May 11, 1954 C. A. HEILAND 2,678,424

DUAL SUSPENSION OSCILLOGRAPH

Filed May 15, 1950 2 Sheets-Sheet 1

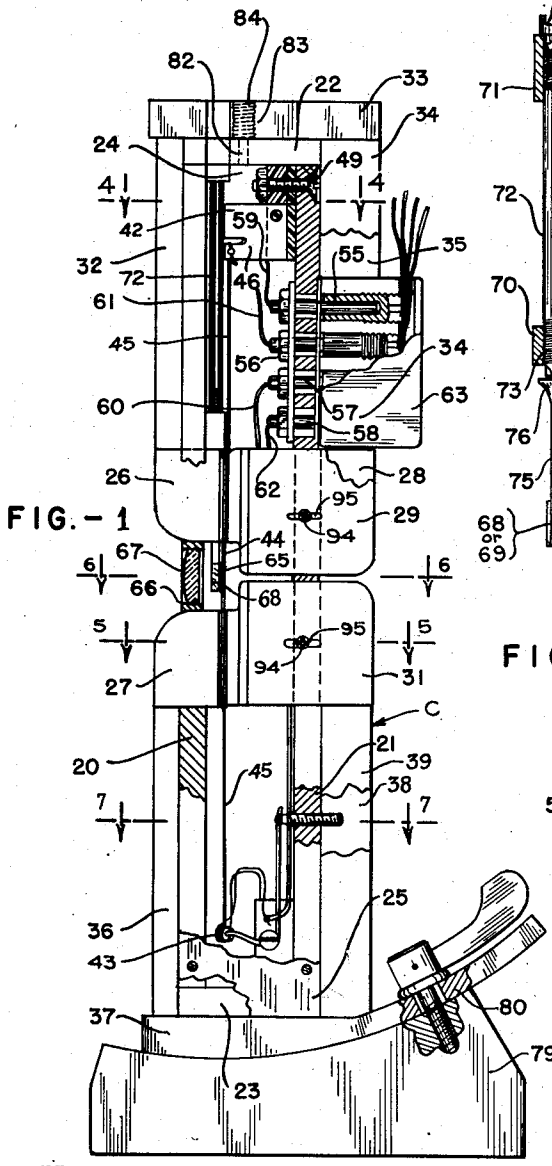


FIG. — 1

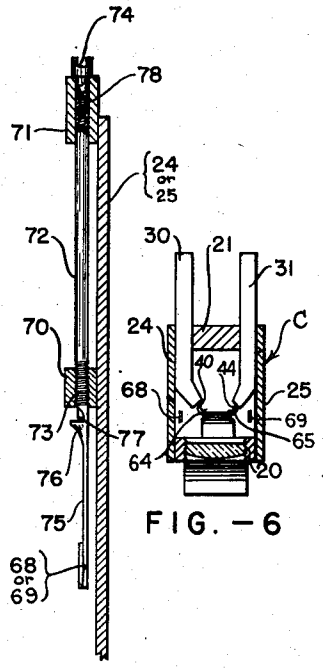


FIG. — 8

FIG. — 6

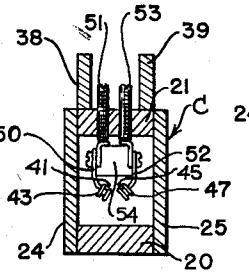


FIG. — 7

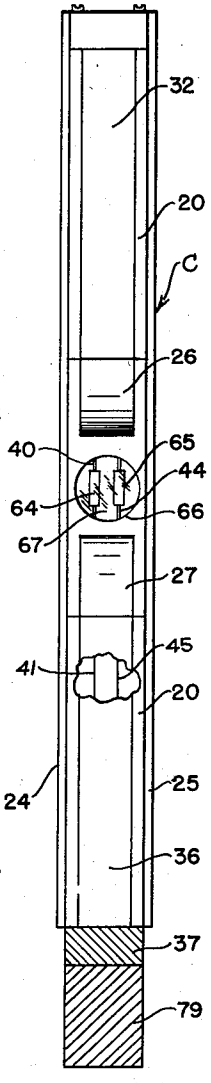


FIG. — 2

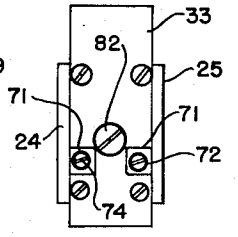


FIG. — 3

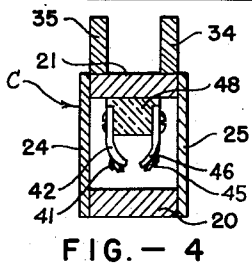


FIG. — 4

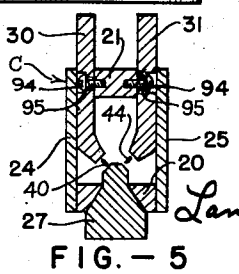


FIG. — 5

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DUAL SUSPENSION OSCILLOGRAPH

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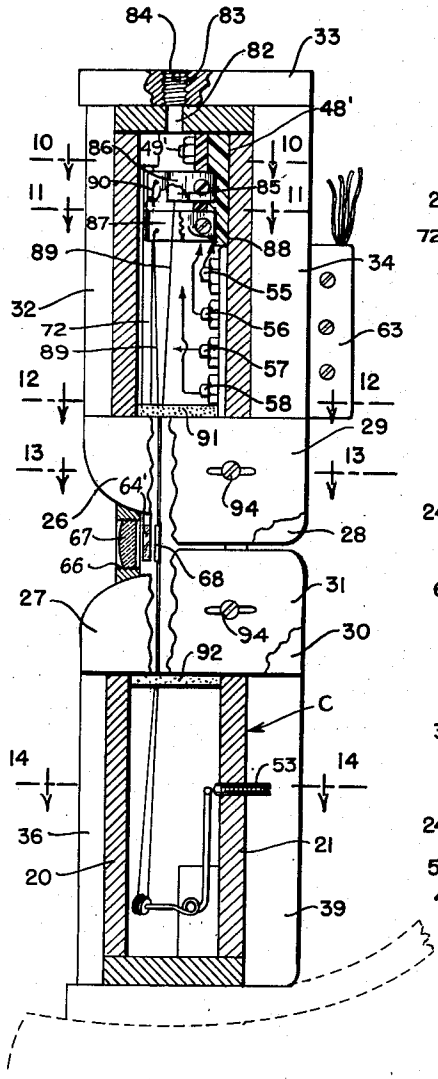


FIG. — 9

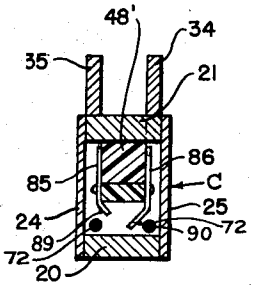


FIG.— 10

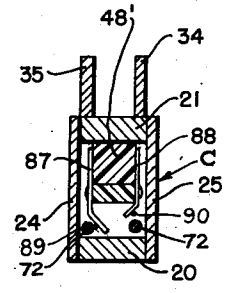


FIG.— 11

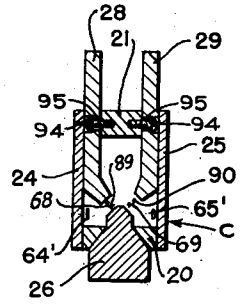


FIG.— 13

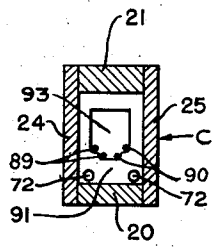


FIG.— 12

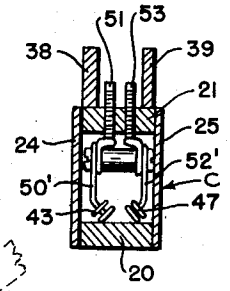


FIG.— 14

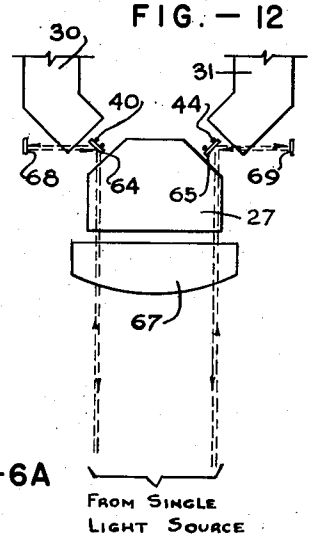


FIG.—6A

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DUAL SUSPENSION OSCILLOGRAPH

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Application May 15, 1950, Serial No. 162,090

10 Claims. (Cl. 324—151)

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This invention relates to oscillographs and more particularly to galvanometer structures therefor.

One of the objects of my invention is to produce a galvanometer of the smallest possible size so that when employed in a multi-channel bank arrangement the overall width thereof can be considerably less than existing arrangements having like number of channels.

A further object is to produce an improved self-contained dual suspension galvanometer having its own magnetic field.

A still further object is to produce a unitary dual suspension galvanometer which will have such a design that it can be individually usable or usable with other like units, and when so used will produce a multi-channel bank arrangement having a small overall width for the units employed.

Another object is to produce a dual oscillograph unit in which a magnetic structure is so employed that two fields are produced in close proximity to each other.

Yet another object is to produce a dual oscillograph in which structures are provided for producing two fields adaptable for permitting either bifilar or coil type suspension.

Still another object is to produce two fields for a dual suspension oscillograph by using one magnet structure having one polarity and linking such to two other magnetic structures of opposite polarity and thereby establishing the two fields at right angles to each other and in close proximity.

A further object is to produce a dual suspension oscillograph in which the two mirrors of the suspensions are at right angles to each other and each mirror is in the plane of the direction of the lines of force.

A further object is to produce an improved galvanometer in which both a suspended and stationary reflecting mirror is employed and so related that the beam reflected from the suspended mirror will be directed to the stationary mirror and then therefrom back to the suspended mirror.

A further object is to produce a galvanometer by the use of suspended and stationary mirrors that the sensitivity of the suspended mirror will be doubled.

Yet a further object is to produce a galvanometer having both a suspended or vibrating mirror and a stationary mirror and provide for such adjustment of the stationary mirror that light spots can be adjusted both horizontally and

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vertically without disturbance of the suspension of the suspended mirror.

A still further object is to construct a unitary dual suspension galvanometer having separate fields so related for the suspension of mirrors and to provide therefor adjustment for the entire unit which will permit the unit to be moved about the centers of both suspended mirrors during adjustment.

Another object is to produce a dual suspension oscillograph that can be economically manufactured, efficient in operation, easily adjusted and of superior, compact construction.

Referring to the drawings:

Figure 1 is a side view of a dual suspension oscillograph embodying my invention, with parts thereof broken away and in section to show details, said oscillograph having coil type of suspensions for the vibrating mirrors;

Figure 2 is a front view of the unit shown in Figure 1;

Figure 3 is a top view;

Figures 4, 5, 6 and 7 are cross sectional views of the unit, respectively, on the lines 4—4, 5—5, 6—6 and 7—7 of Figure 1;

Figure 6A is an enlarged view similar to Figure 6 showing the two light paths;

Figure 8 is a view showing details of the mounting of a stationary mirror on a cover plate and its manner of adjustment;

Figure 9 is a view of another unit embodying my invention, but being adapted for a bifilar type of suspension, said view being a side view similar to that of Figure 1; and

Figures 10, 11, 12, 13 and 14 are cross sectional views of the structure shown in Figure 9, said views being taken respectively on the lines 10—10, 11—11, 12—12, 13—13 and 14—14 of Figure 9.

Referring first to Figures 1 to 8, inclusive, a dual suspension oscillograph unit is disclosed embodying my invention and being of the type in which coil suspensions are employed. The structure shown has a casing C formed of non-magnetic material and comprising front and rear walls 20 and 21, top and bottom walls 22 and 23 and detachable side walls 24 and 25 formed by plates also of non-magnetic material. In suitably formed openings in the front wall are mounted spaced upper and lower permanent magnetic members 26 and 27, said members being braised in the openings and projecting on each side of the wall. In slots on the sides of the rear wall are mounted four other permanent magnets 28, 29, 30 and 31 arranged in pairs and extending on both sides of the wall. The upper mag-

nets 28 and 29 have their inner ends arranged at angles to the body and cooperate with the upper front magnet 26 to produce two magnetic fields at the gaps since the inner end of magnet 26 will be of opposite polarity to the inner ends of the magnets 28 and 29. The lower magnets 30 and 31 are mounted in the rear wall 21 so as to cooperate with the lower permanent magnet 27 in the front wall to thereby establish two other magnetic fields. In this manner there can be said to be two bifurcated fields in parallel planes. The branches of each bifurcated field are to be at right angles to each other. One branch of each bifurcated field will be longitudinally spaced in the casing with respect to a similar branch of the other bifurcated field.

To provide magnetic paths between the outside ends of the companion magnets establishing the bifurcated fields, there is attached to the top part of the front wall a magnet 32, to the top wall a soft iron plate 33 and to the top part of the rear wall parallel magnets 34 and 35. The poles of these magnets are so arranged that there will be established the desired magnetic paths. Similarly, for the magnets 27, 30 and 31, there is attached to the lower part of the front wall a magnet 36, to the bottom wall a soft iron base 37 and to the lower part of the rear wall parallel magnets 38 and 39.

Like branch fields of the two bifurcated fields will have suspended therein vibratory elements. In the fields established between magnets 26 and 28 and between magnets 27 and 30 there is placed the coil 40 which will be suspended by ribbons 41 between a top holding clamp 42 and a lower grommet 43. Similarly, in the field established between magnets 26 and 29 and between magnets 27 and 31, there is a coil 44 which will be suspended by ribbons 45 between a top holding clamp 46 and a lower grommet 47. The top clamps 42 and 46 are mounted on an insulating block 48 suitably attached by a bolt 49 to the rear casing wall 21. Both grommets are mounted for adjustment to thus tension the suspension ribbons. Grommet 43 is mounted on a spring type lever 50 which can be adjusted by a set screw 51 threaded in rear wall 21 so as to be accessible from the exterior of the casing and grommet 47 is mounted on a spring type lever 52 adjustable from the exterior of the casing by a set screw 53. The levers are pivotally mounted on a support block 54.

In the rear wall are four electrical terminal posts 55, 56, 57 and 58. Two posts such as 55 and 57 are connected by wires 59 and 60 to the ends of the suspended coil 40 and the other two posts 56 and 58 are connected by wires 61 and 62 to the suspended ends of the other coil 44. To the posts can be connected the detachable electrical plug 63 having wire to connect the coils in circuits so as to receive electrical impulses of which a wave trace is to be recorded. When current flows through a coil, the coil will be deflected from its normal position which will be in the plane of the direction of the field in which it is situated. The current will be varying and thus the coil will oscillate or vibrate.

To record the vibrations of each suspension, coil 40 will have mounted thereon at its center a mirror 64 and coil 44 will have mounted thereon at its center a mirror 65. These mirrors will thus be between the two bifurcated fields and in order that they may receive rays from a source of radiation as a lamp, the front wall between the permanent magnets 26 and 27 has an opening

or window 66 provided with a lens 67. Each mirror is mounted on its coil so its reflecting surface will be in a plane closely parallel to the plane of the coil and facing toward the window. This positioning will result in the reflecting surfaces of the mirrors being at right angles to each other and each at forty-five degrees (45°) to light rays entering the window from a single source. Consequently these light rays will be reflected by the mirrors in opposite directions and toward the side walls of the casing.

In accordance with one feature of my dual suspension oscillograph, these reflected rays will be arranged to be reflected back to the mirrors on the suspensions by the employment of stationary mirrors. These two stationary mirrors are indicated by the numerals 68 and 69, mirror 68 receiving the rays reflected from suspended mirror 64 and mirror 69 receiving the rays reflected from suspended mirror 65. Both stationary mirrors are mounted in like manner and arranged to be adjustable. This mounting and adjusting structure is shown in detail in Figure 8.

On the inside of each of the side wall plates 24 and 25 will be secured spaced blocks 70 and 71, the latter being at the top and projecting through a slot at the side of the top wall and top soft iron plate 33. Mounted in these blocks will be a tubular rod 72 projecting out of the top block which will place this end so as to be accessible from the exterior. The lower block is provided with a threaded hole to receive threads 73 on the tube. This will permit the tube to be adjusted longitudinally and also rotated to different angular positions by a screw driver cooperating with the slots 74 in the top of the tube. The lower end of the tubular rod has a flat extension 75 on the lower end of which will be mounted the stationary mirror 68 or 69. The flat extension is flexible with respect to the tubular rod and adjacent the tube it has a projection 76 positioned below the bottom end of the tubular rod. In the tubular rod is a second rod 77 mounted by threads 78 and arranged to have its lower end engage the projection 76. The upper end of the rod 77 is accessible from the exterior and by a suitable tool can be turned. This turning will result in a swinging of the extension 75 and a change in the relationship of the plane in which the stationary mirror is positioned with respect to its companion suspended mirror. Thus, each mirror 68 or 69 can be adjusted about two axes at right angles to each other.

By proper positioning of the stationary mirrors the rays reflected from the suspended mirrors can be reflected back to the suspended mirrors and then out through the window in a path which will be close to the incident ray coming from the source of light. This is all illustrated in Figures 6A.

The casing C is arranged to be mounted on a base member 79 which will be fixed in a suitable box or other container for a single unit or a plurality of units in side by side relation. The mounting on the base member is made to permit adjustment. The base magnet 37 is extended beyond the rear of the casing C and its lower surface is curved and rests on a curved top surface of the base member 79. The curvatures of both curved surfaces are the same and the axis about which the curved surface on the base magnet 37 will be formed will coincide with a line passing through points on the two suspended mirrors 64 and 65 at which the light rays from the source will be reflected. Thus, the whole casing can be adjusted as desired and the incident rays coming

from the source will be reflected from the suspended mirrors at the same points. In order to clamp the casing in adjusted position on the base member 79, the base magnet 37 has a slot 80 and there is a hand operated clamp bolt 81 extending therethrough and threaded into the base member 79 as shown.

The casing C is intended to be constructed to be fluid tight so it can be filled with a liquid to provide damping for the suspended coils. In order to introduce fluid into the interior of the casing, the top wall 22 will be provided with an opening 82 and there will be an aligned opening 83 in the top magnetic plate which will be closed by a plug 84, this plug being made of soft iron so as not to interfere with the magnetic path.

In the unit shown in Figures 1 to 8, coils are suspended in the magnetic fields. If it should be desired to use bifilar suspensions in the unit, such can be done with only small modifications in the structure. A bifilar suspension is shown in Figures 9 to 14. In place of the block 48 in the top of the casing for holding the clamps for the coil suspension, there is substituted a block 48' attached by a bolt 49'. As best shown in Figures 9, 10 and 11, this block will have mounted thereon four holding clamps for the suspension, as indicated by the numerals 85, 86, 87 and 88. The holding clamps are arranged in pairs with two positioned on each side of the block. On one side of the block there will be a long and short clamp, with the long clamp at the top and on the other side there will also be a long and short clamp, but the long clamp will be at the bottom. This will insure separation of the upper ends of each for each suspension.

As can be seen from the different views, a ribbon 89 for one suspension will extend from holding clamp 86 down through the magnetic fields established between the magnets 26 and 29 and between the magnets 27 and 31, around the grommet 47 and then back up through said fields to the short holding clamp 88 below the holding clamp 86. This ribbon will have mounted thereon the mirror 65' and such mirror will have its reflecting surface in a plane extending in the same direction as the field in which the ribbon is situated.

In a similar manner a ribbon 90 will extend from the short holding clamp 85 down through the magnetic fields, between the magnets 26 and 28 and between the magnets 27 and 30, around the grommet 43 and then back up through said fields to the long holding clamp 87 on the same side as the short holding clamp 85. On this ribbon will be mounted the mirror 64', said mirror having its reflecting surface in a plane extending in the same direction as the field in which the ribbon is situated. The terminal posts 55, 56, 57 and 58 will be connected by suitable conductors with the upper ends of the ribbons to place the U-shaped bifilar suspensions in circuits. The two grommets 43 and 47 will be mounted on spring type adjusting levers 50' and 52' and are tensioned by the two set screws 51 and 53 in the same manner as the coil suspension ribbons are tensioned. In order that each of the ribbons will have their legs in proper parallel position in the fields, there is provided bridge plate retainers 91 and 92 above and below the permanent magnets establishing the bifurcated fields. The plate retainer 91 is shown in Figure 12 and, as can be seen therefrom, it is made from insulating material with an opening 93 therein, said opening having such a configuration that the two portions of

the ribbon 89 passing through one set of fields will be maintained parallel and the two portions of the ribbon 90 passing through the other set of fields will be maintained parallel. The other plate retainer 92 will be similarly constructed so that the ribbons at the lower ends of the fields will also be maintained parallel. All the rest of the structure in the unit, shown in Figures 9 to 14, having the bifilar suspension will be the same as that of the unit shown in Figures 1 to 8 and, therefore, the like parts are designated by the same reference numerals. Rays of light coming from the source will pass through the window, will be reflected in opposite directions by the suspended mirrors 64' and 65', to the surfaces of the stationary mirrors and by them reflected back to the suspended mirrors and then out through the window in a path close to the incident rays coming from the source of light.

In making coil suspensions and bifilar suspensions in the unit, it is necessary that different gap lengths be provided between the permanent magnets establishing the fields. To provide for adjustment of these gaps to take care of either type of suspension, the magnets 28, 29, 30 and 31 will be attached to the rear wall of the casing C by screws 94. These screws, as can best be seen in Figures 5 and 13, will pass through over-size holes 95 in the magnets. Thus, each magnet can be shifted slightly towards or away from the magnet in the front wall of the casing and consequently change the length gap of the field to make it proper for the particular suspension which is going to be employed. If, after this proper gap is established, it is desired to make such permanent, the magnets 28, 29, 30 and 31 can be braised to the rear wall of the casing.

From the foregoing description of my improved dual suspension oscillograph, it is seen that there has been produced a unitary structure in which two fields and suspensions are provided in close proximity to each other. The proximity is closer than where the fields are parallel. Each unit can be used alone or in banks for multi-channel applications as each unit will have non-magnetic side wall covers. When banks are used, more channels can be employed in a given space than by any previous structures. The unit permits either the coil or bifilar type of suspension, as desired, with only slight alterations required. In both types of suspension the vibrating mirrors will be so mounted that their reflecting surfaces are at right angles to the direction of the magnetic fields. The stationary mirror arrangement is an important feature of the invention. By its use whereby a beam is reflected from the vibrating mirror and then back thereto, the sensitivity of the instrument will be doubled. Also, by having a stationary mirror that is adjustable in two different directions at right angles to each other, the light spots to be recorded can be adjusted both horizontally and vertically without disturbing the vibratory element. The torsion of the suspension, and therefore the natural frequency, will not be affected when light spot adjustment is made in the improved instrument. All adjustments are made outside of the casing containing the suspension. When it is desired to adjust the entire unit, including the suspension, the suspension is not disturbed, yet there will be no change in the point that the incident beam strikes the suspended mirror, as adjustment is made about the point as a center or axis. By having spaced bifurcated fields with the mirrors between the two fields, the suspensions will be better bal-

anced than if the mirror were above the coil, as is done with a single field.

Being aware of the possibility of modifications and the substitutions of equivalent means in the structures shown without departing from the fundamental principles of my invention, I desire that it be understood that the scope of my invention is not to be limited in any manner other than as set forth in the appended claims.

What is claimed is:

1. In a dual oscillograph, means comprising a single magnet and two opposed magnets for establishing two magnetic fields in angular relation, a current carrying vibratory element suspended in each field, a mirror carried by each suspended element, said mirrors having a right angular relation such that radiations from a single source can be reflected by the mirrors in opposite directions, and stationary mirrors for reflecting the radiations back to the suspended mirrors.

2. In a dual oscillograph, means including three magnetic members for establishing bifurcated magnetic fields at right angles to each other with an air gap between the pole members forming the spaced ends, a current carrying vibrating element suspended in each field, and a mirror mounted on each vibratory element, said mirrors arranged to have their reflecting surfaces at right angles to each other and each in a plane extending in the direction of the field in which its vibratory element is positioned, said mirrors also having such positions with respect to each other that a ray from a single source will be reflected from the mirrors in opposed directions, and stationary mirrors for reflecting the rays back to the mirrors.

3. In a dual oscillograph, a casing means having an opening through which rays from a single source can be received and reflected, means comprising three magnetic members for establishing branched magnetic fields having right angular relationship to each other with an air gap between the ends of the fields, a current carrying vibratory element suspended in each field, a mirror associated with each suspension and positioned to have its reflecting surface in a plane extending in the same direction as the field and to receive and reflect rays from the single source, and a stationary mirror for each suspended mirror so positioned as to receive rays reflected from a suspended mirror and reflect it back thereto.

4. In a dual oscillograph, a closed casing means having an opening closed by transparent material through which rays from a single source can be received and reflected, means comprising three magnetic members for establishing branched magnetic fields having right angular relationships to each other and with an air gap between the spaced ends of the fields, a current carrying vibratory element suspended in each field, a mirror associated with each suspension and positioned to have its reflecting surface in a plane extending in the same direction as the field and to receive and reflect rays from the single source, a stationary mirror for each suspended mirror so positioned inside and laterally of the suspended mirror as to receive rays reflected from a suspended mirror and reflect it back thereto, and means accessible from the exterior of the top of the casing for adjusting the stationary mirror from the exterior of the casing means.

5. In a dual oscillograph, a casing structure provided with a front wall having an opening through which rays can pass and a back wall, two permanent magnets of like polarity mounted in the front wall longitudinally spaced on opposite sides of the opening, two pair of permanent magnets each of the opposite polarity mounted in the rear wall in longitudinally spaced relation, each one of a pair being laterally spaced apart with an air gap therebetween and so associated with a front wall magnet that there will be gaps establishing bifurcated magnetic fields above and below the front wall opening, magnetic material carried by the casing for establishing a magnetic path between each front wall magnet and the pair of magnets associated therewith, a single current carrying vibratory element suspended in like magnetic fields of the bifurcated fields, and a mirror mounted on each suspended element and positioned to receive rays passing through the opening and reflect same in different directions.

6. In a dual oscillograph, an independent unitary means comprising a single magnetic member of one polarity and two opposed magnetic members of an opposite polarity with an air gap between for establishing in close proximity two magnetic fields in right angular relation, a current carrying vibratory element suspended in each field, and a mirror carried by each suspended element, said mirrors having a right angular relation such that when the vibratory elements are in rest positions radiations from a single source can be reflected by the mirrors in opposite directions.

7. In a dual oscillograph, an independent unitary structure comprising bifurcated magnetic fields in close proximity and with an air gap between the spaced ends thereof, said fields being in right angle relation and established by a single magnet of one polarity and two magnets of opposite polarity, a current carrying vibratory element suspended in each field, a mirror mounted on each suspended element, said mirrors being positioned so as to have their reflecting surfaces in planes extending in the direction of the field in which its vibratory element is suspended and so positioned that when the elements are in rest positions both can receive radiations from a single source and reflect such radiations in opposite directions, and means for reflecting the reflected radiations back to the mirror from which it was first reflected.

8. In an oscillograph, an independent unitary structure comprising an elongated casing means, a permanent magnetic member of one polarity mounted on one wall of the casing, two other permanent magnetic members each of an opposite polarity mounted on an opposite wall with an air gap between and being provided with angular ends so arranged in spaced relation with the first named member as to establish two magnetic fields in close proximity and at right angles to each other, means establishing by magnetic material magnetic paths between the ends of the magnetic members remote from their spaced ends, a current carrying vibratory element suspended in each magnetic field, a mirror mounted on each vibratory element so that when the elements are at rest they will reflect radiations from a single source in opposite directions, and means for adjusting the magnetic members having like opposite polarity relatively to the other member and in parallel planes so that the space between magnets in which the vibratory elements are suspended can be varied to permit coil or bifilar suspension.

9. In a dual oscillograph, a unitary structure comprising a casing means having a single opening on one side of the casing through which rays from a single source can be received and reflected, means for establishing magnetic fields at right angles to each other, said means including three magnets with one being on the same side of the casing as the opening and the others on the opposite side of the casing, a current carrying vibratory element suspended in each field, a mirror associated with each suspension and positioned to receive and reflect rays from the single source, said mirrors being so positioned that the reflected rays from each will be in opposite directions, and a stationary mirror for each suspended mirror so positioned as to receive rays reflected from a suspended mirror and reflect such back thereto and then through the single opening.

10. In a dual oscillograph, an independent unitary structure comprising a casing means, three permanent magnet means carried by the casing for establishing two magnetic fields in bifurcated relation and common to one magnet, a current carrying vibratory element suspended in each field, a mirror mounted on each suspended element and being so related as to receive light from a single source and reflect it in opposite directions when the elements are at rest, and

means including a cylindrical seat and a cylindrical surface on the casing structure for adjusting the casing as a unit and with it the magnet means, vibratory elements and mirrors about an axis which is so positioned as to pass through the points of reflection of both mirrors, said seat constituting the sole support for the casing structure.

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