

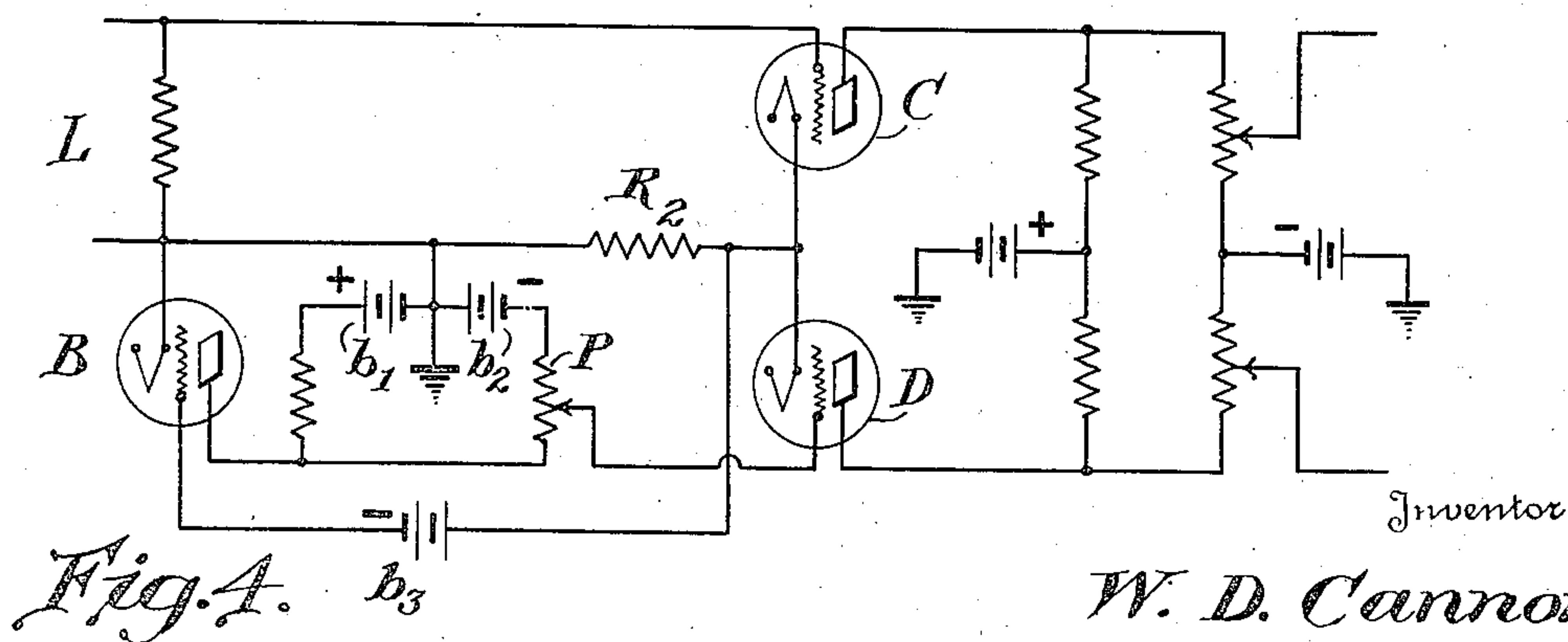
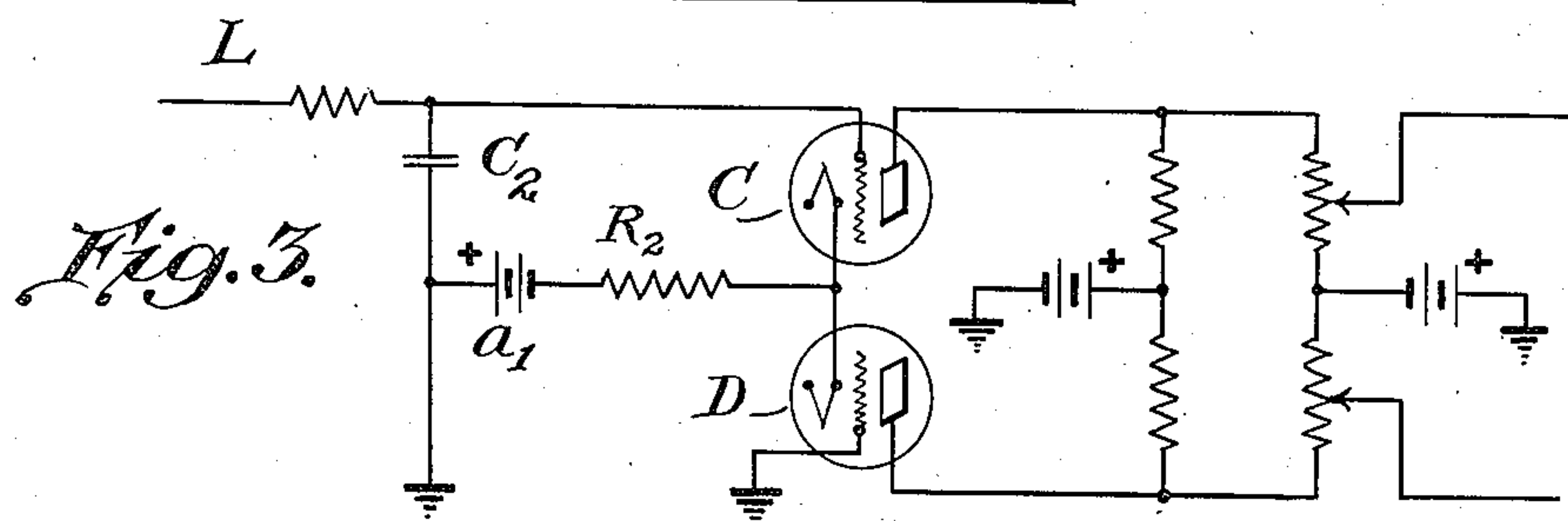
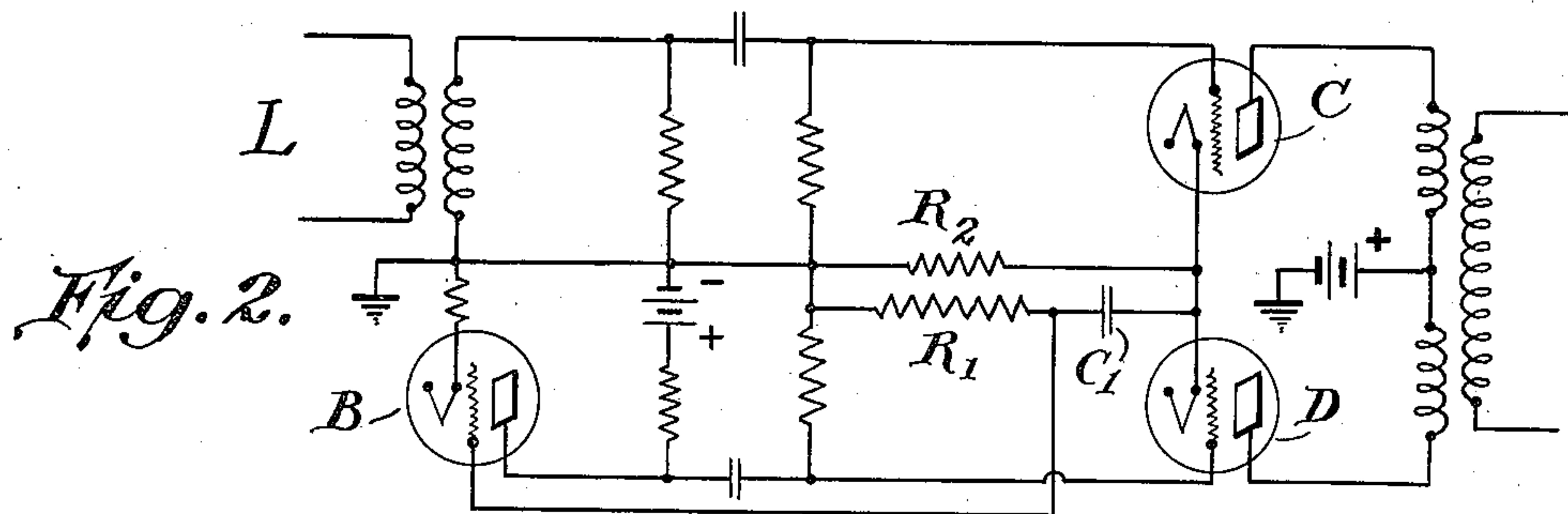
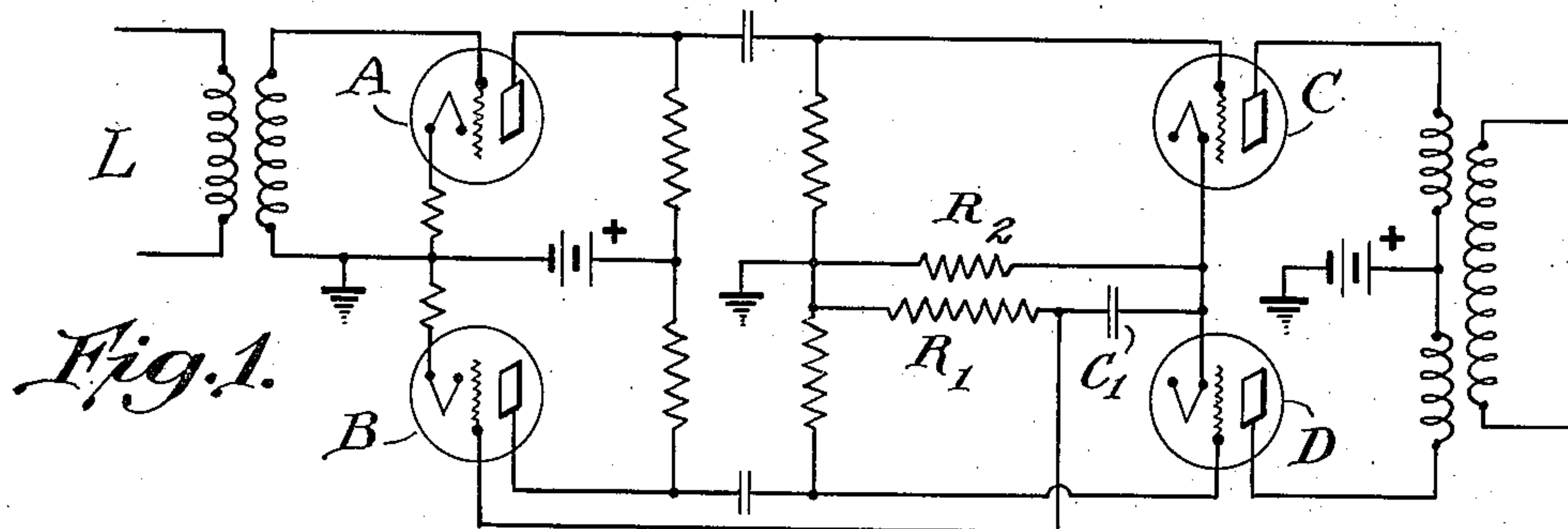
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PHASE INVERTER FOR PUSH-PULL AMPLIFIERS

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PHASE INVERTER FOR PUSH-PULL AMPLIFIERS

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4 Claims. (Cl. 179—171)

This invention relates to electric signaling transmission systems and more particularly to electron discharge amplifier circuits adapted to join an unbalanced type of amplifier in which the circuit is grounded on one side, to an amplifier stage which is balanced or symmetrical with respect to ground.

The connection of such amplifier circuits may be readily accomplished by means of transformers but in cases where transformers are objectionable on the ground of frequency limitations, as where very low or very high frequencies are to be amplified, the problem is more difficult.

The object of this invention is to provide an arrangement of amplifier circuits for accomplishing the above mentioned purpose, wherein the two electron tubes of a balanced or push-pull stage are excited by voltages of exact equality but of opposite phase.

In the accompanying drawing I have illustrated in Figs. 1 to 4 inclusive different modifications embodying this invention.

Referring to Figure 1, tubes C and D comprise the balanced output stage of the amplifier, which require the grids to be supplied with exciting voltages equal in magnitude but opposite in phase. The grid of the tube C is coupled to the output of amplifier tube A of the unbalanced or grounded circuit and is directly excited by signal voltage in the normal manner. The exciting voltage for the grid of the other tube D, of the push-pull stage, is derived through the agency of an auxiliary phase inverter tube B. The grid of tube B, however, receives its excitation from the resistance R_1 , which reflects the potential occurring across the self-bias resistance R_2 included in series with the cathode circuit of the output stage C, D. A condenser C_1 , acts as a blocking condenser to isolate the grid of tube B from the cathode potential of the two output tubes. With this arrangement no degenerative action can take place in the operation of the inverter tube B.

When the two tubes of a push pull amplifier are properly matched, no signal component appears in the common portion of the circuit which includes the resistance R_2 . The potential across this resistance should be constant and is due to the steady component of the plate current of the tubes C and D. Now if an A. C. potential should appear across this resistance R_2 , due to any unbalance between the tubes C and D, this potential will also exist across resistance R_1 and be impressed upon the grid of tube B, which will then impress via its plate circuit, a compensating

potential upon the grid of tube D. Thus the tube D tends to continuously neutralize any tendency of tube C to produce an alternating component across the resistance R_2 and hence maintains a zero A. C. potential across the said resistance. The phase inverter is thus self-balancing in its action and renders unnecessary a high degree of symmetry in the tubes and the coupling elements.

The magnitude of the voltage applied to the grid of tube D can be made to match that applied to the opposing tube through regulation of the gain of tube B. Ordinarily this tube should be of a high gain type. In fact, a multi-stage amplifier could be used in this position, so long as the phase of the potential applied to tube D is maintained 180° from that applied to tube C. That the voltage applied to the grid of tube B is 180 degrees out of phase with that applied to tube A is evident as it is well known that a complete phase reversal is present between successive stages in resistance coupled amplifiers.

The other features of this amplifier are conventional and are familiar to engineers and those skilled in this art. Transformer coupling to both input and output of the amplifier have been shown, but direct coupling may also be employed and furthermore, transformer coupling may be used for any intermediate stages. This amplifier circuit possesses a particular advantage in that the signal or A. C. currents in the plate circuit of the two output tubes C and D are maintained continuously equal. This is the condition for neutralization of the A. C. component in the resistance R_2 , and is accomplished through the functioning of the phase inverter tube B. In this manner the distortion which so frequently occurs when push pull tubes are imperfectly matched is avoided.

The element R_2 has been indicated as a resistance but it may to advantage be an inductance. An inductance would serve for example to provide an extraordinarily high degree of balance at high frequencies while leaving the D. C. relations undisturbed.

Figure 2 differs from Figure 1 only in that the tube A has been omitted. The gain due to this tube is therefore sacrificed but in all other respects the functioning of the amplifier is identical with that of Figure 1. The amplifier coupling condenser and resistance associated with tube A in Fig. 1 have been retained in Fig. 2. In general, however, these elements may be dispensed with in the circuit of Fig. 2.

Figure 3 illustrates another modification of the

invention showing a stage of an amplifier provided with tubes in push-pull arrangement, having the advantage of being conductively coupled throughout and is adapted to function with the positive and negative grounded batteries normally available in telegraph offices. The tubes C and D comprise a balanced direct coupled amplifier stage excited from a single grounded source, viz., condenser C₂.

Assume that an impulse of positive polarity is received over the line L, thereby impressing a positive control potential upon condenser C₂ and the grid of tube C. The plate current of the tube C will be increased and since this current must flow through resistance R₂, the cathode of this tube will be made more positive with respect to ground. The plate current of tube C will remain large under the influence of the positive signal, but the plate current of tube D will diminish since the grid is more negative than the cathode. Hence the grid of tube C will be positive while the grid of tube D will be negative with respect to their cathodes and the respective plate potentials of the two tubes will have the opposing positive and negative values corresponding to normal push pull operation. The gain of tube C will undergo some reduction, but this reduction will not exceed that which normally occurs in push pull tubes where the input signal is divided between two tubes. Generally the resistance R₂ will be rather high in value to produce proper balanced operation. The battery a₁ is therefore added for the purpose of restoring the grid potentials of the two tubes to the proper position on the tube operating characteristic.

The arrangement illustrated in Fig. 4 shows an amplifier which combines features of Figs. 1 and 3, together with certain alterations to provide a conductively coupled amplifier possessing the advantages of the arrangement shown in Fig. 1. Batteries b₁ and b₂ having the mid-point grounded, provide positive plate potential for the tube B, and also provide an appropriate negative potential for the grid of tube D. Since a condenser is not permissible in the grid circuit of the tube B, a biasing battery b₃, is included in this circuit to provide an appropriate bias for tube B. The output circuit corresponds to that shown in Fig. 3 but it may be altered in various ways familiar to engineers and persons versed in amplifier principles.

In the conductively coupled amplifier of Fig. 4, equality of the plate currents of the tubes C and D is obtained by adjustment of the potentiometer P. Exact equality of normal or D. C. plate currents is not important in the amplifiers of Figs. 1, 2, and 4, since the sum of these two currents serves only to provide the continuous self-bias in the resistance R₂, while the signal or A. C. components vary upward or downward from this steady bias as a mean value.

While I have shown several embodiments of my invention, it will be understood that I do not wish to be limited thereto, since other arrangements and modifications of amplifiers with phase-inverter circuits embodying the principles disclosed herein may be employed without departing from the scope of my invention as defined in the appended claims.

I claim:

1. In a signal wave transmitting apparatus, a push-pull amplifier comprising two electron tubes having an input circuit including portions individual to said tubes and a grounded circuit common to the cathodes of said tubes including a self-bias resistance, an unsymmetrically grounded line, a non-inductive coupling means for connecting the line to the input of one tube, without substantial phase change and means for connecting the line to the input of the other tube with interposed phase reversal, said means including an auxiliary electron tube having its input connected so as to be actuated by any signal voltage components occurring between said cathodes and ground and having its output connected to the input of the other of said tubes, to thereby counteract any tendency to unbalance between said tubes.

2. In a signal wave transmitting apparatus, a push-pull amplifier comprising two electron tubes having an input circuit including portions individual to said tubes and a grounded circuit common to the cathodes of said tubes including a self-bias resistance, an unsymmetrically grounded line, a non-inductive coupling means for connecting the line to the input of one tube without substantial phase change and an auxiliary phase reversing electron tube having its cathode grounded, its output connected to the other of said tubes and its input connected to receive any signal voltage components occurring between the cathodes of said tubes and ground but free from any continuous potentials in said common cathode circuit and thereby operating to nullify any unbalance in the output of said tubes.

3. In a signal transmitting system, a push-pull amplifier stage for connecting a non-symmetrical circuit to a symmetrical circuit, comprising two electron tubes in push-pull relation, having individual input circuits and a common grounded cathode circuit, a signaling line having one side grounded and its other side connected to the input of one of said tubes, an auxiliary phase-inverting electron tube connected to said line and having its input connected to receive any potential variations occurring between ground and the cathodes of said push-pull tubes and its output connected to the input of said other electron tube, said phase inverting tube thereby operating to maintain said push-pull tubes in balanced relation.

4. In a signal repeating system, a push-pull stage comprising two electron tubes having input circuits and having a common grounded cathode circuit containing an impedance, a signaling line having one side grounded and having its other side connected to the input circuit of one of said tubes, an auxiliary phase reversing electron tube having its cathode grounded, its output connected to the input of the other of said tubes, and having its input operatively connected to receive potential variations caused by signal components occurring in said common cathode circuit, to thereby counteract any unbalance between the tubes of said push-pull stage.

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