Sept. 15, 1942. J. C. WILSON 2,295,816

SIGNAL-TRANSLATING STAGE

Filed Sept. 9, 1940 2 Sheets-Sheet 1

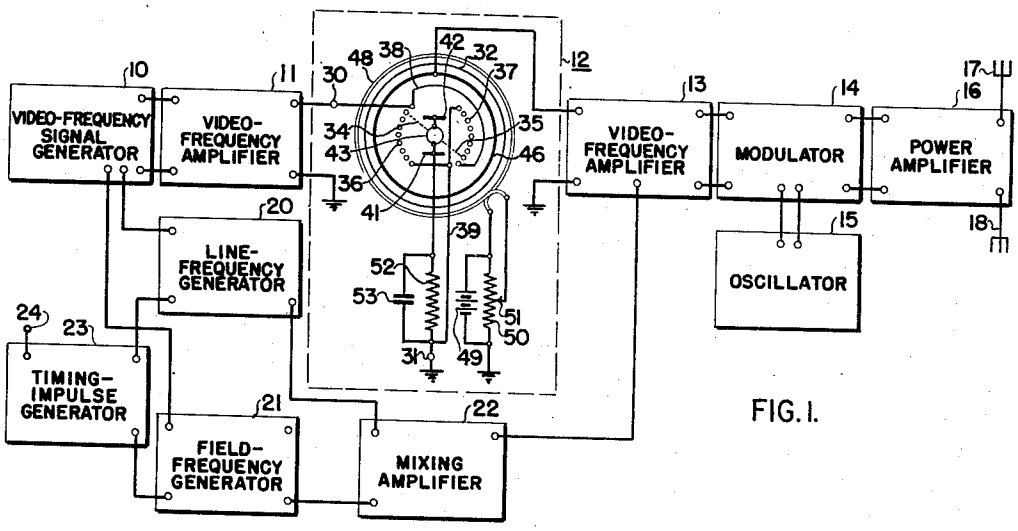


FIG. 1.

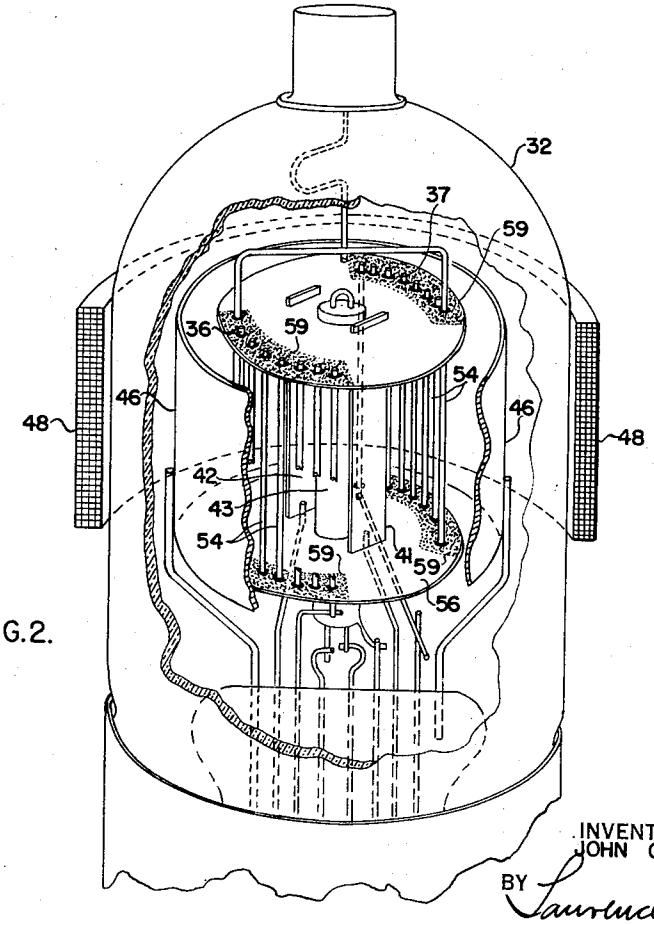


FIG. 2.

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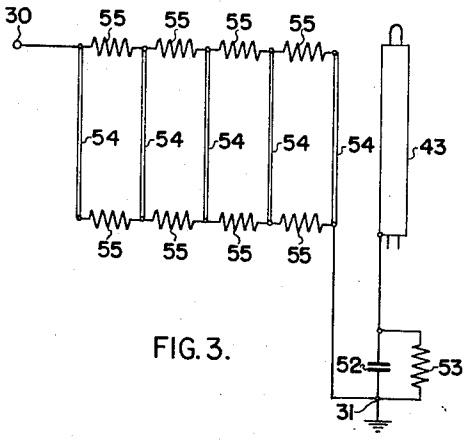


FIG. 3.

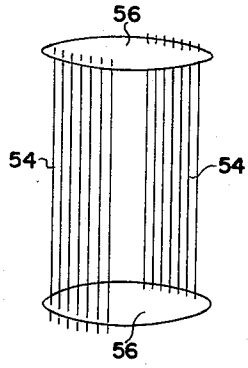


FIG. 4

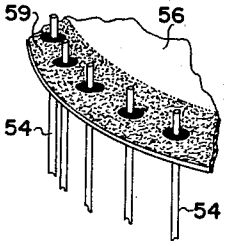


FIG. 5.

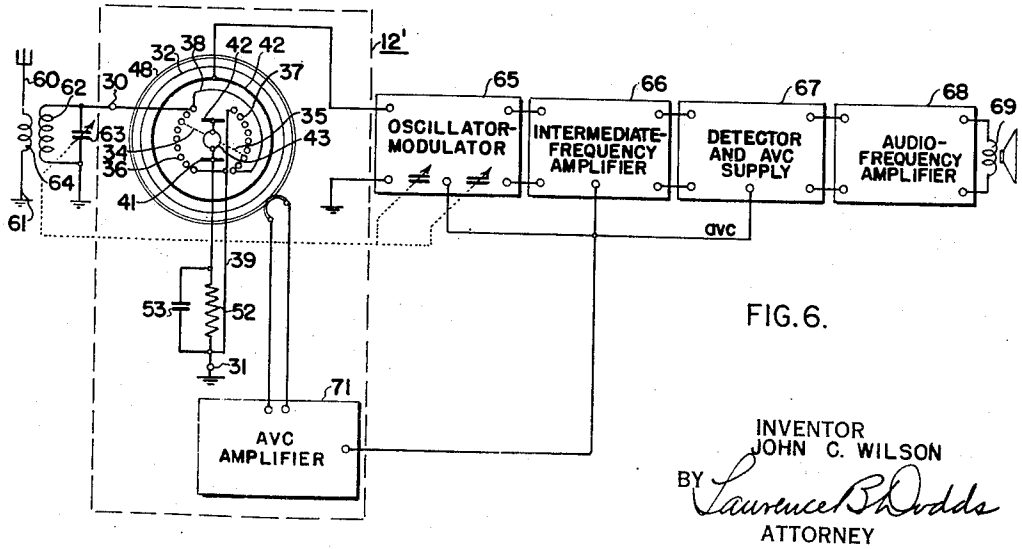


FIG. 6.

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SIGNAL-TRANSLATING STAGE

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Application September 9, 1940, Serial No. 355,942

9 Claims. (Cl. 179—171)

This invention relates generally to a signal-translating stage adapted to translate a signal input having a wide amplitude range and particularly to such a signal-translating stage in which the direct current component in the output circuit thereof does not vary appreciably as the gain of the stage is adjusted over a relatively wide range.

In some modulated-carrier signal-translating systems, the amplitude of the signal input to a signal-translating stage varies within very wide limits. This is true of the first signal-translating stage of a modulated-carrier wave-signal receiver under normal operating conditions. For weak signals it is desirable to maintain the transmission characteristic, or the response, of the preselector between the antenna and the first repeater stage of the receiver at a maximum in order to raise the received signal substantially above the noise level, thus to procure maximum useful sensitivity of the receiver. However, with a high gain in the preselector, as the strength of the desired received signal increases to such an extent that the grid swing of the first repeater stage includes a substantial nonlinear portion of the characteristic curve of the repeater, distortion of the desired signal-modulation envelope and cross modulation of the desired signal-carrier wave by strong undesired signals may result. This is particularly true in the case of receivers provided with automatic amplification control by which strong signals cause the grid of the first repeater stage to be biased toward that portion of its characteristic which is most nonlinear. Undesired signals, as well as desired signals, which reach the grid of the first repeater stage of the receiver have the effect of causing the grid to swing over such an amplitude range that these disturbing effects result. It is well known that such envelope distortion and cross modulation are effects which cannot be filtered out by succeeding selector circuits of the receiver.

In general, the preselector of a receiver should be selective to pass a band of desired modulation frequencies sufficiently wide to provide the desired fidelity of reproduction. Generally speaking, if an attempt is made to decrease the total desired and undesired signal input of the first repeater stage by discriminating against the undesired signals passed by the selector by adjusting its band width, the fidelity of reproduction is impaired to an undesirable degree. Further, this does not remove the envelope distortion of abnormally strong desired signals.

Various expedients have heretofore been proposed for automatically and adjustably attenuating the input to the first repeater stage of a modulated-carrier signal receiver in order to eliminate the disturbing effects described above. In certain of these arrangements, adjustable impedance elements, such as vacuum tubes, have been connected in circuit with the preselector circuit of the receiver adjustably to damp such circuit, thereby adjustably to attenuate the signal input to the first repeater stage. Other proposed arrangements for this purpose comprise two feed-forward coupling paths between the antenna and the first vacuum-tube repeater of the signal-translating channel so arranged as to apply signal voltages of opposite phase to the input circuit of the first repeater, the transmission characteristic of one of the coupling paths being adjustable. While such arrangements provide generally satisfactory operation, they have usually required the use of one or more additional vacuum tubes, or other circuit complexities which tend to increase the cost of the receiver.

Another arrangement which has been utilized for the purpose is that described and claimed in the copending application of Arthur V. Loughren, Serial No. 335,238, filed May 15, 1940, now Patent No. 2,263,825, November 25, 1941, and assigned to the same assignee as the present application. While the arrangement of the said copending application is generally satisfactory, one characteristic of the system which is undesirable in certain applications is that the direct current component in the output circuit of the stage varies as the gain of the stage is varied. This characteristic is also found in the other prior art arrangements mentioned above.

In certain applications it is disadvantageous to utilize an adjustable-gain signal-translating stage the unidirectional component of the output current of which varies with the gain of the stage. Thus, in a television video-frequency amplifier it is necessary to translate signal components of very low frequencies. If such a signal-translating stage having an adjustable gain is utilized in a television transmitter, any gain adjustment which is effected upon the stage usually has the effect of temporarily interrupting or adding spurious transients to the picture transmission for an appreciable interval, due to the time constants of the circuits utilized in the coupling system of the video-frequency amplifier. Such interruptions and spurious transients are highly undesirable and it is, therefore, desirable to provide a signal-translating stage the gain of which may be adjusted within wide limits and the unidirectional component of the output current of which is not

subject to an appreciable variation with the gain adjustment.

Also in preattenuator circuits of the types described above, the direct current component of the adjustable-gain stage used in such stages varies widely with an adjustment of gain of the signal-translating stage, as described above. This is particularly true of adjustable-gain signal-translating stages utilizing a variable-mu tube of conventional type. The range of variation of the direct current component of such stages may be more than 10:1 and such a wide range of variation may tend to affect appreciably the voltage regulation of the supply source. It is, therefore, highly desirable to provide an adjustable-gain signal-translating stage the gain of which may be varied over wide limits and the output current of which is substantially constant under any conditions of gain control.

It is an object of the present invention, therefore, to provide an improved signal-translating stage which is not subject to one or more of the above-mentioned disadvantages of prior art arrangements.

It is a further object of the invention to provide an improved signal-translating stage the gain of which is adjustable over a wide range of values.

It is still another object of the invention to provide a signal-translating stage the gain of which is adjustable over a wide range of values and the direct current output of which does not vary appreciably with adjustments of the gain of the signal-translating stage.

In accordance with the invention, a signal-translating stage comprises a pair of signal-input terminals and a vacuum tube, including means for forming an electron beam the cross-section of which is limited in at least one dimension, and a control grid intersecting the electron beam and wide relative to the width of the beam in the limited dimension. The stage further includes means for coupling the control grid between the input terminals effectively to comprise a voltage divider across its width and means for deflecting the electron beam in the direction of its limited dimension to control the gain of the stage by the action of the control grid.

For a better understanding of the present invention, together with other and further objects thereof, reference is had to the following description taken in connection with the accompanying drawings, and its scope will be pointed out in the appended claims.

In the accompanying drawings, Fig. 1 is a schematic circuit diagram of a complete television transmitting system including a signal-translating stage in accordance with the invention; Figs. 2, 3, 4, and 5 illustrate details of the tube of the signal-translating stage of Fig. 1 incorporating the invention; while Fig. 6 is a circuit diagram, partly schematic, of a complete television receiving system embodying a signal-translating stage in accordance with the invention as the first stage in the signal-translating channel of the receiver.

Referring now more particularly to Fig. 1 of the drawings, there is shown a schematic circuit diagram of a television transmitting system comprising a video-frequency signal generator 10, which may include the usual cathode-ray signal-generating tube and scanning and wave-shaping apparatus. Connected in cascade to the output circuit of the signal generator 10, in the order named, are a first video-frequency amplifier 11, a second video-frequency amplifier 12, a third video-frequency amplifier 13, a modulator 14 and an associated carrier-frequency oscillator 15, a power amplifier 16, and a radiating antenna system 17, 18. For the purpose of developing and transmitting a composite synchronizing signal and for synchronizing the scanning of the video-frequency generator 10 therewith, there is provided apparatus including a line-frequency generator 20 and a field-frequency generator 21 having their output circuits coupled to a mixing amplifier 22, the output circuit of which is, in turn, coupled to the video-frequency amplifier 13. Output circuits of line-frequency generator 20 and field-frequency generator 21 are also coupled to the video-frequency signal generator 10. There is also provided a timing-impulse generator 23 for the purpose of controlling the operation of line-frequency generator 20 and field-frequency generator 21. The generator 23 is preferably stabilized by means of a connection 24 to a suitable source of periodic voltage, for example, to the power-supply circuit or to the synchronizing-voltage source of motion picture mechanism, where such is employed.

Neglecting for the moment the details of operation of the signal-translating stage 12, the system just described comprises the elements of a television transmitting system of conventional design and, since the various parts thereof with the exception of stage 12 may be of any well-known construction, a detailed description of the general system and its operation is unnecessary. Briefly, the image of the scene to be transmitted is focused on the target in the signal generator 10 and a video-frequency voltage is developed thereby in the usual manner and is applied to the video-frequency amplifier 11, wherein this voltage is amplified and from which it is transmitted through amplifier 12 to the video-frequency amplifier 13. The composite synchronizing signal developed by the mixing amplifier 22, as will presently be described in more detail, is also applied to the video-frequency amplifier 13 in which it is mixed with the video-frequency signal and further amplified. The amplified composite signal is supplied to the modulator 14 wherein it is so impressed upon the carrier wave generated by the oscillator 15 as to develop a modulated-carrier signal. This signal is delivered to the power amplifier 16 for amplification therein and is thereafter impressed upon the antenna system 17, 18 to be radiated.

Timing pulses developed by the generator 23 are applied to the generators 20 and 21 to lock the same in synchronism. An output voltage of each of the generators 20 and 21 is applied to the mixing amplifier 22 in order to generate the required composite synchronizing signal for transmission. Output voltages of generators 20 and 21 are also supplied to the video-frequency signal generator 10 to synchronize the operation thereof.

Referring now more particularly to the apparatus 12 embodying the present invention, the signal-translating stage comprises a pair of input terminals 30, 31 and a vacuum tube 32 including means for forming one or more electron beams, the cross-sections of which are limited in at least one dimension; for example, a relatively narrow electron beam of ribbon shape may be formed, as indicated by the dotted lines 34

and 35. The tube structure is illustrated in more detail in the partially sectionalized perspective drawing of Fig. 2. The tube is provided with control grids 36 and 37 which intersect the beams 34 and 35, respectively, the control grids being wide relative to the widths of the beams in the above-mentioned limited dimension. Conductor 38 and conductor 39 are effective individually to couple the grids 36 and 37 between the input terminals 30, 31, effectively to cause the grids to comprise voltage dividers across the width of the grids. Focusing plates 41, 42, maintained near the potential of the cathode 43 of the tube, are provided for generating the beams 34 and 35 which are limited to a ribbon shape, as described above. The tube is also provided with an anode 46, the cathode 43 and the anode 46 effectively comprising concentric cylinders surrounded by the envelope of the tube. In order to deflect the electron beams 34 and 35 in the direction of the limited dimensions of the beam, that is, circumferentially within the tube 32, to control the gain of the stage 12, there is provided a suitable beam-deflecting means, such as a winding 48, surrounding the tube 32 and adapted to be excited by direct current from a source 49 through a voltage divider 50 having an adjustable tap 51. The voltage divider 50 and the adjustable tap 51 therefore are included in a means for adjusting the amount of deflection of the electron beams 34 and 35 to adjust the gain of the stage to any desired value within relatively wide limits by the action of the control grids 36 and 37. The use of such a magnetic beam-deflecting means rather than an electrostatic deflecting means facilitates the desired deflection without affecting the mean anode current of the tube. A cathode-biasing resistor 52 is provided for tube 32, by-passed for currents of signal frequency by means of a condenser 53.

Reference is made to Figs. 3, 4, and 5 for a more detailed description of the construction of the grids of the tube of the signal-translating stage 12. Each of the grids 36 and 37 is constructed effectively to comprise a voltage divider coupled between terminals 30, 31, as indicated schematically in Fig. 3, where the vertical members 54 represent the wires of the grid which are parallel to the cathode 43 of the tube. The grid is so constructed as effectively to provide resistors 55 coupling adjacent ends of conductors 54, as illustrated in Fig. 3. The control grid therefore effectively comprises across its width electron-controlling conductors effectively spaced by resistors. The grid may be constructed, for instance, as illustrated in Fig. 4, where mica discs 56, 56 are utilized to support the grid wires 54. A conductive material, for instance, some sputtered resistive coating on discs 56, is utilized effectively to form the resistors 55 of Fig. 3. A more complete detail of this construction is illustrated in Fig. 5, wherein the resistive coating is designated by the reference numeral 59.

In considering the operation of the signal-translating stage 12 of Fig. 1, it will be seen that, due to the voltage-dividing properties of grids 36, 37, substantially the entire signal voltage is available for utilization to control the intensity of beams 34 and 35 when deflected to the position shown, since the beams intersect the grids near their high signal-potential terminals. Thus, under this condition of operation, the signal-translating stage 12 effectively has a relatively high gain. However, if the tap 51 on voltage divider 50 is adjusted to change the current in winding 48, thereby to deflect the beams 34 and 35 in a counterclockwise direction, the beams then intersect portions of the voltage-dividing grids which are at an appreciably lower signal potential. Therefore, under these conditions, the gain of the stage is materially reduced. However, it will be noted that the unidirectional bias provided for the grids 36 and 37 by the cathode resistor 52 is not changed by this adjustment and, inasmuch as the control grids 36 and 37 are homogeneous, that is, they have the same spacing for all equivalent circumferential portions, the direct space current of the tube does not vary with the gain adjustment. The cathode resistor 52 therefore is included in the means for uniformly biasing the control grid.

Therefore, it is seen that the signal-translating stage 12 is one adapted to have its gain adjusted over a wide range and in which the direct current component in the signal-output circuit of the stage does not vary appreciably with the gain adjustment, thus providing the advantages mentioned in the preliminary portion of the specification.

Referring now more particularly to Fig. 6 of the drawings, there is illustrated a superheterodyne receiver including a signal-translating stage in accordance with the invention as the first stage in the signal-translating channel of the receiver. This receiver comprises, coupled in cascade with an antenna-ground circuit 60, 61, a radio-frequency amplifier 12' coupled to antenna circuit 60, 61 through a selective circuit 62, 63, 64, a frequency changer or oscillator-modulator 65, an intermediate-frequency amplifier 66 of one or more stages, a detector and A. V. C. supply 67, an audio-frequency amplifier 68 of one or more stages, and a sound reproducer 69. Automatic amplification control is secured in a well-known manner by applying a unidirectional voltage derived from A. V. C. supply 67 to the control electrodes of one or more of the tubes included in the oscillator-modulator 65 and intermediate-frequency amplifier 66.

A novel type of automatic amplification control is also provided within the signal-translating stage 12', the constructional details of which are generally similar to those of stage 12 of Fig. 1 and circuit elements which are similar in the two figures have identical reference numerals. The signal-translating stage 12' differs from that of stage 12 of Fig. 1 primarily in the means provided for supplying direct current to the winding 48 to control the gain of the stage. In the circuit of Fig. 6 the voltage provided by the A. V. C. supply 67 is amplified in an A. V. C. amplifier 71, the output of which is utilized to provide the direct current for winding 48. The general operation of the superheterodyne receiver of this figure is entirely conventional and need not be described in detail.

It is believed that the operation of the signal-translating stage 12' of Fig. 6 will be readily apparent from the description which has been given above of the operation of the signal-translating stage 12, the only difference in the operation being that the gain control is effected in the circuit of Fig. 6 by the direct current supplied by amplifier 71 rather than by the direct current supplied by the battery 49. Therefore, the gain of signal-translating stage 12' may be varied within very wide limits with substantially no effect upon the

source of supply of the unidirectional operating voltages provided for the tubes of the receiver. As brought out above, if the voltage of such source of supply tends to vary, the operation of the various parts of the receiver circuit may be adversely affected.

While there have been described what are at present considered to be the preferred embodiments of this invention, it will be obvious to those skilled in the art that various changes and modifications may be made therein without departing from the invention, and it is, therefore, aimed in the appended claims to cover all such changes and modifications as fall within the true spirit and scope of the invention.

What is claimed is:

1. A signal-translating stage comprising, a pair of signal-input terminals, a vacuum tube including means for forming an electron beam the cross-section of which is limited in at least one dimension and a control grid intersecting said beam and wide relative to the width of said beam in said limited dimension, means for coupling said grid between said input terminals effectively to comprise a voltage divider across its width, and means for deflecting said electron beam in the direction of its limited dimension to control the gain of said stage by the action of said control grid.

2. A signal-translating stage comprising, a pair of signal-input terminals, a vacuum tube including means for forming an electron beam the cross-section of which is limited in at least one dimension and a homogeneous control grid intersecting said beam and wide relative to the width of said beam in said limited dimension, means for coupling said grid between said input terminals effectively to comprise a voltage divider across its width, and means for deflecting said electron beam in the direction of its limited dimension to control the gain of said stage by the action of said control grid.

3. A signal-translating stage comprising, a pair of signal-input terminals, a vacuum tube including means for forming an electron beam the cross-section of which is limited in at least one dimension and a control grid intersecting said beam and wide relative to the width of said beam in said limited dimension, means for coupling said grid between said input terminals effectively to comprise a voltage divider across its width, means for deflecting said electron beam in the direction of its limited dimension to control the gain of said stage by the action of said control grid, and means for uniformly biasing said control grid.

4. A signal-translating stage comprising, a pair of signal-input terminals, a vacuum tube including means for forming an electron beam the cross-section of which is limited in at least one dimension and a homogeneous control grid intersecting said beam and wide relative to the width of said beam in said limited dimension, means for coupling said grid between said input terminals effectively to comprise a voltage divider across its width, means for deflecting said electron beam in the direction of its limited dimension to control the gain of said stage by the action of said control grid, and means for uniformly biasing said control grid.

5. A signal-translating stage comprising, a pair of signal-input terminals, a vacuum tube including means for forming an electron beam of ribbon shape in said tube whereby the cross-section is limited in one dimension and a control grid intersecting said beam and wide relative to the width of said beam in said limited dimension, means for coupling said grid between said input terminals effectively to comprise a voltage divider across its width, and means for deflecting said electron beam in the direction of its limited dimension to control the gain of said stage by the action of said control grid.

6. A signal-translating stage comprising, a pair of signal-input terminals, a vacuum tube including means for forming an electron beam the cross-section of which is limited in at least one dimension and a control grid intersecting said beam which is wide relative to the width of said beam in its limited dimension and which effectively comprises across its width electron-controlling conductors effectively spaced by resistors, means for coupling said grid between said input terminals effectively to comprise a voltage divider across its width, and means for deflecting said electron beam in the direction of its limited dimension to control the gain of said stage by the action of said control grid.

7. A signal-translating stage comprising, a pair of signal-input terminals, a vacuum tube including means for forming an electron beam the cross-section of which is limited in at least one dimension and a control grid intersecting said beam and wide relative to the width of said beam in said limited dimension, means for coupling said grid between said input terminals effectively to comprise a voltage divider across its width, and magnetic means for deflecting said electron beam in the direction of its limited dimension to control the gain of said stage by the action of said control grid.

8. A signal-translating stage comprising, a pair of signal-input terminals, a vacuum tube including means for forming an electron beam the cross-section of which is limited in at least one dimension and a control grid intersecting said beam and wide relative to the width of said beam in said limited dimension, means for coupling said grid between said input terminals effectively to comprise a voltage divider across its width, and a winding surrounding said tube and adapted to be energized by a unidirectional current for deflecting said electron beam in the direction of its limited dimension to control the gain of said stage by the action of said control grid.

9. A signal-translating stage comprising, a pair of signal-input terminals, a vacuum tube including means for forming an electron beam the cross-section of which is limited in at least one dimension and a control grid intersecting said beam and wide relative to the width of said beam in said limited dimension, means for coupling said grid between said input terminals effectively to comprise a voltage divider across its width, means for deflecting said electron beam in the direction of its limited dimension, and means for adjusting the amount of deflection to adjust the gain of said stage by the action of said grid to any desired value within relatively wide limits.

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