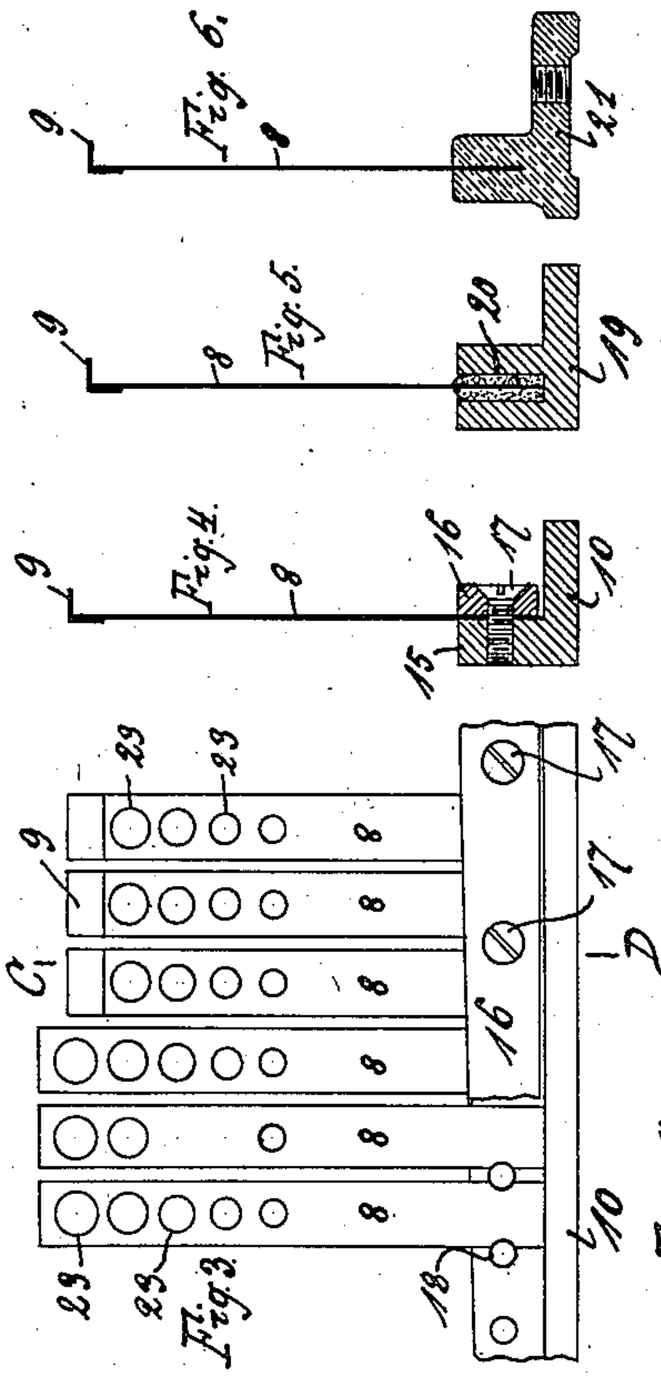
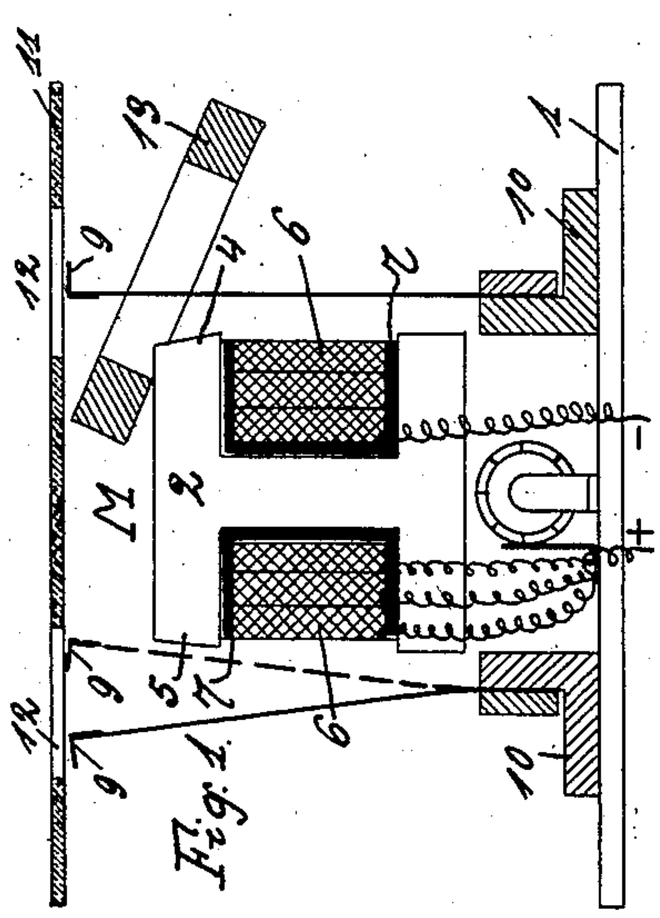
R. HARTMANN-KEMPF.

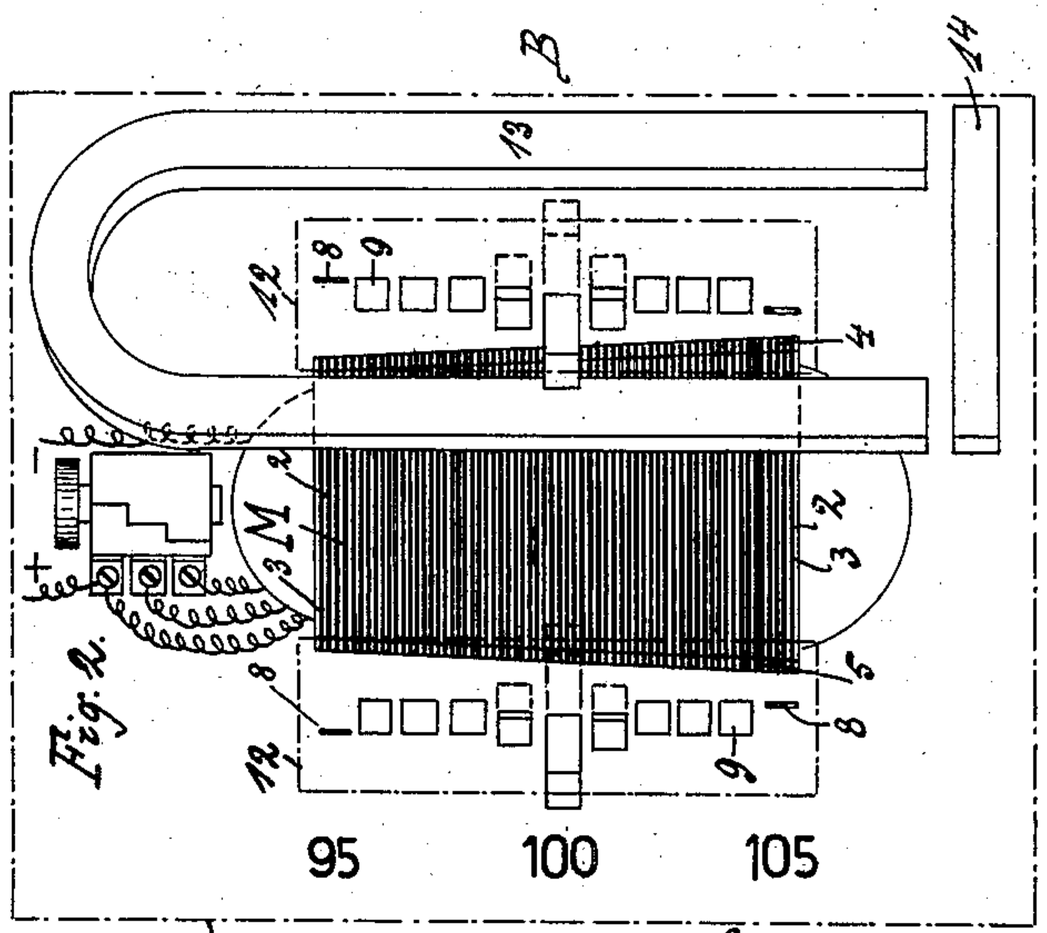
RESONANCE TACHOMETER.

APPLICATION FILED MAR. 12, 1906.

959,934. **Patented May 31, 1910.**







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RESONANCE-TACHOMETER.

959,934. Specification of Letters Patent. Patented May 31, 1910.

Application filed March 12, 1906. Serial No. 305,710.

To all whom it may concern:

Be it known that I, ROBERT HARTMANN-KEMPF, a subject of the German Emperor, and a resident of Frankfort-on-the-Main, Germany, have invented certain new and useful Improvements in Resonance-Tachometers, of which the following is a specification.

There are known resonance-tachometers for measuring the frequency of periodical impulses, in which series of resonators or steel spring bands are arranged along magnets and tuned to scales, so that either of the resonators having the respective frequency is attracted by the magnet and put into vibrations, which can be watched at the scale. Such tachometers are, however, very difficult to adjust.

My invention relates to improvements in such tachometers, whereby their manufacture is facilitated and their adjustment is rendered easy.

The several improvements will be fully described hereinafter and pointed out in the claims, reference being had to the accompanying drawings, in which—

Figure 1 is a vertical cross section through an improved resonance-tachometer on the line A—B in Fig. 2, Fig. 2 is a plan of the same, the double scale at the top being indicated by dotted lines, Fig. 3 is an elevation of several modified resonators, Fig. 4 is a cross section through the line C—D in Fig. 3, Figs. 5 and 6 are similar cross sections and show modifications of the foot plate, Figs. 7^a to 7^e show the several stages of the manufacture of a flag for a resonator, Figs. 8^a and 8^b show a modified flag in its stretched and finished states respectively, Fig. 9^a is an elevation of the upper parts of resonators with broad flags, Fig. 9^b is a plan of the same.

Similar characters of reference refer to similar parts throughout the several views.

Figs. 1 and 2 show an improved resonance-tachometer according to my invention. The base plate 1 is adapted to support in any known manner an electromagnet M. The latter is formed by a series of iron sheets 2 and insulating sheets 3, which alternate with each other and should each have about the same thickness. The material of the insulating sheets 3 may be paper or the like. It is to be noted, that the thickness of the insulating sheets 3 is about ten times that of the paper sheets between iron sheets in dynamos, so that about half the usual weight of such an electromagnet may be saved. The sheets 2 and 3 have approximately the shape of an I and the upper poles 4 and 5 of the electromagnet so formed are not only beveled off, see Fig. 1, but also inclined on both sides to the longitudinal axis, as is shown at Fig. 2. The coil 6 is insulated from the electromagnet M by an insulation 7 and may be either single or in several (in Fig. 1 three) pieces and is connected with the source of current in any known manner. On both sides of the electromagnet M two parallel series of vertical resonators 8, 8 are disposed, which are steel spring bands clamped or secured at their lower ends in two foot plates 10, 10 on the base plate 1 and provided at their upper ends with flags 9, 9. A scale plate 11 with two slots 12, 12 is supported above the base plate 1 in any known manner. In each series eleven resonators 8, 8 are shown, which are assumed to make 95, 96, 97, 98, 99, 100, 101, 102, 103, 104 and 105 vibrations respectively per second, if energized or attracted by the electromagnet M, as is marked with the figures 95 . . . 100 . . . 105 in Fig. 2. When an alternating current with 100 alternations per second is sent through the coil 6, the middle resonators will be thrown into vibrations in resonance with the current and their flags 9, 9, which are preferably lacquered with a white color, will produce white strips in the two slots 12, 12 of the scale plate 11, as is clearly shown in Fig. 2. The figures 100, 100 of the two scales will then indicate the number of these vibrations. The flags 9, 9 of the two neighboring resonators 8, 8 (indicated by the figures 99 and 101 of the scale) will also produce white strips, which are however much shorter, as is also shown.

The number of the resonators 8, 8 depends upon the circumstances. If it is not large, a single series of resonators may be disposed on the one side of the electromagnet M, in which case a single scale and a single slot 12 will suffice. If however this number amounts up to 40 or 100, the single series would be too long, so that it is best to dispose two series of resonators 8, 8 on both sides of the electromagnet M, as shown. Thereby a saving in the space required for the tachometer is made.

The distance between the resonators and the pole surfaces should increase and this

relation may be provided in various ways; and in Fig. 2 I have made the two beveled-off pole surfaces 4 and 5 to converge to one side.

The scale-plate 11 is shown as above, but it may be on a side, if the tachometer is turned and secured on some wall, so that the white strips in the slots 12, 12 may be visible over distances. In order to render the tachometer useful in this respect in wide rooms, it is of course necessary, that the amplitude of the vibrations of the flags 9, 9 should be made large. My experience shows, that it is difficult to attain this result with any kind of steel bands, as the following examples will prove.

For the manufacture of resonators capable of making 100 vibrations per second steel bands as used say for watch-springs are taken, which may be .2, .4 and .6 millimeter thick. When clamped at their lower ends they require to have a clear length of about 30, 55 and 75 millimeters respectively. The three resonators were disposed along an electromagnet at such a distance therefrom, that the amplitude of oscillation of the flag 9 of each resonator was about 25 millimeters long. If a current of exactly 100 alternations per second was passed through the coil of the electromagnet for three consecutive days, the resonator of .6 millimeter thickness would probably show a fracture at the foot plate, while the other two resonators would swing exactly as well as at the beginning. This proves, that in spite of the deflection of the resonator of .6 millimeter thickness being not half that of the resonator of .2 millimeter thickness, the former can not withstand so large an amplitude for a long time. Although it stands to reason that stronger and longer resonators ought to be used, the trials show, that they are of little use. Also the resonator of .2 millimeter thickness presents two defects, viz., first, if even quite a thin flag be put on its upper end, its number of vibrations would be thereby very considerably reduced; and, second, if the tachometer be put on a trembling wall, the resonators are very apt to be set in vibrations, which are certainly small, yet disagreeably conspicuous. From this it follows, that only a thickness between certain limits, say between .3 and .5 millimeter will do. In order to obtain a good and long strip visible in the slot of the scale-table for 100 vibrations per second, it is therefore necessary to employ resonators of about 50 millimeters clear length. If the three resonators of the same number of vibrations and of different thickness were all disposed at the same distance from the electromagnet, perhaps the resonator of .6 millimeter thickness would furnish a strip of 15 millimeters length, the resonator of .4 millimeter thickness a strip of 25 millimeters length and the resonator of .2 millimeter thickness a strip of 40 millimeters length. It is also easy to show, that three resonators of .4 millimeter thickness and making quite different numbers of vibrations will produce strips of different lengths, if they are disposed at the same distance from an electromagnet and for the same consumption of current, for example a strip of 50 mm. length for 30 vibrations per second, a strip of 20 mm. length for 100 vibrations per second and a strip of 10 millimeters strength for 120 vibrations per second. This proves, how difficult it is to adjust many resonators of the same appearance and of the same behavior before an electromagnet. If for example a tachometer with 60 resonators were to be constructed for from 60 to 120 alternations per second and each resonator were to be tuned for one alternation more than the preceding one, it would not be advisable to employ steel bands of the same thickness, but it is better to use steel bands of two or more different thicknesses. For example 31 resonators of .35 millimeter thickness might be disposed on the one side of the electromagnet and might be adjusted for 60 to 90 alternations per second, while 31 resonators of .45 millimeter thickness might be disposed on the other side of the electromagnet and might be adjusted for 90 to 120 alternations per second. The thinner resonators can be excited more easily and therefore they require to be disposed farther off from the electromagnet. The thicker resonators require more power for attracting them and therefore they are placed nearer to the electromagnet. Moreover the relation between the resonators and magnet might be adjusted in any equivalent or well known manner, so as to vary the distances of its pole-surfaces from the resonators and thereby to distribute its forces to the several resonators in a proportion corresponding to their numbers of vibrations. I have observed, that on the last resonators in the series, for example in the above case on the resonators making 60, 90, 90 and 120 vibrations per second respectively an irregular force is exerted, and for this reason I prefer to add to each series one or two more resonators (one in the above case) without flags, the vibrations of which are not to be visible and which additional resonators serve for rendering regular the forces acting upon the neighboring resonators.

The manner of fastening the resonators is of particular importance. It is essential, that the fastening should be perfectly safe and uniform, and that the resonators in the series be uniform in appearance. Frequently the space at disposal is restricted, so that the spaces between the several resonators are necessarily made narrow.

Figs. 3 to 6 illustrate various ways of fastening the resonators, which I have in-

vented. The resonators are fastened in groups in a suitable pattern and in this state they are simultaneously applied to a foot plate 10 and are soldered therein. If the resonators are thick, for example .4 millimeter thick, their lower ends are coated with tin and are soldered up between two metallic jaws 15 and 16, of which the one 15 is made in one piece with the plate 10 and the other 16 is separately made, see Figs. 3 and 4. The two jaws 15 and 16 are preferably pressed on each other in some vise during the soldering operation or they may be connected with each other by means of screws 17, 17. In this case the lower ends of the resonators 8, 8 may be cut out at 18 for the screws 17, 17, if the resonators 8, 8 are placed very near to each other. Fig. 5 shows a foot plate 19 with a groove 20 between its two vertical ribs. In this groove 20 thin resonators 8 may be fastened by filling it up with solder. In case a larger number of series of resonators 8, 8 is to be produced, it may be advisable to fasten each series of resonators in a suitable pattern and to form on their lower ends a foot plate 21, Fig. 6, by casting. Of course during the casting of the metal, the latter may inclose any other metallic parts, such as screws, nuts and the like.

After soldering the resonators in the foot plate the pattern is taken off and the upper ends of the resonators are preferably cut by means of a pair of scissors or the like, so as to render the resonators uniform in length and appearance. In Fig. 3 the first three resonators 8, 8 on the left are not shortened.

The flags 9, 9 are improved upon to facilitate their manufacture and their application to the resonators 8, 8 as follows: The usual manner of forming the flags by annealing and bending the ends of the steel bands is very difficult and the flags so formed are not at all uniform or regular. The application of simply bent flags is objectionable, since their riveting is difficult and dear and the adjustment of the resonators is rendered nearly impossible, since the reheating of the solder for loosening the flags is not permitted. For these reasons I manufacture the flags in several stages illustrated by Figs. 7ª to 7ᵉ. First blanks of the shape shown at Fig. 7ª are cut out of thin sheet metal, then these blanks are bent in several different lines, see Figs. 7ᵇ to 7ᵈ, next they are folded on the upper ends of the resonators 8 and at last they are soldered thereon, see Fig. 7ᵉ. The flags so formed will be quite secure in spite of any subsequent soldering or filing. If a small quantity of tin 22 is soldered on the flag 9, it can be filed off partly or wholly during the adjustment of the resonators, whereby this operation is much facilitated.

It is not necessary that the flag 9 should have the same breadth as the resonator 8, on the contrary, the white strip produced by the vibration of the flag in the slot 12 of the scale-plate 11 will be better visible, if the flag is given a certain breadth. Fig. 8ª shows a blank, which when properly bent will give a very broad flag as shown at Fig. 8ᵇ. Now that such broad flags may in some cases not find sufficient space, if arranged one beside the other, it will be necessary to dispose them one above and one beneath the other in an alternating order, as is clearly shown at Fig. 9ª. When such a resonator 8 is set in vibration, its broad flag 9 will produce a white strip of its breadth, see Fig. 9ᵇ.

If it is desired to increase the amplitude of the vibrations, the upper part of the resonator 8 may be made lighter by cutting holes 23, 23 in it, see Fig. 3. Thereby for the same number of vibrations the length of the resonator 8 is increased. Preferably the diameters of the several circular holes 23, 23 are decreased from the upper end downward, so as not too much to weaken the material of the resonator. The resistance of the air against the vibrations of the resonator 8 will be considerably reduced by the circular holes 23, 23, through which the air is permitted to pass.

What I claim as my invention, and desire to secure by Letters Patent, is—

1. In an instrument of the character described, the combination of a graduated plate, a plurality of resonators arranged in groups adjacent said plate according to thickness and tuned in accordance with the values represented by the graduations thereon, the resonators of the same thickness being supported independently of the others, and an electromagnet for setting the resonators in motion.

2. In an instrument of the character described, the combination of a graduated plate, a plurality of resonators arranged in a plurality of independently supported groups adjacent said plate and tuned in accordance with the values represented by the graduations thereon, and an electromagnet for setting the resonators in motion, the members of the several groups of resonators being arranged at different distances from the magnet, the member having the lowest number of vibrations being at the greatest distance from the magnet.

3. In an instrument of the character described, the combination of two scales or graduated members, an electromagnet, and two series of resonators, the members of each group being arranged at different distances from the magnet in accordance with the number of vibrations represented thereby and tuned in accordance with the values represented by the adjacent scale graduations.

4. In an instrument of the character described, the combination of a slotted scale or graduated plate, a plurality of resonators tuned in accordance with the graduations on said plate and one or more of said resonators having a lateral projection adapted to oscillate transversely across the slot in said plate as the resonators vibrate, and an electromagnet for vibrating the resonators, the several resonators being arranged at different distances from the magnet, the space separating the magnet and different resonators decreasing gradually from the one representing the lowest number of vibrations to that representing the highest.

5. In an instrument of the character described, the combination of a slotted scale or graduated plate, a series of resonators tuned in accordance with the graduation on said plate, all of said resonators except those at the ends of the series having lateral projections adapted to oscillate transversely across the slot in said plate as the resonators vibrate, and an electromagnet for vibrating the resonators.

6. In an instrument of the character described, the combination of a series of resonators, an electromagnet for vibrating the resonators, each of the resonators except those at the ends of the series having a lateral projection at its free end, and a graduated plate or scale arranged adjacent the resonators and having its graduations representing the different rates of vibration of the several resonators.

7. In a resonance-tachometer, the combination with a plurality of parallel resonators made of watch spring steel, of a foot-plate, in which the lower ends of said plurality of parallel resonators are fastened, and a plurality of flags made of thin sheet metal and secured on said plurality of parallel resonators by folding on their upper ends, substantially as set forth.

8. In a resonance-tachometer, the combination with a plurality of parallel resonators made of watch spring steel, of a foot-plate, in which the lower ends of said plurality of parallel resonators are fastened, and a plurality of flags secured on the free ends of said plurality of parallel resonators and being of a greater breadth than the resonators, substantially as set forth.

9. In a resonance-tachometer, the combination with a plurality of parallel resonators made of watch spring steel and provided at the free ends with flags of a greater breadth than themselves, of a foot-plate in which the lower ends of said plurality of parallel resonators are fastened, their broad flags overlapping each other, substantially as set forth.

10. In a resonance-tachometer, the combination with a plurality of parallel resonators made of watch spring steel and cut out on various places in their upper vibrating parts to reduce their weight, of a foot-plate in which the lower ends of said plurality of parallel resonators are fastened, substantially as set forth.

In testimony whereof I have signed my name to this specification in the presence of two subscribing witnesses.

ROBERT HARTMANN-KEMPF.

Witnesses:
ERWIN DIPPEL,
MICHAEL VOLK.