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ELECTRICAL SYSTEM

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FIG. 1.

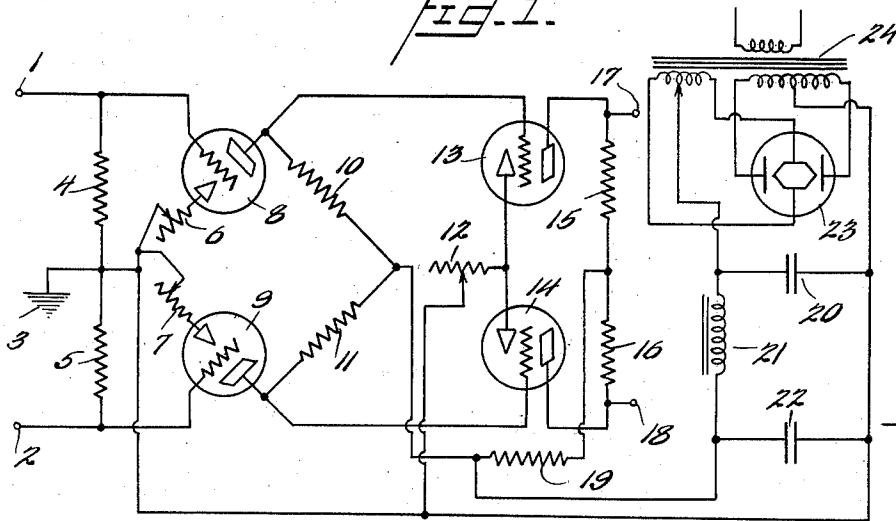
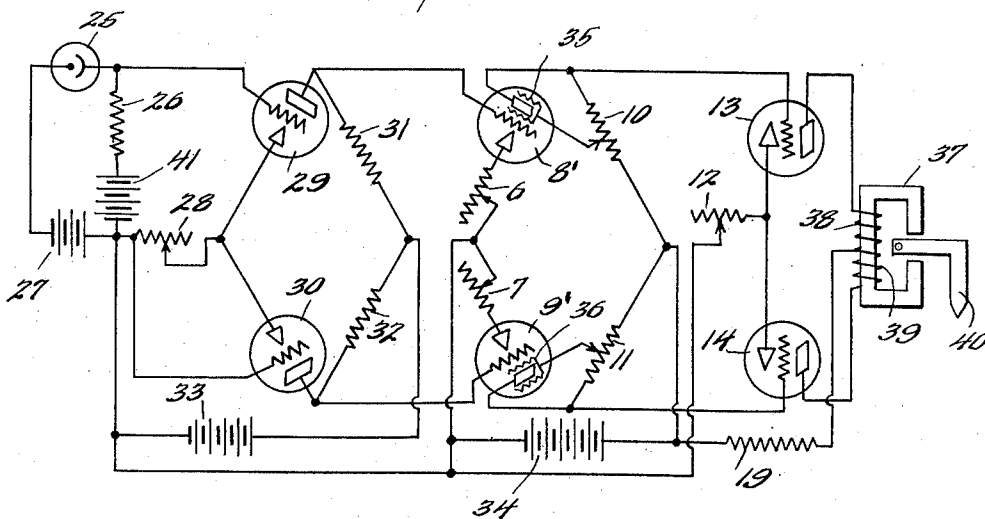


FIG. 2.



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ELECTRICAL SYSTEM

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2 Claims. (Cl. 179—171)

Our invention relates broadly to electrical systems, and particularly those making use of the effects available in assemblies of thermionic discharge devices and associated electrical circuits.

More specifically, our invention relates to use and control over amplifying ability and other effects of assemblies of thermionic discharge devices and associated electrical circuits.

An object of our invention is accomplishing stability within such systems while utilizing high orders of amplification, particularly in so-called direct-current amplifier systems functioning to amplify unidirectional currents undergoing variation of amplitude.

One particular object is the provision of a system of high amplifying ability adapted to fit the peculiar requirements of pantographic scanning combined with engraving, wherein the cutting action of an engraving tool faithful to a subject to be engraved reproduced is sought.

Another particular object is inclusion of provision for varying the amplifying ability of the system in keeping with desirability for such varying, pantographic scanning and engraving practice being an example of an activity in which such capability can usefully serve.

The modes of accomplishment of the aforementioned objects and others are understood from the following descriptive references to the figures of the accompanying drawing, in which like reference characters represent like elements in the different figures where appropriate; it being understood that no limitations are intended beyond those imposed by the annexed claims by reason of the particular arrangements chosen for explanatory purposes. The figures of the drawing are as follows:

Fig. 1 diagrammatically illustrates a system embodying some of the features of our invention; and

Fig. 2 illustrates a system including extensions of the system of Fig. 1 providing for inclusion of additional features over those realizable in the system of Fig. 1.

Referring to Fig. 1, 1 and 2 are input terminals connected to the grids of tubes 8 and 9 respectively for the application to the system of electrical potentials to be operated upon, across which terminals potential developing resistances 4 and 5 are connected in series relation, a point between these resistances being grounded at 3, and connected by way of resistances 6 and 7 to the cathodes of 3-electrode tubes 8 and 9 respectively as shown.

The anodes of tubes 8 and 9 are connected

through resistances 10 and 11 of approximately equal resistance value, and also directly to the grids of 3-electrode tubes 13 and 14 respectively, the cathodes of these tubes being connected to ground 3 through resistance 12. Resistances 10 and 11 therefore act as coupling elements between the outputs of tubes 8 and 9 and the inputs of tubes 13 and 14, and therefore have suitable ohmic values for this purpose.

The anodes of tubes 8 and 9 are positively like energized from a common-to-them suitable source, as by the alternating current rectifier and filter system shown comprising transformer 24, rectifier 23, filter condensers 20 and 22, and filter inductance 21, the positive side of the filter system being connected to a point between output resistances 10 and 11 (or to an approximately mid value point in the event but one resistance element is used), and the negative side to the cathodes of tubes 8 and 9 by way of bias potential developing resistances 6 and 7, and to the cathodes of tubes 13 and 14 by way of bias potential developing resistance 12.

The anodes of output tubes 13 and 14 are connected by way of series related resistances 15 and 16, preferably of approximately equal value, spanned by connections to output terminals 17 and 18, the point between resistances 15 and 16 being connected to the positive side of the filter system by way of potential reducing resistance 19, thus positively like energizing the anodes of both output tubes 13 and 14 to desired degree. The energizing of the anodes of the tubes of the two stages of the system is therefore accomplished from a common to them, single source of energizing potential.

Adjustment before operation of the system is preferably as follows: With no potential applied across input terminals 1 and 2, bias developing resistances 6 and 7 are adjusted so that the anode current flows from tubes 8 and 9 through resistances 10 and 11 are about equal in value, and of value about midway between maximum and minimum values obtainable for the particular anode energizing potential and load employed. This results in having substantially no difference of potential applied as between the grids of output tubes 13 and 14, thus making the current flows in output resistances 15 and 16 more or less equal, and, being polarizedly opposed, substantially no potential exists between output terminals 17 and 18.

These current flows in resistances 15 and 16 are also preferably adjusted by variable bias developing resistance 12 to have their approximate-

ly equal values fixed at about midway between maximum and minimum current values obtainable.

The system outlined, being of the so-called direct-coupled type, functions to pass onward through the system any potential difference, direct (unidirectional), or otherwise, applied to the input terminals as highly amplified manifestations in kind of the applied potentials upon arrival in the output thereof. That is, even a prolonged, unvaryingly steady difference of potential applied across input terminals 1 and 2 will result in producing and maintaining a highly amplified, otherwise corresponding difference of potential across output terminals 17 and 18. In other words, in addition to being an amplifier in general, the system functions most effectively as a so-called direct-current amplifier.

In operation, if the input terminals be either briefly or prolongedly unilaterally polarized (as terminal 1 being made positive and terminal 2 negative), there results amplified increase of current flow through resistance 10 and decrease of current flow through resistance 11, which effects will carry on through as decreased current flow in output resistance 15 and increased current flow in output resistance 16. The differential between these effects raises the potential difference across output terminals 17 and 18 from the initial zero neighborhood to a finite value amplifiedly proportional to the applied input potential difference, and which will endure as long as the applied potential difference endures, or vary in keeping with any variation of it.

Since the direct-coupled type of amplifier is the only form so far known to be capable of highly amplifying and faithfully handling the character of effects involved in pantographic scanning for engraving and like purposes (many of the effects of which are prolongedly sustained and others are quite rapid, so that highly aperiodic action is essential), it has been the trend in the development of pantographic scanning to rely upon the direct-coupled type of amplifier for the very high order of amplification needed. However, it has long been appreciated that the very nature of the direct-coupled type of amplifier from which it derives the ability to indiscriminately amplify currents from the zero neighborhood to the highest of used high frequencies makes its use, as it has heretofore existed, fraught with difficult-to-contend-with idiosyncracies. The very property the arrangement possesses of amplifiedly passing on all effects from one end of the system to the other, and sometimes reflectedly back, includes difficult-to-do-away-with in practice unwanted effects. For example, if current flow is modified in any manner in any part of the system, whereby a new difference of potential is established, this new difference of potential is at once manifested in all succeeding portions of the system. If occurring in a part of a system preceding a large amount of amplifying ability, the result can well be practically ruinous, the result of throwing the output tube completely off a workable portion of its output characteristic curve not being outside of the possibilities.

Results of the above mentioned kind are commonly termed "drift", and may be caused by such practically encountered effects as unequal heating of resistors, unequal variation of tube cathode emission, variation of potential of available energizing sources, and the like. In fact, the effects are so pernicious, and the results so pro-

nounced, that even though the direct-coupled type of amplifier came into being contemporaneously with the transformer-coupled type in about 1912, and had its efficient functioning as an amplifier almost immediately established, yet because of the seemingly incorrigible idiosyncracies it possessed, it was not permitted to leave the laboratory until the first announced successful efforts at stabilizing against drift was released by Loftin and White in the Proceedings of the Institute of Radio Engineers for February 1928.

While the work of Loftin and White was far-reaching in surmounting the drift difficulties in adaptations limited to the usual audio and radio frequencies, it left room for improvement in the region of zero and near zero frequencies, as had in pantographic scanning for engraving and the like, the accomplishment of which is one of the principal features of our present invention.

Referring again to Fig. 1, it is seen that the critically positioned, paralleledly associated preceding tubes 8 and 9, and their associated circuits and elements, are connected in a manner conforming to the well-known Wheatstone bridge, the purpose being that the arrangement provides for the usual drift producing effects being locally duplicately produced, and made to locally neutralize one another so as not to reach the output region of the system. For example, it is usual to heat a pair of cathodes, such as the cathodes of tubes 8 and 9, for electron emission from the same source, so that if the heating current changes in tubes so used in our system, both cathodes will be affected to like extent in emission change. The space charge variation, resulting from like emission change in both tubes, will be the same, so that any resulting change in current value in resistance 10 will be offset by corresponding, but oppositely acting, change in current value in resistance 11.

It is obvious that similar neutralizing will take place in the event of change of degree of anode energizing potential, since the anodes of both tubes are energized in parallel from the same source. It is of course a simple matter to provide for resistances 10 and 11, or 6 and 7, suffering like offsetting change of temperature in the event apparatus containing such resistances is subjected to resistance varying ranges of temperature variation.

Since output tubes 13 and 14 are usually of high power, high current, and low amplifying ability form, and are not followed by amplification, drift effects originating in this region are not so vital. Also, out of the large assortment of commercial tubes now available, the output tubes may be chosen to require lower anode energizing potential than the preceding tubes without sacrifice of needed power capacity, so that the potential reducing resistance can be of even larger value, thereby increasing its ability to take part in obviating drift in the output current, and materially isolating preceding tubes from reflections of output current variations. This resistance accordingly contributes to obtaining the high order of stability against output current drift of unwanted nature so essential to perfected pantographic scanning for engraving.

It being no part of our invention, we have not shown any details of means for heating the tube cathodes, it being understood that any one of the conveniently employed procedures may be used without affecting the results we obtain.

Referring to Fig. 2, we show an additional stage of amplification comprising 3-electrode tubes

and 30 in Wheatstone bridge arrangement as before. This stage has separate anode energizing, the source being symbolically indicated as battery 33. This isolation of the energizing of an additional stage, making for a higher order of amplification, is a desirable procedure towards not upsetting with additional amplification the high order of stability we insist upon.

The second stage of amplification, including Wheatstone bridge connected tubes 8' and 9', shown to include screen grids 35 and 36 respectively, provides for bringing about different degrees of variation of rate of change of amplifying ability, which accomplishment is of value to certain practices, of which pantographic scanning for engraving purposes is an example.

Referring to tube 8', if its screen grid 35 is contacted with the anode side of coupling resistance 10, the effective energizing potential had on this grid is the same as that had on the anode, and they remain of equal value as any change of current flow through coupling resistance 10 changes the difference of potential across the same, and thereby alters the resulting effective potential applied to the anode and screen grid. Since an increase of current flow in coupling resistance 10 increases the difference of potential across the same, there results a corresponding reduction of potential applicable to the anode and screen grid, and we find that this reduction acts to reduce the rate of change of amplifying ability had by the tube. If the screen grid is connected to some point within coupling resistance 10, so as to suffer but a part of the reduction of applicable anode potential, the loss in amplifying ability is reduced in proportion to the difference of potential existing between the higher screen grid potential and the lower anode potential. Viewed in another way, the arrangement providing for variably selecting the point of contact of the screen grid with the anode-connected coupling resistance makes possible varying the degree of nonlinearity of the usual output characteristic curve of the tube to satisfy any encountered need therefor.

As an example of the value of having available the ability to vary the rate of change of amplification encounterable in thermionic tubes; in pantographic scanning, in covering the dark portions of a subject, where the light values are low, it is desirable to have a highly sensitive response to the slight light changes had in these portions of the subject to well bring out the characterizing details; whereas, in the light portions, where the light values are high, less sensitive response is preferred.

In Fig. 2 the output stage is the same as in Fig. 1, except that we show an electromagnetically operated cutting tool in lieu of the resistance output system of Fig. 1, the output system in Fig. 2 comprising an electromagnetic core 37 having a split exciting winding composed of half sections 38 and 39. A pivoted cutting tool 40 is operatively positioned in the gap of core 37 as shown.

We also show a novel way of connecting a photoelectric responsive device 25 to the input of the

system of Fig. 2. The arrangement includes the usual photoelectric cell energizing source 27, symbolically illustrated as a battery, and a potential developing resistance 26 connected across the photoelectric device 25 and the input electrodes of tube 29. In addition to resistance 28 acting to develop the normal biasing potential for the grids of tubes 29 and 30, it acts, when the photoelectric device acts on the grid of tube 29 to increase its output current, to develop further degree of negative potential acting on the grid of tube 30 in a sense opposite to the action of the photoelectric device on the grid of tube 29, the result being a so-called push-pull effect.

Since the permanent current flow through photoelectric device 25, under the potential of battery 27, establishes a potential that is impressed upon the grid of tube 29, and not on the grid of tube 30, a balance between the biasing of the grids of the two tubes may be had by resorting to a source of reverse potential for the grid of tube 29 of value substantially equal to that developed in resistance 26, as by inserting the indicated battery 41 in series with resistance 26, and oppositely poled to the developed potential to be neutralized.

In Fig. 2 indicated battery 34 takes the place of the rectifier and filter source of energizing potential for the two final stages as is shown by the rectifier and filter arrangement in Fig. 1.

Having fully described our invention, we claim:

1. In an electrical system, a pair of like thermionic tubes, each having a cathode, anode and control electrode, resistance means connected between the anodes of said tubes, a source of potential positively connected to an approximate mid value point in said resistance means and negatively connected to said cathodes, a third resistance connected between said point and said cathodes, a source of input potential connected between a control electrode of only one of said tubes and the side of said third resistance removed from said cathodes, and a connection from said last mentioned side of said third resistance to the control electrode of the other one of said tubes substantially impedance free.

2. In an electrical system, a pair of like thermionic tubes, each having at least a cathode, anode and control electrode, a pair of series related, approximately equally valued resistances connected between the anodes of said tubes, a source of potential positively connected to a point between said resistances and negatively connected to said cathodes, a third resistance connected between said point and said cathodes, a source of input potential connected between a control electrode of only one of said tubes and the side of said third resistance removed from said cathodes, and a connection between said last mentioned side of said third resistance and the control electrode of the other one of said tubes substantially impedance free.

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