

July 8, 1930.

A. P. DAVIS

1,769,988

SYNCHRONIZING APPARATUS

Filed Feb. 5, 1927

Fig. 1,

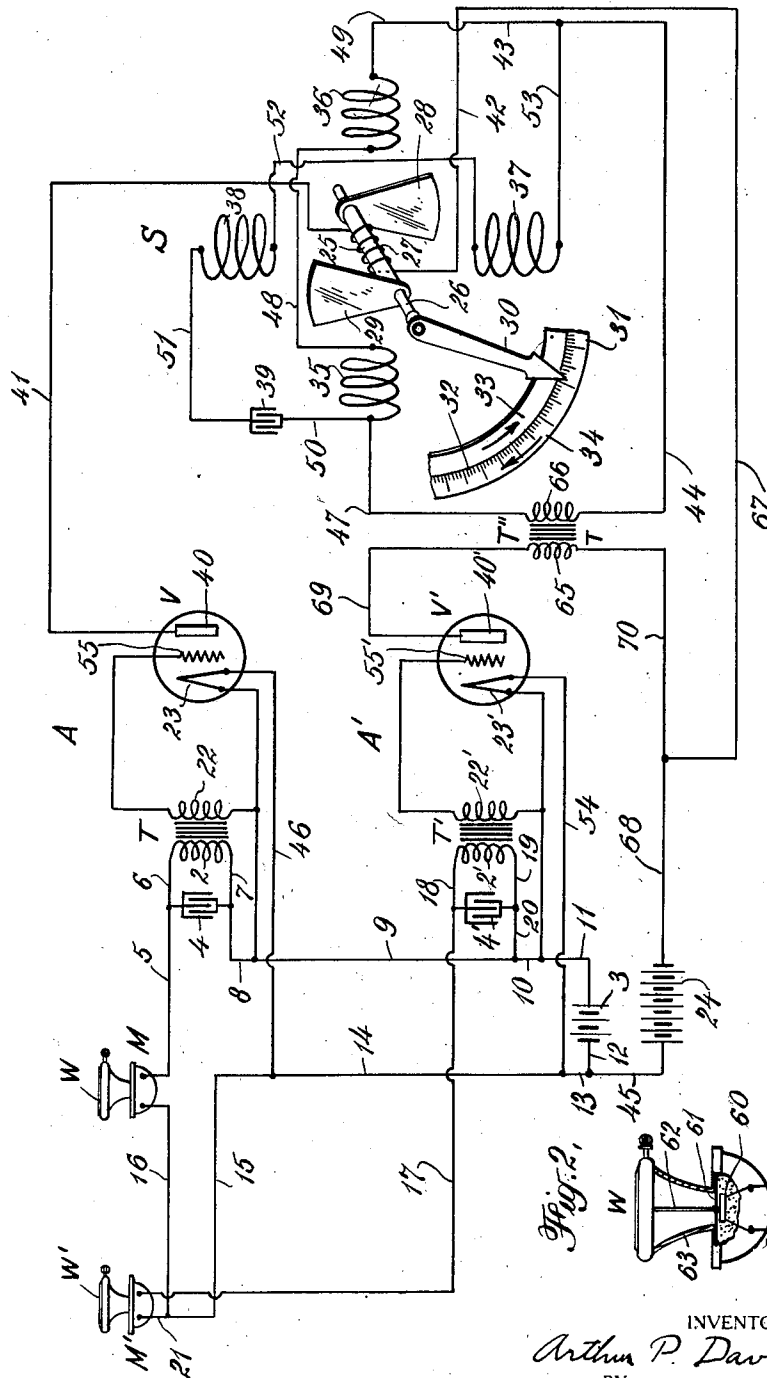
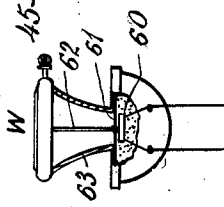


Fig. 2,



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SYNCHRONIZING APPARATUS

Application filed February 5, 1927. Serial No. 166,083.

This invention relates to a system for automatically comparing the frequencies of sounds emitted periodically from a plurality of different sources, and more particularly concerns a system for comparing frequencies of the beats of a watch, clock or other time piece to the frequency of the beats of a standard or substantially accurate time piece of the same type.

All time pieces of a given type are usually constructed from identical parts, but because of slight variations in the physical properties of the materials used, as well as variations in assembling these parts, there is frequently a marked variation between the speed of operation of time pieces so constructed.

After being assembled, time pieces are usually compared with a standard time piece, that is, one which runs accurately at standard time, and are adjusted until they run approximately at the same rate as does the standard time piece. This adjustment is usually accomplished by observing the movement of the hands, and this type of comparison must continue over an extended period of time if accurate results are to be obtained, a comparison lasting twenty-four hours or more being necessary to obtain an ordinary degree of accuracy.

In the manufacture of watches and certain other time pieces, it is customary to construct all of a given type of such instruments to give a predetermined number of beats per minute when adjusted to standard time. Thus a comparison between the rate of operation of a standard watch and a watch to be adjusted may be obtained by comparing the frequencies of the beats thereof. As most watches are constructed to run at the rate of about three hundred beats per minute, it is obviously impossible, from a practical standpoint, to accurately compare the beats of watches directly by ordinary physical methods.

With the above and other considerations in mind, it is an object of the present invention to provide a system by means of which the beats of a plurality of watches or other time pieces may be very quickly and ac-

curately compared and, more specifically it is proposed to provide a system of this nature including a device which directly indicates which of two watches is running at the higher rate, and also gives a direct indication of the difference between the rates of operation of the two watches.

It is a further object of the present invention to provide a system including means for amplifying the beats of the watches being compared, so that these beats may operate suitable indicating means.

Other specific objects, advantages and characteristic features of the present invention will become apparent as the description thereof progresses.

In describing the invention in detail, reference will be made to the accompanying ratas of the present invention; and

Fig. 1 is a simplified and diagrammatic showing of the frequency comparing apparatus of the present invention; and

Fig. 2 is a sectional view of a modified form of means for responding to the beats of the watches being compared.

Referring to the drawing, and more particularly to Fig. 1, the apparatus of the present invention comprises, in general, two microphones or other sound responsive devices M and M' for responding to the beats of the watches being compared, two amplifying devices A and A' for amplifying the electrical impulses produced in the microphones, and an indicating instrument S responsive to the output currents of the two amplifiers, for indicating directly the difference in speed of operation of the two watches and also indicating which of the two watches is operating at the higher speed.

The sound or vibration responsive devices M and M' and the amplifiers A and A' have been shown as microphones and vacuum amplifiers respectively in the preferred embodiment of the invention illustrated. It should be clearly understood, however, that other forms of responsive devices and other forms of amplifiers, such as mechanical amplifiers of the relay, tuned reed or other type, might be used without departing from the scope of the invention disclosed.

The sound responsive devices M and M' may take any one of a number of suitable forms, and in the embodiment shown, comprises microphones of the well known type in which the resistance of an electric circuit is varied by sound impulses impressed on a diaphragm. The microphones M and M' are connected respectively to the primary windings 2 and 2' of two transformers T and T' through circuits including the battery 3, these circuits being tuned to resonance at substantially the frequency of the beats of the watches by means of the condensers 4 and 4'. The circuit for the microphone M may be traced as follows:—from the microphone M, wires 5 and 6, primary winding 2 of transformer T, wires 7, 8, 9, 10 and 11, battery 3, and wires 12, 13, 14, 15 and 16 to the microphone M. The circuit for the microphone M' may be traced as follows:—from the microphone M', wires 17 and 18, primary winding 2' of transformer T', wires 19, 20, 10 and 11, battery 3 and wires 12, 13, 14, 15 and 21 to the microphone M'.

The transformers T and T' may take any suitable form, and are preferably of the iron core type, having any suitable or desired ratio of voltage transformation. The input circuits of the transformers T and T' are rather broadly tuned by the condensers 4 and 4', so that these circuits are particularly sensitive to a band of frequencies representing the usual variations from standard beat frequency ordinarily encountered in watches that have not been regulated.

In the vacuum tube amplifier of the disclosed embodiment of the invention, the secondary windings 22 and 22' of the transformers T and T' are directly connected respectively to the input or grid-filament circuits of two vacuum tubes V and V' of the well known three element type. The filaments 23 and 23' of the vacuum tubes V and V' are heated by currents from the battery 3 through circuits which are obvious from the drawing, and the plate circuits of these tubes are connected through a plate battery 24 to the armature and field windings respectively of the indicating instrument S as hereinafter described. The plate circuit of the vacuum tube V' is preferably connected in series with the primary winding 65 of a transformer T'' of any suitable form, and the field windings of the instrument S are connected with the secondary winding 66 of this transformer as hereinafter described, and in this manner an alternating current is impressed on these field windings. It should be understood that a transformer may also be included in the plate circuit of the tube V which supplies energy to the armature winding of the instrument S, or the plate circuits of both of the tubes V and V' may be connected directly to

the windings of the instrument as may be found preferable.

The indicating instrument S may take any suitable form, but is preferably of the form generally known as a synchroscope, that is, an instrument having a rotary armature element which indicates, by its speed of rotation, the difference in the frequency between two alternating or pulsating currents impressed respectively on its field and armature windings, and also indicates, by the direction of rotation of the armature, which current has the higher frequency. In the embodiment shown, the instrument S includes a rotor or armature 25 comprising a pivotally mounted shaft 26 of soft iron or other suitable magnetic material, surrounded by a stationary armature coil or winding 27, and carrying two oppositely disposed sector shaped vanes 28 and 29 at the ends thereof as shown. The shaft 26 is journaled in suitable bearings carried by a frame, not shown, and a pointer 30 is fixed to one end of the shaft and arranged to move in close proximity to a stationary circular scale 31, a section of which has been shown in the drawing. The scale is preferably provided with graduations 32, and with oppositely directed arrows 33 and 34, the arrows being designated by suitable distinctive indicia and acting to designate the significance of the direction of rotation of the pointer 30.

The field structure of the instrument S comprises a plurality of spaced field windings, and as shown, each pair of diametrically opposite windings 35, 36 and 37, 38 is connected in series and these two pairs are also connected in multiple. A condenser 39 is connected in series with the windings 37 and 38 and acts to maintain a phase displacement between the currents flowing in the two pairs of windings.

The plate circuit of the vacuum tube V is connected in series with the armature winding 25 through a circuit which may be traced as follows:—from plate 40 of the tube V, wire 41, armature winding 27, wires 42, 67 and 68, plate battery 24 and wires 45, 13, 14 and 46 to the filament 23 of the vacuum tube V. The plate circuit of the vacuum tube V' is connected to the primary winding of the transformer T'' through a circuit which may be traced as follows:—from the plate 40' of the vacuum tube V', wire 69, primary winding 65 of transformer T'', wires 70 and 68, plate battery 24 and wires 45, 13 and 54 to the filament 23' of vacuum tube V'. The secondary winding 66 is connected with the field windings of the instrument S through a circuit which may be traced as follows:—from the winding 66, wire 47, divided through two parallel paths, one of which comprises field winding 35, wire 48, field winding 36 and wires 49 and 43, and the other of which comprises wire 50, condenser 39, 130

wire 51, field winding 38, wire 52, field winding 37 and wire 53, thence through wire 44, to the secondary winding 66 of the transformer T''.

In the operation of the apparatus described, two watches or other time pieces W and W' are placed in close proximity in microphones M and M' respectively, these watches being preferably supported by the mouthpiece of the microphone as shown. One of these watches, say the watch W', is a standard watch, that is, a watch which has been accurately adjusted to run at standard time, while the other watch W is a watch to be regulated. The beats of the watches W and W' send out sound waves which act to operate the microphones M and M' and thereby to impress a series of current variations on the input circuits of the transformers T and T' respectively, the frequencies of these series of variations corresponding respectively to the beat frequencies of the watches W and W'. As each watch rests directly on the mouthpiece of the associated microphone M or M', the beats are transmitted to the microphone mechanism by the resultant mechanical vibration of the mouthpiece as well as by sound waves, and hence appreciable variations of current are readily obtainable in the microphone circuits.

The current variations in the primary circuits of the transformers T and T' are amplified by these transformers and by the vacuum tubes V and V' respectively in the well known manner, alternating currents being impressed on the grids 55 and 55' to cause comparatively large variations in the plate currents of the tubes V and V' respectively. The frequencies of these plate currents correspond to the beat frequencies of the watches W and W' respectively, and these plate currents are impressed respectively on the armature and field windings of the instrument S, the plate current from the tube V' being converted from pulsating to alternating current in the transformer T''. The alternating current in the secondary circuit of the transformer T'' produces a rotating magnetic field in the instrument S due to the phase displacement produced by the condenser 39, and, unless the frequency of the plate current from the tube V flowing in the armature winding 27 is of exactly the same frequency as the field current, the armature 25 will rotate in one direction or another, due to the magnetic reactions between the field and the armature. The armature rotates in one direction if the field current is of the higher frequency and in the opposite direction if the armature current is of the higher frequency, and in this manner the direction of rotation of the armature and its associated pointer 30 indicates whether the watch W under test is running faster or slower than the standard watch W'. Also, the speed at which the ar-

mature 25 and the pointer 30 rotate depends upon the difference between the field and armature frequencies of the instrument S and so gives an indication of the difference in speed of operation of the two watches.

As soon as the two watches are placed on the microphones, the comparison between their respective speeds of operation is obtained, and the watch W under test may be regulated to increase or decrease its speed according to whether the instrument S has indicated that this watch is running faster or slower than the standard watch W'. After regulation, the watch W is again compared to the watch W' as before, the speed and direction of rotation of the armature 25 and its associated pointer 30 directly indicating the accuracy with which the watch W under test has been adjusted. If the watch W has been adjusted to run at exactly the same rate as the standard watch W', the armature 25 remains stationary. It is not ordinarily necessary, however, to obtain an absolutely accurate adjustment of the watch under test, the adjustment being sufficient for practical purposes if the armature 25 and the pointer 30 move at a very low rate of speed.

Where the beat of the watch is very light, so that very little sound is emitted thereby, or where it is desired to obtain comparatively large current variations in the microphone circuits, a modified form of microphone as shown in Fig. 2 may be employed. This modified microphone includes the usual variable resisting element 60, connected with a diaphragm 61, a rod 62 being rigidly secured to the diaphragm 61 and the element 60, and extending outwardly to a point substantially in alignment with the outer edges of the mouthpiece 63. When a watch W is placed upon the mouthpiece of a diaphragm of this form, the rod 62 is engaged by the case of the watch, and vibrations due to the beats of the watch are efficiently transmitted to the variable resistance element 60 through this rod.

Obviously, the frequency comparing apparatus of the present invention has many very desirable features. By the use of this apparatus, the rate of operation of two watches may be accurately compared in a very short period of time, less than a minute being consumed making such a comparison. The instrument S quickly and accurately indicates not only the differences in speed between the two watches, but also, which of the watches is operating at the higher rate of speed. Thus, in adjusting a watch, it is not necessary to employ cut and try methods, as the operator is immediately informed as to whether the watch under test is running too slowly or too rapidly, and has a general indication of just how much too slowly or rapidly such watch is running. The apparatus of the

present invention is very simple and rugged in its construction, embodying only one moving element. The operation of the apparatus of the present invention is also extremely simple, and does not require the services of a skilled or specially trained operator.

Although the frequency comparing apparatus of the present invention has been described in connection with certain specific elements and combinations, it should be clearly understood that the invention is not limited in its scope to the exact details or combinations disclosed. For example, means other than microphones may be employed for responding to the beats of the watches, and other forms of amplifying means besides the vacuum tube amplifiers shown might be used. The indicating instrument might take any one of a number of suitable forms and many other changes, modifications and omissions might be made without departing from the scope of the invention as defined by the appended claims.

I claim:

1. Apparatus for comparing the frequencies of periodic vibrations from a plurality of different sources comprising means responsive to said vibrations, and an indicating device controlled by said means for directly indicating which of said frequencies is the higher and for giving a direct indication of the difference between said frequencies.

2. Apparatus for comparing two series of impulses from independent sources comprising separate means responsive to the impulses from each source, means for amplifying the impulses received by said first means from each source, and a single indicating device, responsive to said two series of amplified impulses, for indicating the instantaneous difference in frequency between the two series of impulses and for indicating which series has the higher frequency.

3. Apparatus for comparing two separate series of impulses from independent sources comprising separate means, each responsive to one of said series of impulses, for varying electric currents in accordance with the frequencies of said impulses, and a single electro-responsive device, operated by the simultaneous application of said electric currents thereto, for directly indicating the difference in frequency between said two series of impulses and for directly indicating which series has the higher frequency.

4. Apparatus for comparing two separate series of impulses from independent sources comprising separate means, each responsive to one of said series of impulses, for varying electric currents in accordance with the frequencies of said impulses, means for separately amplifying said electric currents, and a single electro-responsive device operated by the simultaneous differential effect of said electric currents thereto, and having a single

movable element for simultaneously indicating the difference in frequency between said two series of impulses and which of said series has the higher frequency.

5. Apparatus for comparing the speed of operation of two mechanical devices comprising separate means responsive severally to periodic vibrations of said devices, said means acting to vary electric currents in accordance with the frequencies of said vibrations, means for separately amplifying said electric currents, and a single movable element responsive to said two amplified currents for simultaneously indicating the difference in frequency between the vibrations from said devices and which of the vibrations has the higher frequency.

6. Apparatus for comparing the speed of operation of two mechanical devices comprising separate means responsive severally to periodic vibrations of said devices, said means varying electric currents in accordance with the frequencies of said vibrations, two audion tube amplifiers for separately amplifying said currents, and a single movable element responsive to said two amplified currents for simultaneously indicating the difference in frequency between the periodic vibrations from said devices and which of said vibrations has the higher frequency.

7. Apparatus for comparing the speed of operation of two mechanical devices comprising two separate electric control means responsive severally to periodic vibrations produced by the operation of said devices, said control means acting respectively to vary the currents in two electric circuits in accordance with the frequencies of said periodic vibrations, a rotary electro-magnetic indicating device having a field winding and an armature winding, and means for connecting said two electric circuits respectively to said armature and field windings, whereby the speed of rotation of said indicating device gives an indication of the difference between the speeds of said two mechanical devices and the direction of rotation of said indicating device indicates which of said mechanical devices is operating at the higher speed.

8. Apparatus for comparing the operation of two watches comprising separate means responsive severally to the beats of the watches, said means acting to vary electric currents in accordance with the frequencies of said beats, means for amplifying said currents, and a rotary device operated by said amplified currents for indicating, by its direction of rotation, which of said watches is operating at the higher speed, and by its speed of rotation, the difference in speed of said watches.

9. Apparatus for comparing the operation of two watches comprising two microphones, each responsive to the beats of one of the watches, two electric circuits for said micro-

phones carrying currents which are varied respectively by said microphones in accordance with the frequencies of the beats of said watches, and means jointly controlled by said currents for simultaneously showing which of the watches is running at the higher rate of speed and indicating the difference in speed of the watches.

10. Apparatus for comparing the operation of two watches comprising two microphones, each responsive to the beats of one of the watches, two electric circuits for said microphones carrying currents which are varied respectively by said microphones in accordance with the frequencies of the beats of said watches, two audion tube amplifiers having their input circuits connected respectively to said two microphone circuits and means operated by the differential effect of the output currents of said amplifiers for showing which of the watches is running at the higher rate of speed and for indicating the difference in speed of the watches.

11. Apparatus for comparing the operation of two watches comprising separate means responsive severally to the beats of said watches, and an indicating instrument controlled by said separate means for indicating which of the watches is operating at the higher rate.

12. Apparatus for comparing the operation of two watches comprising separate means responsive severally to the beats of said watches, said means acting to vary two electric currents in accordance with the frequencies of said beats, and an indicating device jointly controlled by said currents for directly indicating which of said two watches is operating at the higher speed.

13. Apparatus for comparing the operation of two watches comprising separate means responsive respectively to the beats of said watches, and acting to vary two electric currents in accordance with the frequencies of said beats, means for amplifying said currents and a rotary device operated by the differential effect of said currents for indicating, by its direction of rotation which of said watches is operating at the higher speed.

14. Apparatus for comparing the operation of two watches comprising two microphones responsive respectively to the beats of the watches and acting to vary electric currents in accordance with the frequencies of said beats, means for separately amplifying said varying currents, a rotary indicating device having a plurality of field windings and an armature winding, said amplified currents being supplied to said field windings and said armature winding respectively, and means for producing a phase displacement between the currents in certain of said field windings, whereby said rotary device is caused to rotate in one direction or

the other when one or the other of said watches is operating at the higher speed.

15. Apparatus for comparing the operation of two watches comprising two microphones each connected in a separate tuned circuit including a source of electric current, each of said microphones having means for engaging a watch and vibrating a resistance varying element in accordance with the beats of the watch, whereby the currents in the two tuned circuits are varied respectively in accordance with the speed at which the two watches are operated, and an indicating instrument controlled by the said currents for indicating the difference in rate of operation of said watches and which of said watches is operating at the higher rate.

16. Apparatus for comparing the operation of two watches comprising two microphones each connected in a separate tuned circuit including a source of electric current, each of said microphones having means for engaging a watch case and vibrating a resistance varying element in accordance with the beats of the watch, whereby the currents in the two tuned circuits are varied respectively in accordance with the speed at which the two watches are operated, means for separately amplifying said currents, and a rotary indicating instrument operated by said currents and acting to directly indicate the difference in rate of operation of said watches.

In testimony whereof I affix my signature.

ARTHUR P. DAVIS.

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CERTIFICATE OF CORRECTION.

Patent No. 1,769,988.

Granted July 8, 1930, to

ARTHUR P. DAVIS.

It is hereby certified that error appears in the printed specification of the above numbered patent requiring correction as follows: Page 1, strike out present line 69, insert instead the words "drawing, in which"; page 4, line 89, claim 6, for the misspelled word "separateqy" read separately; page 5, line 42, claim 13, for "respectively" read severally; line 43, for "and" read said means, and line 44, for the misspelled word "accordnace" read accordance; and that the said Letters Patent should be read with these corrections therein that the same may conform to the record of the case in the Patent Office.

Signed and sealed this 9th day of September, A. D. 1930.

(Seal)

M. J. Moore,
Acting Commissioner of Patents.