Jan. 6, 1948. R. H. PARK 2,434,223

HIGH GAIN AMPLIFIER

Filed March 15, 1944 2 Sheets-Sheet 1

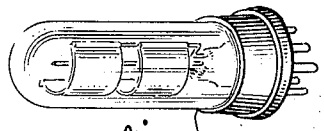


Fig. 3.

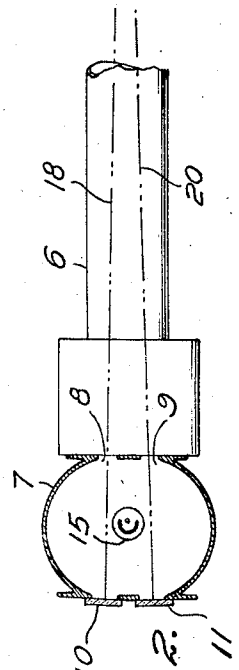


Fig. 2.

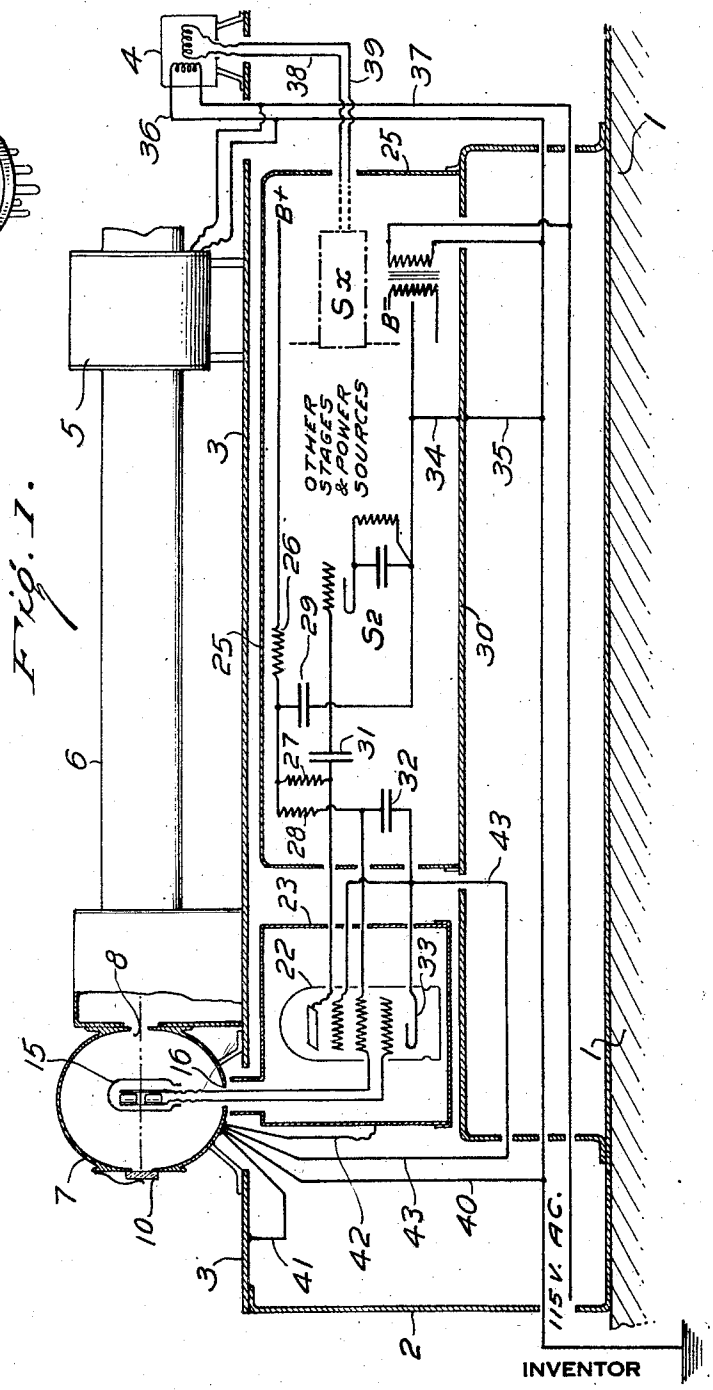


Fig. 1.

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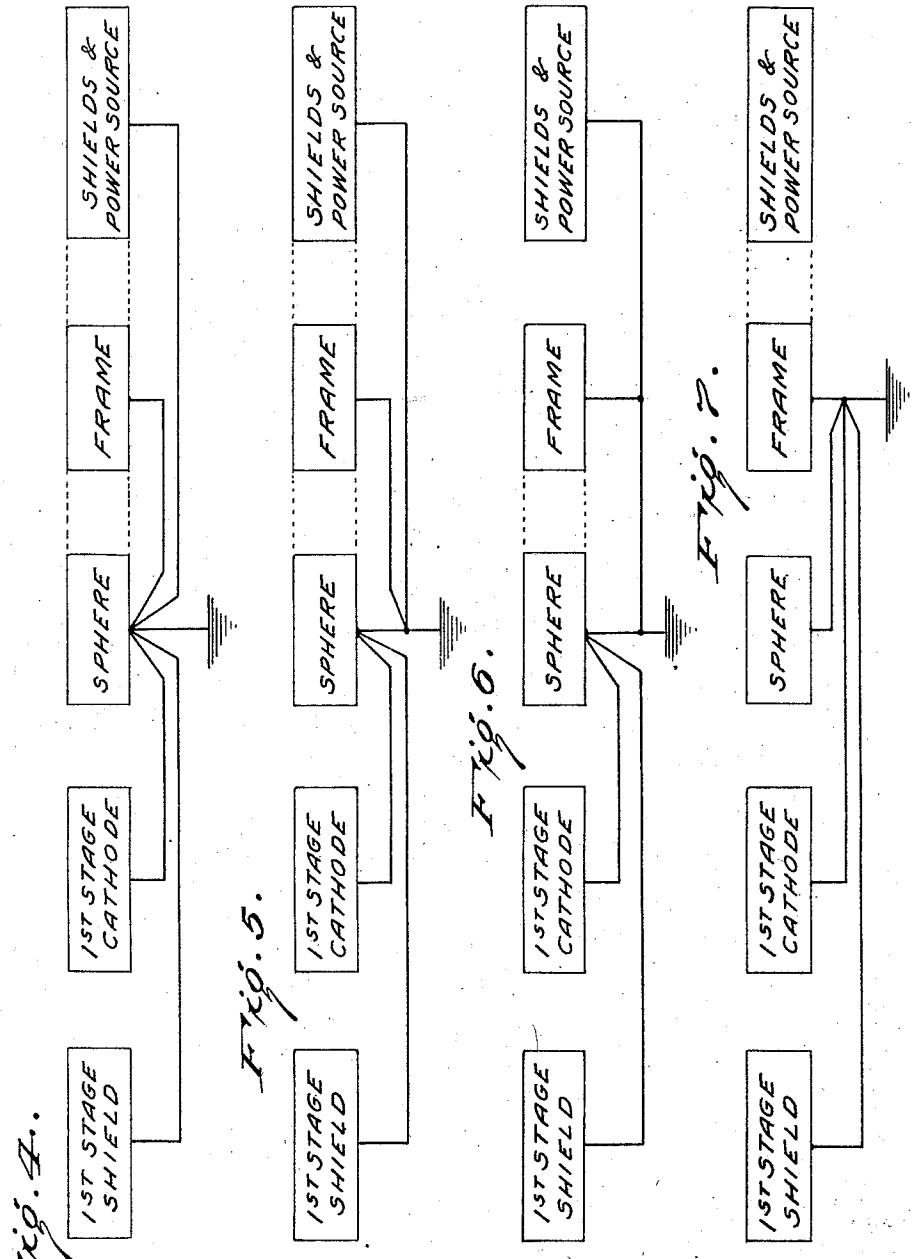


Fig. 4.

Fig. 5.

Fig. 6.

Fig. 7.

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HIGH GAIN AMPLIFIER

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4 Claims. (Cl. 179—171)

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This invention relates to high gain amplifiers and particularly to amplifiers used in conjunction with flickering-beam type spectrophotometers where the amplifier input signal is supplied by some high impedance means, such as a phototube, for converting variations in optical radiations into variations in electrical current. Optical radiations, as used in the instant application and claims is intended to include not only radiant energy in the visual optical range but also those near infrared and ultra-violet frequencies which substantially obey the optical laws.

One of the most serious problems encountered in using high gain amplifiers of the type which are required with flickering-beam type spectrophotometers such as those illustrated, for example, in U. S. Patent 2,107,836 to Orrin W. Pineo is to eliminate spurious signals. This is due to the fact that the true signals are vanishingly small when the photometer is in balance. In general, input signals of the order of magnitude of one microvolt are sufficient to drive the photometer nearer the balance. Lesser signals are lost below the level of unavoidable thermionic "noise." Stray signals, much larger than one microvolt, can be and often are produced by currents flowing through the capacities between transformers and their cases, motors and their frames, shields and the shielded parts and between different parts of the supporting frame and portions of the apparatus attached thereto.

It is, therefore, the object of the present invention to devise a suitable grounding system whereby these stray signals, which otherwise cause the photometer to deviate from true balance, may be simply and effectively eliminated.

It is customary, where it is desired to avoid the effect of capacities to shields and currents flowing in shields, to ground all such parts of the instrument to a single point, usually on some part of the apparatus frame. This is common practice where shielding must be extremely effective as, for example, in radio signal generators where it is necessary to prevent radiation so that the only signal reaching the outside passes through the generator output wires. However, when attempts are made to adapt the standard practice to the high gain amplifiers necessary with the types of apparatus with which the present invention is concerned, serious difficulties are encountered. While amplifiers grounded in this way have been constructed and operated in conjunction with such apparatus, their sensitivity, stability and reliability have left much to be desired.

These difficulties may be due to either structural or electrical problems or both. For example, structural difficulties in adequately shielding the phototube may prevent placing the phototube inside the photometric integrating sphere. This causes a direct loss in sensitivity since the phototube does not then receive as great a portion of integrated light as is possible when it is actually placed inside the sphere. Electrical problems are encountered from the difficulty that not all parts of the frame are at the same potential so that currents great enough to cause an IR drop of more than one microvolt may flow in the grounding system and cause spurious signals.

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As a result of these difficulties, considerable work has been done in the past in attempting to devise suitable grounding arrangements whereby both the structural difficulties, which require compromises in the desired structure of the photometer, and the effects of the stray currents may be eliminated. One such proposed arrangement has been set forth by the same Orrin W. Pineo in U. S. Letters Patent No. 2,345,501, patented March 28, 1944. In that application Pineo contended that for most effective results it was necessary to go contra to the standard practice where maximum shielding is desired. Instead of grounding all parts to one point, the stray capacities are shunted out of the input circuit by means of a low resistance conductor carrying a minimum of current and entirely separate from the other ground wires carrying much larger currents from other portions of the instrument. This is accomplished by a complicated system of grounding the integrating sphere, the supporting frame, the first amplifier stage cathode, the first amplifier stage shield and the power sources. While such a system is effective in accomplishing the desired result, it is complicated and also involves structural difficulties. I have now found that equally good results can be obtained by a much simpler system, and one which is more easily adapted to the structure of the instrument.

In general, the principal object of the present invention is accomplished by providing a suitable grounding and shielding arrangement, particularly with respect to the first amplifier stage shield and the cathode of the first amplifier stage vacuum tube. Grounding connections in the remainder of the apparatus are not as highly critical. The aforementioned shield and cathode are insulated from the rest of the apparatus and are separately grounded to some point on the grounding system by individual conductor wires of low resistance carrying a minimum of current.

The exact nature of the invention will be more

fully illustrated in conjunction with the accompanying drawings in which:

Figure 1 illustrates diagrammatically a high gain amplifier with a photocell input and apparatus associated therewith as used in a flickering-beam type spectrophotometer;

Figure 2 is a horizontal view, partly in cross-section, of the integrating sphere and the associated light tubes of Figure 1;

Figure 3 is a perspective of an improved phototube suitable for use in conjunction with the present invention;

Figure 4 is a diagrammatic representation of the grounding system of Figure 1, simplified for purposes of illustration; and

Figures 5, 6 and 7 represent modifications of the grounding system diagrammatically illustrated in Figure 4.

In Figure 1, a diagrammatic representation of the present invention as applied to a flickering-beam spectrophotometer such as that described in U. S. Patent 2,107,836 is shown. The apparatus comprises a table 1 or some like support upon which is mounted the spectrophotometer assembly. One end of this assembly comprises an enclosed metallic supporting frame 2 on the top metal plate 3 of which is supported a balance motor 4, a synchronous flicker-motor 5, a light-conducting tube 6, and an integrating sphere 7. Slightly divergent beams of substantially paraxial light 18 and 20, from a conventional source which forms no part of the present invention and is not shown, pass through the tube 6 into integrating sphere 5 through light-admitting openings 8 and 9 impinging upon a sample 10, the reflectance of which is to be measured, and a standard or reference sample 11 such as a block of magnesium carbonate, or the like. Reflected light from both samples is integrated by the sphere and picked up by a phototube 15. As shown in Figures 1 and 2, the phototube is located symmetrically within sphere 5.

Any standard type of phototube may be used in a spectrophotometer of this type. However, in Figures 1, 2 and 3 are shown a preferred type of cell having a double cathode, one cathode being blue-responsive and the other red-responsive. When such a tube is used, it is particularly important that the two cathodes be symmetrically located with respect to light beams 18 and 20 and to the remainder of the sphere. This can best be accomplished, as shown in Figures 1 and 2, by placing the two cathodes vertically one above the other and putting the tube in the center of the sphere.

The cathode of phototube 15 is connected directly to the control grid of a pentode vacuum tube 22 forming the first stage of the high gain amplifier. Tube 22 is shielded by a metallic shell 23 which is carefully insulated from supporting frame 30 of the amplifier itself and from the rest of the apparatus. Preferably also, the phototube leads are placed within shell 23. Shell 23 is itself shielded from sources of stray capacitance currents by that portion of the main metallic structure 2 and 3 within which it is enclosed. The remainder of the amplifying system is shielded by one or more metallic shields represented in the diagram by shield 25 which as shown is mounted directly on supporting frame 30.

The plate of the first stage amplifier tube is fed from a source of positive direct current B+ through a high resistance 26 and a load resistance 27, while the screen grid is fed through the same resistance 26 and an additional resistance 28. Resistance 26 also is connected to the load side of the direct current supply voltage B— through a suitable filter condenser 29. The plate of tube 22 is connected through a suitable condenser 31 to the grid of the second amplifier stage S_2. Alternating current from the screen grid of tube 22 is by-passed through a condenser 32 to cathode 33 of the same tube, the suppresser grid being also connected thereto in the conventional way. Operating potential for the anode of phototube 15 is taken from the screen grid of tube 22. The low side of the direct current voltage supply B— is grounded by conductor 34 to the frame 30 and the latter is connected to the grounded side of the alternating current input by conductor 35. The latter connection may ordinarily be omitted if so desired. In the usual manner, alternating current from the input is supplied to synchronous motor 5 and the field coil of balance motor 4 by leads 36, 37 and the rotor of balance motor 4 is fed in the proper place from the amplifier output by leads 38 and 39. The remaining stages of the amplifier are designated generically as S_x since they are conventional in hookup and form no part of the present invention.

In the grounding system, which forms the essential feature of the present invention, a ground wire 40 connects a point on sphere 7 to the grounded side of the 115 volt A. C. input. In the apparatus shown in Figure 1, the integrating sphere 7 is connected to frame 3 by a separate conductor 41. Similarly, shield 23 and the first amplifier stage cathode 33 are connected to the sphere at the same point by conductors 42 and 43 respectively. Shield 25, being directly in contact with frame 30, is grounded also.

By this simple arrangement those parts of the amplifier which are most critically affected by stray currents are effectively protected therefrom. Conductors 42 and 43 should be of sufficient size so that their resistances will not be high enough to permit an appreciably varying potential either along their length or in the metal parts of the instrument which they are grounding. Preferably, these wires are 18 gauge or larger, and as short as possible in order that the IR and reactive drop shall be less than the one microvolt mentioned above. Otherwise, the system is not particularly critical either as to the size of the connecters or the loads thereon. By using the grounding system of the present invention the potential drop normally will be below this desirable limit.

Several modifications of this hookup can be made without departing from the scope of the present invention. Several such modifications are illustrated by the diagrammatic sketches of Figures 4, 5, 6 and 7. The arrangement of Figures 5 and 6 differ from that of Figure 4 in that instead of all the ground leads being connected to a common point on the integrating sphere and grounding this common point, the frame and shield are grounded via the sphere ground.

It is an advantage of the present invention that the grounding system does not require insulation of the sphere from the frame since such insulation involves considerable structural difficulty. Should an insulated sphere be employed, an alternate hookup shown in Figure 7 may be employed. However, such an arrangement possesses no particular advantages over the others shown.

It is also a particularly important advantage of

the present invention that the shielding, other than that around the first stage vacuum tube, need not be insulated from the frame in order to accomplish the desired object. This again avoids considerable structural difficulty and is so shown in all the diagrammatic figures except Figure 6. It may be desirable under some circumstances to construct the apparatus with the shielding so insulated. In that case, a separate ground connector from the extra shields is provided, as shown for example in Figure 6.

Other modifications of the grounding system may be made if so desired, again without departing from the scope of the present invention. The essential features are that the first-stage amplifier tube shield and the first-stage amplifier cathode shall be insulated from the remainder of the instrument and from each other; that any stray currents be shunted therefrom by means of separate grounding conductors of low resistance and reactance; and that the currents flowing in these grounding conductors be kept small enough so that a resistance and reactance drop exceeding about one microvolt cannot occur.

In the form illustrated in Figures 1 and 2, the spectrophotometer is being used to test reflectance samples. If so desired, it may be used in testing transmission, in which case, transmission samples are interposed in the path of the light beams **18** and **20** before the light enters the integrating sphere. In that case, the reflectance sample windows in the back of the sphere may both contain standard samples or the windows may be closed by some other suitable means.

I claim:

1. In combination a high gain, multi-stage vacuum tube amplifier, converting means feeding said amplifier for translating variations in radiant energy into variations in electrical current, a metal supporting frame for said amplifier and said converting means, a metal shell containing said converting means electrically connected to said frame, a first stage vacuum tube for said amplifier having the control grid thereof directly connected to the otherwise ungrounded output of said converting means, a metallic shield surrounding said first stage vacuum tube, said shield and the cathode of said first stage vacuum tube being fully insulated from the remaining metal parts of the apparatus and from each other, and separate conductors electrically connecting said first stage tube shield and cathode to a common point, said metal shell being also directly connected to said common point, and said point being independently and directly connected to ground.

2. An apparatus according to claim 1 in which said common point is on said metal shell.

3. An apparatus according to claim 1 in which the metal shell is insulated from the metal supporting frame except for an independent conductor connecting said shell to said common point, and the frame being independently connected to said common point.

4. An apparatus according to claim 1 in which the power source and additional stages are separately shielded and insulated from said metallic frame and shell and the other remaining metallic parts of the apparatus, said shielding for the power source and additional stages being independently and directly connected to ground.

ROBERT HIRAM PARK.

REFERENCES CITED

The following references are of record in the file of this patent:

UNITED STATES PATENTS

Number	Name	Date
2,345,501	Pineo	Mar. 28, 1944
2,193,590	Gulliksen	Mar. 12, 1940
2,137,278	George et al.	Nov. 22, 1938