Oct. 31, 1933. T. M. BERRY ET AL 1,933,306

ELECTRICAL FREQUENCY ANALYZER

Filed April 30, 1931

Fig. 1.

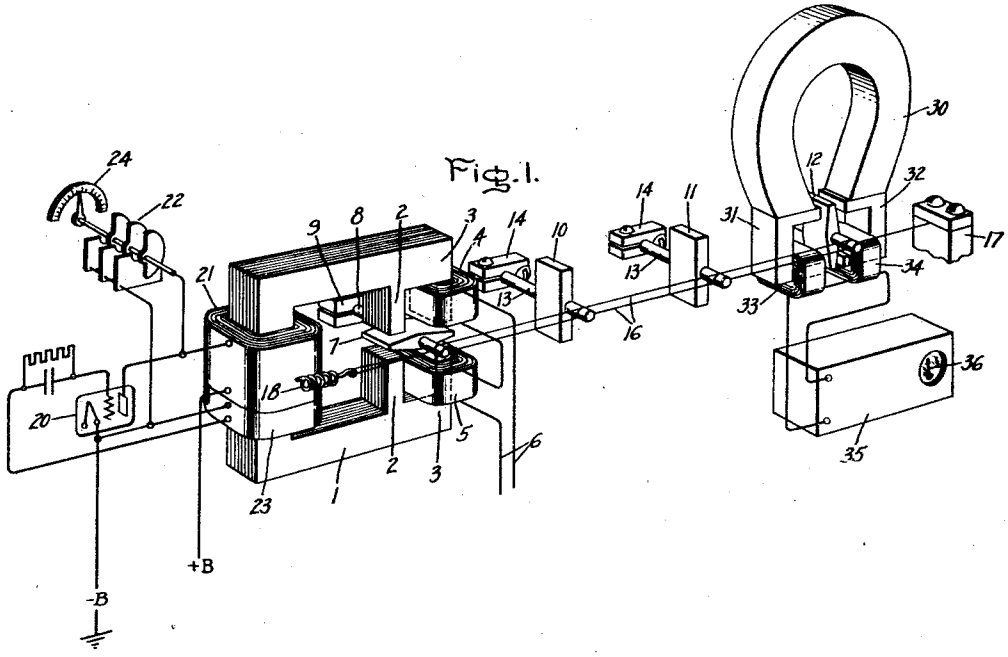


Fig. 2.

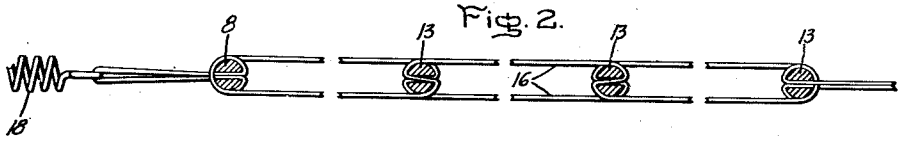


Fig. 3.

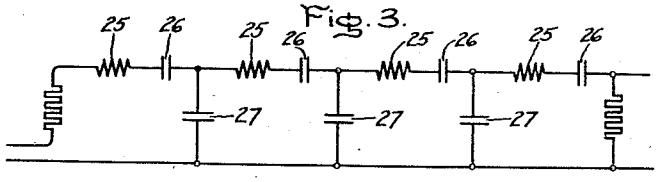
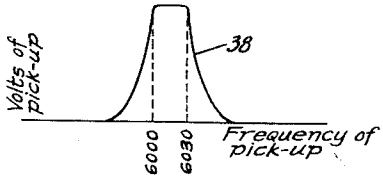


Fig. 4.



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ELECTRICAL FREQUENCY ANALYZER

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9 Claims. (Cl. 175—368)

Our invention relates to electrical frequency analyzers. In certain forms of frequency analyzers heretofore constructed the tuning is relatively sharp which requires that a wave being analyzed shall be maintained at a fixed frequency. In the practical use of such analyzers it often happens that the wave being analyzed cannot conveniently be maintained at such a fixed frequency as is necessary to obtain an accurate analysis. It is one object of our invention therefore to provide an improved frequency analyzer which enables an analysis to be made of a wave while the same is undergoing small variations in frequency. Another object is the provision of a frequency analyzer having a high degree of selectivity.

Our invention will be better understood from the following description taken in connection with the accompanying drawing, and its scope will be pointed out in the appended claims.

Referring to the drawing, Fig. 1 is a combined perspective view and circuit diagram of apparatus comprising one embodiment of our invention; Fig. 2 shows a detail thereof drawn to a larger scale; Fig. 3 is a circuit diagram illustrating an electrical analogue of the mechanical apparatus shown in Fig. 1; and Fig. 4 shows the flat top form of response curve obtained with the mechanical resonator system of our apparatus.

In Fig. 1 of the drawing we have shown a magnet structure 1 of yoke formation having two pairs of opposing polar projections 2 and 3. One pair of projections, namely, projections 3, are provided with windings 4 and 5 which are shown connected in series and are adapted to be connected by the leads 6 with the source of current the frequency of which is to be analyzed. These windings are connected to produce opposing fluxes in the core structure. Arranged symmetrically between the pairs of polar projections 2 and 3 is the armature 7 which is mounted on the torsion shaft 8 adjacent one end thereof. The opposite end of this shaft is held fixed by being secured in the clamp 9. The armature 7 is an inertia device and constitutes a mechanical resonator having a definite natural period of vibration dependent upon its moment of inertia and the torsional compliance of shaft 8 by which it is supported. Mechanically connected with the shaft 8 at a point beyond the armature 7 are a plurality of other inertia devices or mechanical resonators of a somewhat similar construction shown at 10, 11 and 12, forming a mechanical resonator system. These resonators are each supported on a torsion shaft 13 which is similar to shaft 8 and which is held in fixed position at one end by a clamp 14 similar to clamp 9. The resonator shafts are mounted in alignment and are elastically coupled or connected together by compliance means in the form of the tungsten wires 16 which as more clearly shown in the enlarged detail view comprising Fig. 2 are secured to the shafts by being passed around the exterior thereof and through suitable transverse openings therein. The two wires are anchored at one end of the system of resonators by the clamp 17 and at the other end of the system they are attached to one end of the spring 18, secured to a suitable support, by which the wires are maintained under the desired tension. Of the several resonators comprising the system resonators 10 and 11 have twice the moment of inertia of the other resonators but their shafts have only one-half the compliance of the shafts of the other resonators. The several resonators of the system, hence, have the same natural period of vibration but the vibrating system, including the connecting wires, will transmit frequencies lying in a definite range which, for example, may be 6000 cycles to 6030 cycles. The resonator system thus constitutes in effect a mechanical filter which in the example given will pass frequencies of 6000 cycles to 6030 cycles. Inasmuch as the windings 4 and 5 are so connected that the fluxes thereof oppose each other, it will be seen that the armature 7 will not be set into vibration merely by the flux of the wave being analyzed or by the flux from the analyzing current to be described later.

We apply to the core structure 1 a variable frequency alternating flux which is heterodyned with the flux of the windings 4 and 5 to produce a beat note corresponding to the natural vibration period of the resonator system. This variable frequency flux is obtained through the use of the oscillator 20 of well known construction, the oscillation circuit of which comprises the core winding 21 constituting the inductance element thereof and the variable condenser 22. Associated with the winding 21 is the auxiliary wind-

ing 23 which connects with the grid of the oscillator 20. In the well known manner variations in capacitance of the condenser 22 cause variations in the oscillation frequency in the oscillation circuit including winding 21. The frequency range of the analyzing current thus supplied by the oscillator may for example be from 6060 cycles to 11,000 cycles which range may, with the resonator system having the frequency mentioned above, enable one to measure component frequencies from 60 to 5000 cycles in the wave being analyzed. The adjustable condenser 22 is provided with the scale 24 which preferably is calibrated to read directly in terms of frequency of the component being measured.

The operation of the mechanical filter which we have described above is analogous to the well known electrical filter illustrated by Fig. 3. The voltage input in the case of the latter corresponds to the torque impressed upon the armature 7 while the voltage output is proportional to the velocity of vibration in the last resonator 12. The four inductances 25 correspond to the moment of inertia respectively of the four resonators 7, 10, 11 and 12. The series condensers 26 correspond to the torsional compliances of the shafts of the resonators and the coupling condensers 27 correspond to the linear compliance of the wires joining the resonators.

For indicating when the resonator system is in vibration and for measuring the amplitude of such vibration we have provided an electromagnetic pick-up now to be described. This pick-up comprises a magnet 30 having pole pieces 31 and 32 each having two opposite projections between which is mounted resonator 12 which in this case is the armature. One pair of opposing pole pieces is provided with the windings 33 and 34 which in a well known manner will have an E. M. F. generated therein in response to the vibratory movements of the armature resonator 12. The windings 33 and 34 connect with a suitable amplifying device, such as a thermionic amplifier, contained within the casing 35 in which also is mounted a voltmeter or other suitable indicating device having a pointer 36, connected with the output circuit of the amplifier.

As a result of the resonator system which we have shown and described, a high selectivity is obtained so that components which are relatively close together in frequency do not disturb the reading of any one of them. Also, if the frequency of the source undergoes slight variations during the analysis the measurement is not affected by such variations. The reason for this is illustrated by the flat top curve 38 shown in Fig. 4 from which it will be seen the frequency may undergo considerable variation, which variation, as has already been pointed out, is frequently found in practice, yet this variation will not materially affect the accuracy of the analysis.

In the operation of the apparatus the circuit 6 is connected to the circuit whose frequency is to be analyzed through suitable amplifying means if necessary and while the operator watches the pointer 36 he slowly varies the variable condenser 22. Whenever the beat frequency of the oscillation circuit and a component present in the current being analyzed fall within the range of the resonating system, the latter will be thrown into vibration, the amplitude of the last resonator of which is indicated by pointer 36. Thus, as the variable condenser 22 is moved through its range, each of the various components or harmonics present in the wave being analyzed successively manifest themselves in the deflection of the pointer 36, the operator being able to read off from the scale of the variable condenser each particular component frequency and from the pointer 32 the relative value of that component.

We have chosen the particular embodiment described above as illustrative of our invention and it will be apparent that various other modifications may be made without departing from the spirit and scope of our invention which modifications we aim to cover by the appended claims.

What we claim as new and desire to secure by Letters Patent of the United States, is:

1. An electrical frequency analyzer comprising a plurality of mechanical resonators having compliance couplings therebetween, means for causing said resonators to vibrate in accordance with the beat frequency of a component present in a periodic current to be analyzed and an analyzing current, and means for indicating a condition of vibration in said resonators.

2. An electrical frequency analyzer comprising a plurality of mechanical resonators, having the same resonance frequency and resiliently connected together, means for causing one of said resonators to vibrate in accordance with the heat frequency of a component present in a periodic current to be analyzed and an analyzing current and means for indicating a condition of vibration of another of said resonators.

3. An electrical frequency analyzer comprising a plurality of mechanical resonators having the same resonance frequency and resiliently connected together, electro-magnetic means for applying to one of said resonators a force having the beat frequency of a component present ing a periodic current to be analyzed and an analyzing current and means for indicating when said resonators are in a state of vibration.

4. An electrical frequency analyzer comprising a plurality of mechanical resonators having the same resonance frequency and resiliently connected together, means for heterodyning the flux of a harmonic in a periodic current to be analyzed with the flux of an analyzing current, means whereby the resulting beat flux actuates one of said resonators and indicating means responsive to a condition of vibration in another of said resonators.

5. An electrical frequency analyzer comprising a plurality of mechanical resonators having the same resonance frequency and resiliently connected together, means comprising a core structure having pole pieces and an air gap, one of said resonators comprising an armature in said air gas a main winding on said core adatped to be connected with a source of analyzing current and pole winding adapted to be conected with a source of a complex periodic current to be analyzed.

6. An electrical frequency analyzer comprising an oscillator including an oscillation circuit having capacitance and inductance elements, a core structure for said inductance element, an armature associated with said core structure, means for combining the flux of the inductance element with the flux of a complex periodic current to be analyzed, a mechanical resonator actuated by said armature and means for indicating a condition of vibration in said resonator.

7. An electrical frequency analyzer comprising an oscillation circuit including a variable condenser and an inductance winding, a core structure for said winding having polar windings thereon, a mechanical resonator system includ-

ing an armature associated with said core structure and indicating means responsive to the vibration of said system.

8. In an electrical frequency analyzer a mechanical resonator system comprising a plurality of similar resonators having like natural periods of vibration, means resiliently connecting said resonators in a series, means for applying an actuating force to the series at one end thereof and vibration responsive means connected with the series at the other end thereof.

9. An electrical frequency analyzer comprising a plurality of inertia devices, compliance coupling means for said devices, means for causing one of said devices to vibrate in accordance with the beat frequency of a component present in a periodic current to be analyzed and an analyzing current and means for indicating a condition of vibration in another of said devices.

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