

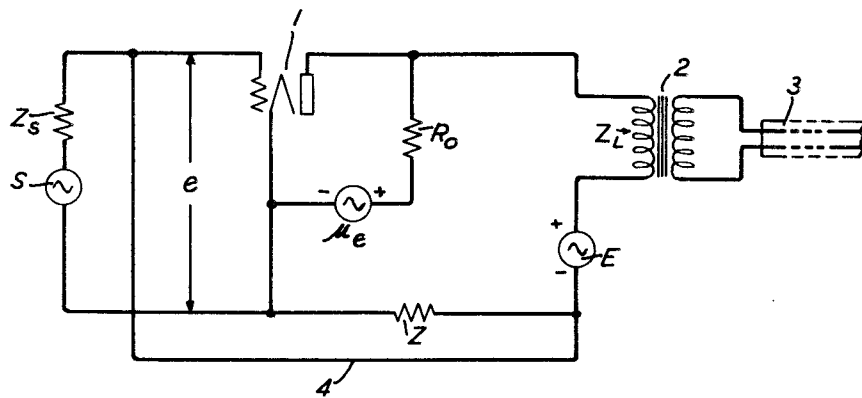
April 24, 1934.

E. PETERSON

1,955,828

WAVE TRANSLATING SYSTEM

Filed Aug. 11, 1932



INVENTOR
E. PETERSON
BY *H.A. Burgess*
ATTORNEY

UNITED STATES PATENT OFFICE

1,955,828

WAVE TRANSLATING SYSTEM

Eugene Peterson, New York, N. Y., assignor to
Bell Telephone Laboratories, Incorporated, New
York, N. Y., a corporation of New York

Application August 11, 1932, Serial No. 628,377

5 Claims. (Cl. 178—44)

This invention relates to wave translation systems, as for example, systems employing vacuum tube or other types of amplifiers.

An object of the invention is to control modulation in such systems, as for example to reduce distortion caused by modulation in amplifiers and in amplifier load impedance.

As explained for example in the copending application of H. S. Black, Serial No. 606,871, filed April 22, 1932, for Wave translation systems, assigned to the assignee of this application, and in British Patent 317,005, negative or gain-reducing feed-back has been used in amplifiers to reduce distortion produced in the amplifier (for example distortion produced in the tube circuits in the case of a vacuum tube amplifier), by feeding back a fraction of the output which reappears out of phase with respect to the original distortion. In one specific aspect the present invention is a system in which modulation or distortion produced by non-linearity of the impedance of a load or terminating circuit for a feed-back vacuum tube amplifier is so fed back in the amplifier that load modulation currents as well as tube modulation is reduced.

Other objects and aspects of the invention will be apparent from the following description and claims.

The single figure of the drawing shows a vacuum tube circuit embodying the specific aspect of the invention referred to above.

In the drawing, a vacuum tube 1 of a feed-back vacuum tube amplifier receives voltage from an incoming circuit represented as a generator S and impedance Z_s , and transmits amplified waves to load impedance or outgoing circuit Z_L , shown as comprising an output transformer 2 for the amplifier and a ferro-magnetically loaded transmission line 3 which may be for example a submarine cable circuit.

The output circuit of tube 1 comprises an impedance Z in series with the impedance Z_L . The impedance Z may be a resistance, for example.

Distortion (waves of new frequencies) produced by non-linearity of the termination or load impedance Z_L may be caused for example by a ferro-magnetically loaded circuit such as circuit 3. Such distortion may be represented as a voltage E, and is indicated as the voltage of a fictitious generator E. This distortion voltage causes distortion currents to flow through impedance Z and so the distortion is fed back from the termination to the input circuit of the amplifier as a voltage e applied from across impedance Z to the grid of tube 1, for example through conductor 4.

The consequent voltage in the plate circuit is μe and is indicated as the voltage of a fictitious generator μe in series with the internal plate impedance R_o of tube 1. The plus and minus signs at generators E and μe indicate relative polarities at a given instant, in the circuit shown. The voltage received by tube 1 from the incoming circuit may be of sufficient magnitude to produce undesired tube modulation in tube 1 comparable in magnitude to the load modulation. Thus the load modulation and the tube modulation may each be of objectionable magnitude.

With series feed-back as shown, the phase relations required or most favorable for reduction of tube modulation (yet avoidance of objectionable singing tendencies) are not opposed to or inconsistent with the phase relations desired for reduction of load modulation currents. Both types of modulation are reduced by the feed-back action of the amplifier, with the feed-back voltage obtained from impedance Z connected in series with the load impedance, between the cathode of the tube and the load impedance.

Considering only modulation components generated impedance Z_L and designating as β the fraction of the total plate electromotive forces ($E + \mu e$) that is fed back,

$$-\beta(E + \mu e) = e.$$

The total plate electromotive forces are then reducible by this relation to

$$(E + \mu e) = E / (1 + \mu\beta).$$

Thus we have accounted for modulation in the load, and it is known that the same effect exists for tube modulation. That is, both the load modulation and the tube modulation are reduced, being multiplied by the factor $1/(1 + \mu\beta)$ or divided by the quantity $(1 + \mu\beta)$, for a given power output level from the amplifier.

The tube 1 may be replaced by any number of tubes in cascade or tandem connection, but preferably the number of tubes (or other phase reversing means) in the feed-back loop is odd, to facilitate avoidance of singing difficulties. In designing a wide band feed-back amplifier, phase shift around the feed-back circuit presents one of the principal limitations (particularly at high frequencies), since this phase shift may cause singing which can not be permitted at any frequency either within or without the utilized frequency range. In practice, having the phase shift in the neighborhood of 180° in the utilized frequency range tends to prevent unavoidable

phase shifts at frequencies well above or below that frequency range from causing singing.

The amount of gain reduction effected by the feed-back may be large, for example, of the order of 30 or 40 decibels in the case of multistage vacuum tube amplifiers for instance. The gain of the amplifier without feed-back should then correspondingly exceed the gain required with feed-back.

As applied to reduction of head end (near end) modulation in a submarine cable, for example, to facilitate use of courier switching systems (for instance of types such as those disclosed in R. C. Mathes Patents 1,829,805 and 1,829,806, November 3, 1931), the invention is especially advantageous inasmuch as liberal design with respect to loading that would reduce modulation in the loading material would entail very expensive construction.

The impedance of a circuit may be defined as the ratio of an introduced sinusoidal electromotive force to the current flowing in that circuit produced by the introduced electromotive force, both quantities being complex quantities. In feed-back circuits, the additional voltage due to feed-back appears in circuit so that the flow of current is modified, resulting in an impedance change.

What is claimed is:

1. A wave translating system comprising a vacuum tube device, a non-linear impedance, means connecting said impedance in serial relation with an anode-cathode space path of said device and a portion of a grid-cathode circuit of the device, with said portion connected between the cathode and the non-linear impedance, said device transmitting to said impedance waves that produce objectionable modulation components in said impedance, and means for supplying to said device waves of magnitude sufficient to produce therein modulation components of objectionable magnitude, the voltage across said portion of said grid-cathode circuit producing negative feed-back in said device for reducing said modulation produced in said device and said modulation components produced in said impedance.

2. A wave translating system comprising a vac-

uum tube amplifier, a non-linear load impedance therefore that generates objectionable modulation components, means for supplying waves to said amplifier that generates in a space path of said amplifier modulation components comparable in magnitude to those generated in said load impedance, and means producing negative feed-back in said amplifier for reducing said modulation components generated in said space path and in said load impedance, said last mentioned means comprising an impedance common to a grid-cathode circuit and an anode-cathode circuit of said amplifier and connected between a cathode of said amplifier and said non-linear impedance and in serial relation to an anode-cathode space path of said amplifier and said non-linear impedance.

3. A wave translating system comprising a vacuum tube amplifier, a non-linear load impedance therefor producing objectionable load modulation components, an impedance connected in serial relation to an anode-cathode space path of said amplifier and said load impedance, and means producing gain-reducing feed-back in said amplifier and reducing said objectionable load modulation components, said means comprising a connection to a grid of said amplifier from a point between said impedances.

4. A wave translating system comprising a vacuum tube amplifier, means for supplying thereto waves that generate objectionable tube modulation components in said amplifier, a non-linear load impedance for said amplifier generating objectionable load modulation components, a second impedance connected in serial relation to an anode-cathode space path of said amplifier and said load impedance, and means feeding back from said second impedance to a grid of said amplifier modulation components generated in said amplifier and in said load impedance for reducing said objectionable tube modulation components and said objectionable load modulation components by negative feed-back action of said amplifier.

5. The system of claim 1, said non-linear impedance comprising a loaded submarine cable circuit.

EUGENE PETERSON.