove and two opposed depressions subjacent its point of suspension, a plurality of elongated metallic hammers tapering in cross-section in one plane to a relatively thin striking edge and generally rectangular with two opposed depressions in cross-section in a perpendicular plane mounted adjacent said rods and operable to strike said rods, a coil with a magnetized core registering with each of said rods a distance below the point of suspension of said rod proportional to the length of said rod, whereby electrical signals are induced in said coils by the movement of said rods, an audio-frequency amplifier for amplifying said signals, means for controlling the output volume of said amplifier, and a loud-speaker for converting said signals into audio tones of desired quality.

5. A musical instrument of the class described including: a metallic mass, a plurality of magnetized rods tuned to various frequencies of vibration and having one end secured to said mass, means for imparting motion to said rods, a plurality of series of coils, one coil of each said series being wound around each of said rods in such a manner that there will be induced in the coils of a series electrical signals of similar overtone content, means for combining in variable ratio the signals induced in the several said series of coils, and means for converting said signals into audio tones.

6. A musical instrument of the class described including: a metallic mass; a plurality of magnetized rods tuned to various frequencies of vibration, having one end secured to said mass; a hammer supported adjacent each of said rods and operable to strike said rod; means for selectively actuating said hammers; a plurality of coils wrapped around each of said rods and spaced longitudinally thereon so that each coil is at a node of transverse vibration of one of the partials in the natural mode of vibration of said rod, the coils at the nodes of the lowest of such partials in the rods being electrically connected in series, the coils at the nodes of the next higher partials being likewise connected in series, and so on; means for combining in variable ratio the signals induced in the said several series of coils;

an audio amplifier for amplifying said signals; means for controlling the amplitude of the output of said amplifier; and a loud-speaker for converting said signals into sound waves.

7. A musical instrument of the class described including: a metallic mass; a plurality of magnetized rods tuned to various frequencies of vibration and having one end secured to said mass; a hammer mounted adjacent each of said rods and operable to strike said rod; means for selectively actuating said hammers; a plurality of coils around each of said rods and spaced longitudinally thereon so that each coil is at a node of transverse vibration of one of the partials in the natural mode of vibration of said rod, the coils at the nodes of the lowest of such partials in the rods being electrically connected in series, the coils at the nodes of the next higher partials being likewise connected in series, and so on; means for combining in variable ratio the signals induced in the said several series of coils; an audio amplifier for amplifying said signals; means for controlling the amplitude of the output of said amplifier; a loud-speaker for converting said signals into sound waves; a plurality of electromagnets magnetically coupled with each of said rods and spaced longitudinally thereof so that each of said electromagnets is adjacent one of said coils, the electromagnets adjacent the coils of a series being likewise connected in series; and a variable source of electrical current for each of such series of electromagnets.

8. A musical instrument of the class described including: a metallic bar; a plurality of metallic lugs mounted on said bar; a plurality of magnetized rods tuned to various frequencies of vibration and being clamped at one end by and depending from said lugs, a plurality of elongated metallic hammers tapering in cross-section in one plane and generally rectangular with two opposed depressions in cross-section in a perpendicular plane, a plurality of keys interconnected with said hammers for selectively actuating said hammers, a plurality of coils wrapped around each of said rods and spaced longitudinally thereon so that each coil is at a node of transverse vibration of one of the partials in the natural mode of vibration of said rod, the coils at the nodes of the lowest of such partials in the rods being likewise connected in series, and so on; means for combining in variable ratio the signals induced in the several said series of coils; an audio amplifier for amplifying said signals; means for controlling the amplitude of the output of said amplifier; a loud-speaker for converting said signals into audio tones; a plurality of electromagnets adjacent each of said rods and spaced longitudinally thereof so that each of said electromagnets is adjacent one of said coils, the electromagnets adjacent the coils of a series being likewise connected in series; and a variable source of electrical current for each of said series of electromagnets.

9. In a musical instrument of the class wherein the oscillations of tuned vibrating elements of magnetic material are translated into electrical signals, amplified and converted into sound waves, means for translating the oscillations of said vibrating elements into electrical signals comprising a plurality of coils each wound on a magnetic core and positioned adjacent a common area of nodal points of the partials set up in one of said vibrating elements, and a magnet adjacent each vibrating element in the vicinity of each of said coils.

10. In a musical instrument of the class wherein the oscillations of tuned vibrating elements of magnetic material are translated into electrical signals, amplified and converted into sound waves, means for translating the oscillations of said vibrating elements into electrical signals comprising a plurality of coils around each of said vibrating elements and placed at different points along the length thereof, and means for varying the wave form of the signals induced in said coils by combining said signals in variable ratio, and a magnet adjacent each vibrating element in the vicinity of each of said coils.

11. In a musical instrument of the class wherein the oscillations of tuned vibrating elements of magnetic material are translated into electrical signals, amplified and converted into sound waves, means for translating the oscillations of said vibrating elements into electrical signals comprising a plurality of coils around each of said vibrating elements and placed along said vibrating element so that each coil is adjacent a node of transverse vibration of one of the partials in the mode of vibration of said element and means for varying the wave form of the signals induced in said coils by combining said signals in variable ratio, and a magnet adjacent each vibrating element in the vicinity of each of said coils.

12. In a musical instrument of the class wherein the oscillations of tuned vibrating elements of magnetic material are translated into electrical signals, amplified and converted into sound waves, a plurality of electromagnets adjacent each of said vibrating elements for augmenting the intrinsic magnetization of said elements, a variable source of electrical current for each of said electromagnets, and a pick-up device adjacent each electromagnet responsive to vibra-

tions for translating vibrations into electric signals.

13. In a musical instrument of the class wherein the oscillations of tuned vibrating elements of magnetic material are translated into electrical signals, amplified and converted into sound waves, a plurality of electromagnets adjacent each of said vibrating elements and spaced along said element so that each of said electromagnets is adjacent a node of transverse vibration of one of the partials in the mode of vibration of said element, a variable source of electrical current for each of said electromagnets, and a pick-up device adjacent each electromagnet responsive to vibrations for translating vibrations into electric signals.

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