

Dec. 11, 1945.

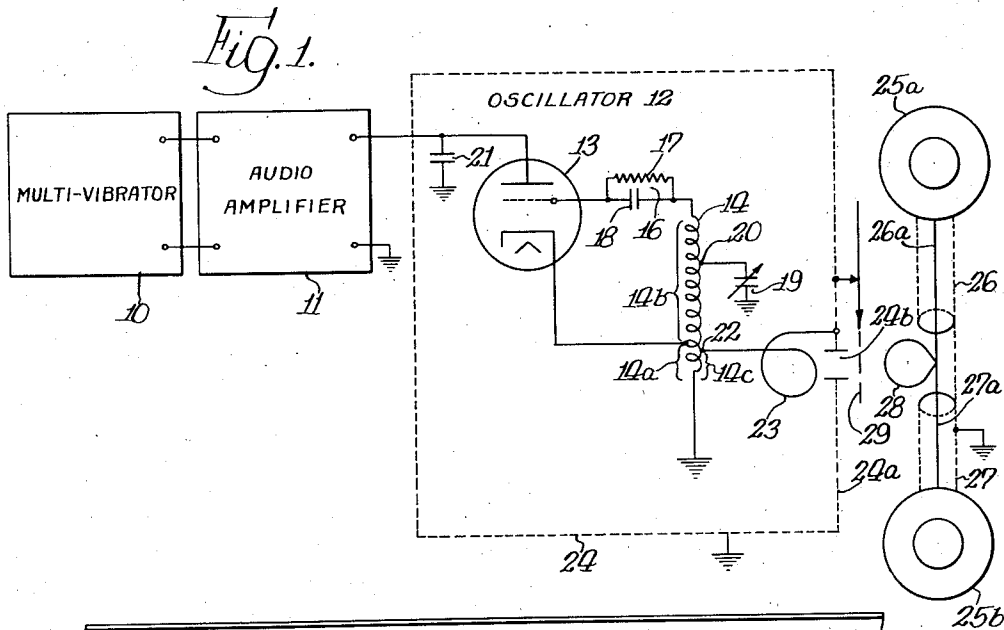
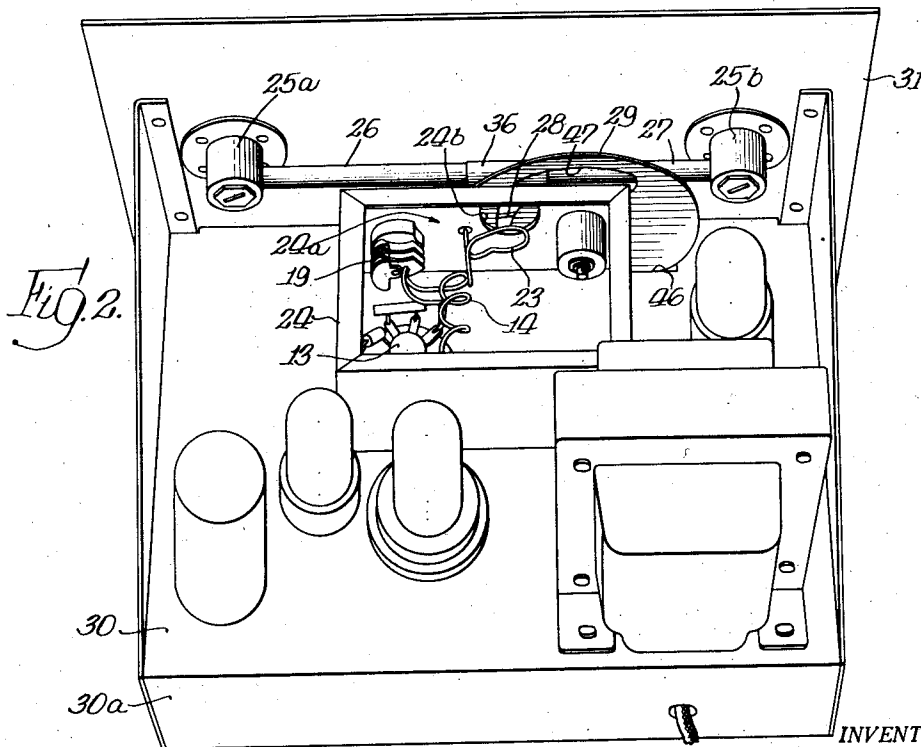
G. E. ARCHENBRONN

2,390,489

HIGH FREQUENCY ATTENUATING DEVICE

Filed June 21, 1943

2 Sheets-Sheet 1



INVENTOR.
George E. Archenbronn.
BY
Thomas L. Muelly
Atty.

Dec. 11, 1945.

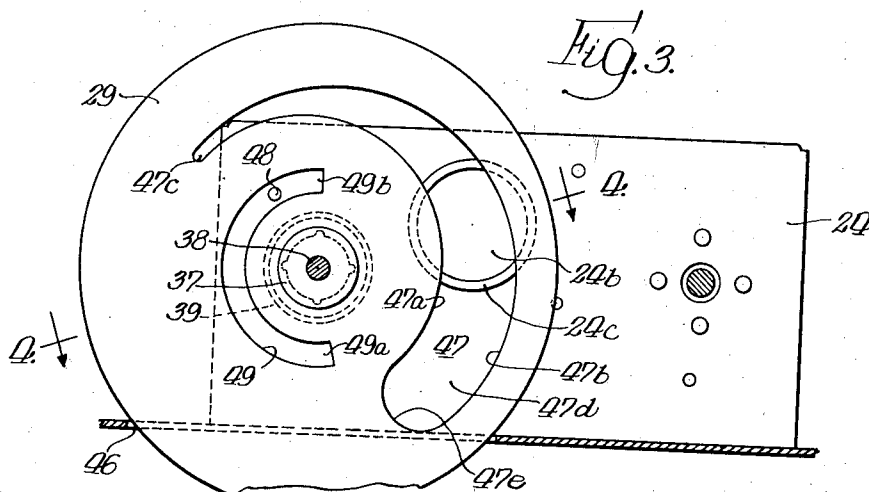
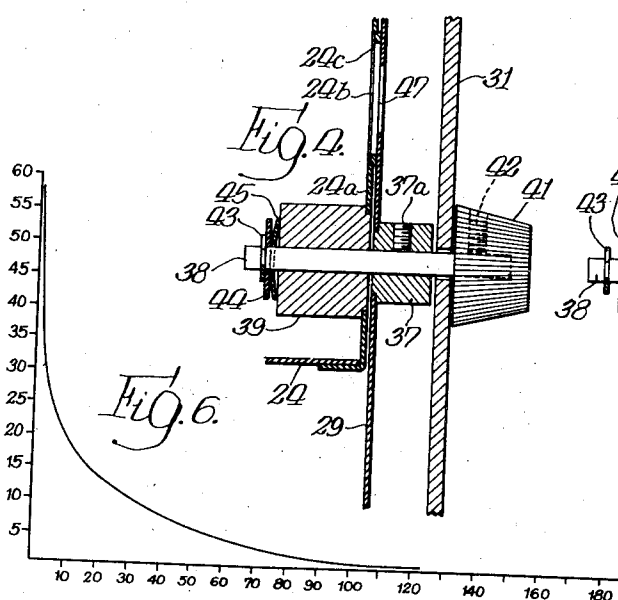
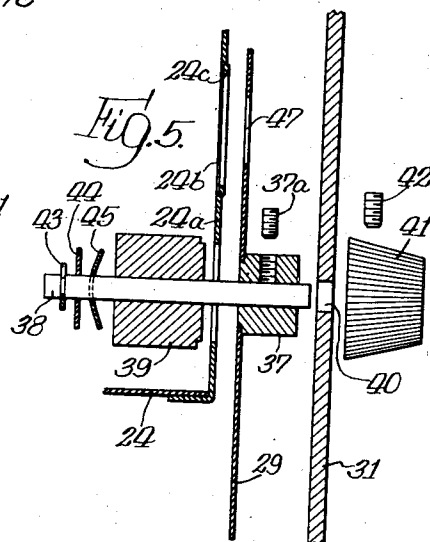
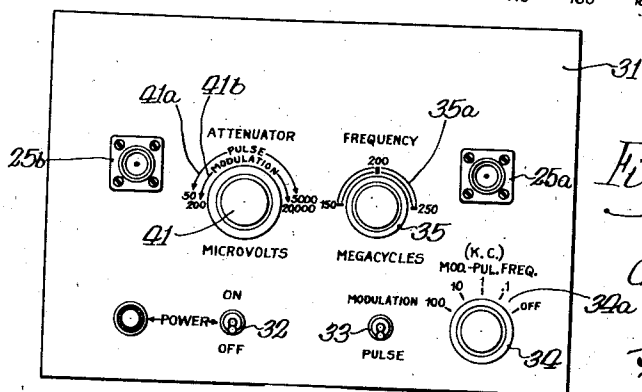
G. E. ARCHENBRONN

2,390,489

HIGH FREQUENCY ATTENUATING DEVICE

Filed June 21, 1943

2 Sheets-Sheet 2



INVENTOR.
George E. Archenbromm;
BY
Forman L. Muelly
Atty.

UNITED STATES PATENT OFFICE

2,390,489

HIGH FREQUENCY ATTENUATING DEVICE

George Edward Archenbronn, Chicago, Ill., assignor, by mesne assignments, to Belmont Radio Corporation, Chicago, Ill., a corporation of Illinois

Application June 21, 1943, Serial No. 491,614

1 Claim. (Cl. 250—36)

The present invention relates to variable high frequency attenuating devices and more particularly to an improved arrangement for variably attenuating the signal energy transfer between the output circuit of a high frequency signal generator or the like and the pickup circuit of apparatus in which the transferred signal energy is to be utilized.

In certain applications it is necessary to utilize signal generators which are capable of producing a radio frequency voltage which may be unmodulated, pulse modulated at a fixed but adjustable audio rate, or modulated with an audio voltage of fixed but adjustable audio frequency. These applications usually require that the signal energy delivered by the generator to the utilization circuit be variable within rather wide limits. To meet this requirement, the usual practice is that of providing a generator capable of producing a signal energy output exceeding that which is required; to operate the generator continuously at its maximum output; and to provide facilities for variably attenuating the energy transfer from the generator to the energy utilizing circuit. Various expedients have been resorted to in attempts to obtain the desired attenuation, all of which are somewhat complicated in character and are limited in the obtainable attenuation range.

It is an object of the present invention, therefore, to provide an improved and exceedingly simple arrangement for variably attenuating the energy transfer from a source of high frequency current to an associated pickup circuit.

In accordance with another object of the invention, an improved variable attenuating device is provided having an exceedingly wide range of attenuation.

According to a further and more specific object of the invention, the output circuit of a high frequency generator is provided with an output inductance which is coupled to the pickup inductance of the utilization circuit through an opening in one wall of the shielding housing for the high frequency section of the generator, and improved facilities are provided for variably closing the opening in order to vary the coupling between the two inductance elements and thus variably attenuate the energy transfer therebetween.

In accordance with still another object of the invention, an improved arrangement is provided for minimizing stray coupling between the two inductance elements, thereby to render the obtained coupling directly dependent upon the

size of the opening through which the two elements are intercoupled.

The invention, both as to its organization and method of operation, together with further objects and advantages thereof, will best be understood by reference to the following specification taken in connection with the accompanying drawings, in which:

Fig. 1 illustrates in schematic form a signal generator and associated pickup facilities having provided therebetween a variable attenuation device characterized by the features of the present invention;

Fig. 2 is a top perspective view illustrating the mechanical construction and arrangement of the apparatus schematically shown in Fig. 1;

Fig. 3 is an end view of the attenuating device provided in the apparatus;

Figs. 4 and 5 are sectional views taken along the line 4—4 of Fig. 3 illustrating in assembled and disassembled relationship, the elements of the attenuating device shown in Fig. 3;

Fig. 6 is a curve illustrating the operating characteristics of the attenuating device; and

Fig. 7 is a front plan view of the control panel forming a part of the assembly shown in Fig. 2.

Referring now to the drawings, and more particularly to Fig. 1 thereof, the invention is illustrated in its embodiment in a signal generator for the purpose of attenuating the signal energy transfer between the output side of the generator and an associated pickup circuit. In brief, the illustrated signal generator comprises a multi-vibrator or modulating stage 10, an audio frequency amplifier 11 and a radio frequency carrier producing oscillator 12 connected in tandem in the order named. The audio frequency amplifier 11 and the multi-vibrator or modulating stage 10 are entirely conventional in character and, accordingly, have been only schematically illustrated. It is pointed out, however, that these two stages of the generator are arranged for plate circuit control of the oscillator 12 and include facilities for either pulse modulating the radio frequency output of the oscillator, or continuously modulating the generated radio frequency output of the oscillator at a fixed but adjustable audio frequency rate. To this end, suitable switching facilities are provided for rearranging the circuit elements of the two stages 10 and 11 so that either type of modulation of the signal output from the oscillator 12 is produced. Additional switching facilities are provided for changing the circuit constants of the modulation frequency determining circuits provided in

the multi-vibrator 10 so that the oscillator output may be either unmodulated or may be subjected to pulse or continuous modulation at as many as four different frequencies.

Briefly considered, the oscillator 12 comprises a three-electrode electron discharge tube 13 having its anode and cathode coupled to the output side of the audio frequency amplifier 11 through the lower section 14a of a tank circuit inductance element 14. The upper section 14b of the inductance element 14 is connected between the cathode and grid of the tube 13 through a grid leak and condenser network 16 which comprises the leak resistor 17 and shunt connected condenser 18. For the purpose of variably tuning the inductance element 14 so that the oscillator will oscillate at any desired radio frequency within a desired range, a variable tuning condenser 19 is provided which is connected between a point 20 along the inductance element and ground. The output circuit of the audio frequency amplifier 11 is bypassed for radio frequency currents by means of a condenser 21. From the above explanation, it will be understood that the oscillator 12 is in the nature of a conventional Hartley oscillator arranged for plate circuit modulation. The output voltage from this oscillator is derived by tapping the inductance element 14 at a point 22 therealong and shunting the lowermost section 14c of this inductance element with an output inductance element 23. As will be apparent from Figs. 1 and 2 of the drawings, all elements of the high frequency oscillator 12, including the output inductance element 23, are provided within a conductive housing 24 which is maintained at the reference ground potential and acts to shield the elements of the oscillator against stray coupling with extraneous circuits and current sources.

For the purpose of transferring energy from the output inductance element 23 of the generator to a utilization circuit, a pickup arrangement is provided which includes two connectors 25a and 25b, two shielded conductors 26a and 27a, and a pickup inductance element 28, the terminal ends of which are connected respectively to the adjacent ends of the conductors 26a and 27a. The two inductance elements 23 and 28, which may each comprise only a single turn at the frequencies involved, are disposed in parallel planes and in proximity to each other upon either side of the housing wall 24a. They are mutually coupled through an opening 24b provided in this housing wall and having a center which is substantially in axial alignment with the centers of the two elements. Primarily, the magnetic or mutual inductive coupling between the two elements 23 and 28 is relied upon to obtain the desired energy transfer between the output side of the oscillator and the utilization circuit in which the pickup element 28 is provided. Accordingly, it is necessary to provide facilities for suitably attenuating or varying this coupling in order to adjust the energy transfer between the two inductance elements. To this end, an adjustable rotor plate 29 is provided for variably closing the opening 24b through the housing wall 24a in the manner more fully explained below.

As indicated above, the mechanical construction and arrangement of the signal generator and its associated pickup facilities are illustrated in Figs. 2 to 5, inclusive, and 7 of the drawings. More specifically, the conductive housing 24 is mounted upon a metal chassis 30 which is provided with a front control panel 31 arranged in

spaced-apart relation from the front housing wall 24a through which the two inductance elements 23 and 28 are coupled. All circuit elements of the oscillator 12 are disposed within the conductive housing 24 and a suitable conductive lid, not shown, is provided for closing the top of the housing in the completed generator assembly. Thus, the oscillator tube 13 is mounted upon a socket which is supported upon the top wall of the chassis within the walls of the housing 24; the frequency adjusting condenser 19 is supported upon the inner side of the front wall 24a of the housing; the tuning inductance element 14 is appropriately supported between the rear wall of the housing, the cathode terminal of the tube socket and one terminal of the frequency adjusting condenser 19; and the ends of the output inductance element 23 are soldered to the inductance element 14 and the front housing wall 24a so that the single turn thereof is aligned with the opening 24b. The remaining circuit elements of the generator, including the elements of a suitable power pack and the elements of the two stages 10 and 11, are disposed outside of the housing 24 and certain thereof are disposed within the compartment defined by the base 30a of the chassis 30.

As best shown in Fig. 7 of the drawings, the control elements for the switching apparatus which is utilized to condition the equipment for operation, to selectively arrange the equipment for pulse or audio frequency modulation of the output voltage, and to vary the pulse or continuous modulation frequency, are all extended through the front control panel 31 of the chassis for easy manipulation by an operator. These control elements include the actuating arm of an on-off switch 32, the actuating arm of a switch 33 which is utilized selectively to condition the apparatus for pulse or audio frequency modulation of the output voltage, and the actuating knob of a five-position rotary switch 34 which is utilized selectively to rearrange the circuit elements of the multi-vibrator 10 so that an unmodulated signal voltage or a modulated voltage of any one of four different frequencies is produced by the generator. The five different positions of the switch 34 are respectively indicated by a scale 34a which is arranged to be indexed by a pointer carried by the actuating knob for the switch. The front control panel 31 of the chassis 30 also has an opening therein through which the rotor shaft of an adjustable tuning condenser 19 extends, this shaft being provided at its extended end with an actuating knob 35 having a pointer assembly mounted thereon which is arranged to coact with a suitably calibrated scale 35a to indicate the output carrier frequency to which the oscillator 12 is tuned.

Referring now more particularly to the mechanical construction and arrangement of the pickup facilities to which signal energy is transferred from the output inductance element 23 of the signal generator, it will be noted that the two connectors 25a and 25b are of the female type and are suitably supported upon the front control panel 31 of the chassis 30 by means of assembly screws or the like. These two connectors are respectively provided with tubular elements which are disposed rearwardly of the panel 31, and respectively terminate and support opposite ends of tubular metal shielding elements 26 and 27 within which the conductors 26a and 27a are supported by means of suitable insulating disks. The inner ends of these two tubular elements 26 and 27 extend between the inner sur-

face of the panel 31 and the outer surface of the housing wall 24a, and are suitably joined by means of a tubular metal sleeve 36. This sleeve is provided with a slot in the wall thereof which faces the housing wall 24a, whereby the ends of the pickup coil 28 may be connected to the inner cable conductors 26a and 27a.

Briefly to consider the mechanical construction and arrangement of the assembly for rotatably supporting the rotor plate 29 upon the front wall 24a of the conductive housing 24, it is pointed out that this assembly comprises a sleeve 37 having a hub of reduced diameter upon which the rotor plate 29 is rigidly mounted. This sleeve is rigidly mounted upon an operating shaft 38 by means of a set screw 37a, and the shaft 38 is journaled in a bearing 39 rigidly mounted upon the front wall 24a within the housing 24. The operating end of the shaft 38 extends through an opening 40 drilled through the control panel 31 and is adapted to receive an actuating knob 41 which is mounted upon the shaft end by means of a set screw 42. Suitably calibrated scales 41a and 41b may be provided in indexing relationship with a pointer carried by the knob 41 in order to indicate the extent of attenuation obtained at any given setting of the rotor plate 29. For the purpose of retaining the enumerated parts of the rotor plate assembly in the desired assembled relationship, three assembly washers 43, 44 and 45 are provided, the first of which is of the split ring type and is adapted to be retained within an annular slot formed at the inner end of the shaft 38. The second washer 44 is strictly a friction washer and is adapted to engage the outer convex surface of the dish-shaped washer 45. The third washer 45 is adapted to be flattened during the assembly operation, for the purpose of spring biasing the control shaft 38 to the left as viewed in Figs. 4 and 5 of the drawings, and is utilized to maintain the rotor plate in engagement with the housing wall 24a, thereby to minimize stray coupling between the two inductance elements 23 and 28 in the manner more fully explained below.

As best shown in Figs. 2 and 3 of the drawings, the rotor plate 29 extends within the lower compartment of the chassis 30 through a slot 46 cut in the top wall of the chassis, and overlies the opening 24b of the housing wall 24a through which the two inductance elements 23 and 28 are intercoupled. This plate is provided with an arcuate slot 47 which is of gradually decreasing width from the lower end to the upper end thereof, as viewed in Fig. 3 of the drawings, and is so formed that, regardless of the position of the rotor plate, the portion thereof in registry with the opening 24b overlies the central portion of the opening. More specifically, the two edges 47a and 47b of the slot are eccentrically or non-concentrically disposed with respect to the center of rotation of the rotor plate, whereby portions of the rotor plate adjacent both edges of the slot overlie the opening 24b.

In order to prevent stray coupling between the two inductance elements 23 and 28, it is essential that the portions of the rotor plate which cover the opening 24b be maintained in good physical and electrical contact with the adjacent portion of the housing wall 24a. To this end, the edge of the housing wall which defines the opening 24b is provided with a struck out flanged portion 24c which extends toward the adjacent surface of the rotor plate 29 and may be formed by a stamping operation or the equivalent. The inner sur-

face of the rotor plate 29 is held in abutting contact with the outer surface of the flange 24c due to the spring bias exerted axially along the shaft 38 by means of the dished biasing washer 45. Thus the arrangement is such that all portions of the flanged edge 24c are held in tight engagement with the adjacent surface of the rotor plate 29, regardless of the position to which this rotor plate is adjusted through rotation of the knob and shaft assembly 41, 38. In order to improve the electrical contact between the engaged surfaces of the flange 24c and the rotor plate 29, a heavy coating of silver or other precious metal contact material is provided on the outer annular surface of the flange 24c and at all points within the area of the rotor plate surface which may engage the plated surface of the flange 24c during rotation of this plate.

For the purpose of limiting the extent of rotation of the rotor plate 29, a suitable stop mechanism is provided which includes a stop pin 48 mounted upon the housing wall 24a and extending outwardly therefrom through an annular slot 49 cut in the rotor plate 29 concentrically about the center of rotation of this plate. The pin 48 is so positioned along the front housing wall 24a that when engaged by the end 49a of the slot 49, the opening 24b is substantially entirely closed by the rotor plate 29. At the other extreme position of the rotor plate 29, i. e. that position wherein the stop pin 48 engages the slot end 49b, the enlarged end portion 47d of the slot 47 overlies the opening 24b, but the edge 47e of this slot is removed a substantial distance from the adjacent edge of the opening 24b. The stoppage of the slot edge at a point removed from the edge of the opening 24b is necessary in order to prevent the approaching end portion of the slot edge from producing rather a sharp change in the coupling between the two inductance elements with a resulting distortion of the attenuation curve characterizing the degree of energy transfer between the two elements.

In considering the operation of the apparatus described above, it will be understood that connections from the signal generator to a signal utilization circuit may be made by appropriately plugging male type of connectors into the female connectors 25a and 25b. Also, by suitable manipulation of the switch 33, the switch 34 and the condenser adjusting knob 35, the equipment may be conditioned to generate, at any desired carrier frequency, an unmodulated radio frequency carrier voltage, a carrier voltage which is pulse modulated at a desired rate, or a carrier voltage which is continuously modulated at a desired frequency rate. In this regard it will be understood that the selective actuation of the switch 33 to either of its two operating positions determines whether the apparatus will produce a pulse or continuously modulated carrier voltage; that the setting of the switch 34 in one of its five positions determines whether the generated carrier voltage shall be unmodulated or shall be modulated at a particular frequency; and that the setting of the condenser adjusting knob 35 determines the particular carrier frequency at which the signal voltage shall be generated. It will also be apparent from the preceding explanation that the setting of the rotor plate adjusting knob 41 will determine the extent of coupling between the output inductance element 23 and the pickup inductance element 28 and, hence, the

energy transfer between the output side of the generator and the utilization circuit.

After the above adjustments have been made, the switch 32 may be actuated to its "on" position for the purpose of delivering cathode heating current to the tubes provided in the three stages 10, 11 and 12, thereby to initiate the operation of the generator. When cathode heating current is supplied to the tube 13, the oscillator 12 generates an oscillatory voltage at the particular radio frequency determined by the setting of the tuning condenser 19. In this regard it will be noted that the carrier or radio frequency current traversing the space current path of the tube 13 also traverses the condenser 21 and the lower section 14a of the inductance element 14. This section of the inductance element is inductively coupled to the upper section 14b thereof so that radio frequency energy may be transferred from the output circuit to the input circuit of the tube 13 for the purpose of sustaining the generated oscillatory voltage. The modulating voltage developed through operation of the multi-vibrator 10 is amplified through the audio frequency amplifier 11 and is utilized for plate circuit modulation of the carrier frequency voltage developed between the anode and cathode of the oscillator tube 12. This modulating voltage may either be utilized to continuously modulate the voltage appearing across the inductance element section 14a at a frequency determined by the setting of the rotary switch 34, or to pulse modulate the radio frequency voltage developed by the oscillator 12 at a particular frequency determined by the setting of the switch 34. The type of modulation obtained depends upon the particular position occupied by the switch 33. It will be understood, therefore, that, depending upon the setting of the switch 33, a pulse or continuously modulated radio frequency carrier voltage is developed across the lower section 14a of the inductance element 14, i. e. that portion of the inductance element 14 which is included in the output circuit of the tube 13. A portion of this modulated voltage, i. e. that appearing across the section 14c of the inductance element 14, is impressed directly across the terminals of the output inductance element 23. Due to the mutual inductive coupling which exists between the two inductance elements 23 and 28 through the opening 24b, a voltage is developed between the terminal ends of the pickup inductance element 28. This voltage is impressed upon the utilization circuit through the conductors 26a and 27a and the inner contacts of the connectors 25a and 25b to which these conductors are respectively connected. The magnitude of this voltage and, hence, the extent of energy transfer between the two inductance elements 23 and 28 is of course determined by the amount of inductive coupling therebetween, and this coupling is in turn determined by the setting of the rotor plate 29. More specifically, if the rotor plate is so adjusted that the narrow end portion 47c of the slot 47 overlies the opening 24b, whereby the effective coupling area between the two coils 23 and 28 is small, only a negligible amount of coupling is present between the two coils 23 and 28 and, accordingly, the voltage developed between the terminals of the element 28 is of a low order of magnitude. On the other hand, if the rotor plate 29 is so adjusted that the portion of the slot 47 of maximum width overlies the opening 24b, a substantial coupling area between the two inductance elements 23 and 28 is provided, such that the

maximum voltage is developed between the terminals of the inductance element 28. As the rotor plate is adjusted to positions intermediate the two described extreme positions, the coupling between the two inductance elements 23 and 28 is correspondingly varied between the minimum and maximum values to correspondingly change the voltage produced across the terminals of the pickup inductance element 28.

While it will be understood that the structural specifications may vary according to the design of a particular application for the attenuating device, the following specifications for the illustrated device are given by way of example as being satisfactory when used in conjunction with a signal generator having an output carrier frequency variable between 150 and 250 megacycles which may be continuously or pulse modulated at a frequency range extending from 100 cycles to a maximum value of 100 kilocycles:

Output inductance element 23:

A single loop of No. 14 copper tinned wire having an inside diameter of -----

.4375"

Pickup inductance element 28:

A single loop of No. 14 copper tinned wire having an inside diameter of -----

.4375"

Diameter of the opening 24b -----

.875"

Distance between inductance elements 23 and 28 -----

.3125"

Mean radius of slot 47 -----

1.25"

Maximum width of slot 47 -----

.625"

Minimum width of slot 47 -----

.0937"

Angle covered by slot 47 -----

Ap. 195°

Angle of rotation of plate 29 -----

Ap. 180°

Referring now more particularly to Fig. 6 of the drawings, the attenuation curve there illustrated is an exact reproduction of a curve obtained by testing a working embodiment of the invention characterized by the physical and structural dimensions outlined above. In this curve, the signal attenuation from the available maximum value as measured in decibels is plotted as a function of the position of the rotor plate 29. From an examination of this curve it will be apparent that when the rotor plate occupies the position in which the opening 24b is substantially closed such that minimum coupling between the two inductance elements is obtained, the attenuation of signal energy transfer is at a maximum which is of the order of 58 decibels. As the rotor plate is rotated to increase the area of the opening through which the two elements are coupled, the attenuation of energy transfer is sharply reduced. As the rotor plate is rotated to a position in which the maximum coupling area is provided, the attenuation is substantially negligible. From an examination of this curve and a further consideration of the configuration of the slot 47, it will be understood that by suitably shaping this slot, any desired characteristic attenuation curve may be obtained. Thus, by appropriate design of the slot configuration, there may be obtained an attenuation curve which is substantially linear from the point of maximum attenuation to the point of minimum attenuation.

From the foregoing explanation, it will be understood that the described attenuating device is particularly applicable for use in governing the signal energy transfer between the output side of a signal generator or other source of high frequency current and an associated pickup circuit. It will also be understood that the device is of

rugged structure and may be constructed to provide an extremely wide range of attenuation. Moreover, it is thoroughly reliable in operation and may easily be calibrated to provide a visual indication of the extent of attenuation for any setting of the rotor plate 29 embodied therein.

While one embodiment of the invention has been disclosed, it will be understood that various modifications may be made therein, which are within the true spirit and scope of the invention.

I claim:

In combination with a signal generator which includes circuit elements disposed within a conductive housing and is provided with an output inductance element disposed within said housing adjacent one wall thereof, a chassis supporting

5 said housing and provided with a control panel spaced apart from said one wall of said housing, terminal connectors supported upon said panel, shielded conductor sections extending between said wall and said panel from said connectors to points in proximity to said inductance element, a pickup inductance element connected between the adjacent ends of said conductor sections and disposed between said one wall and said panel in proximity to said output inductance element, said one wall being provided with an opening therein through which said inductance elements are mutually coupled, and means for variably closing said opening, thereby to vary the coupling between 10 said inductance elements. 15

GEORGE EDWARD ARCHENBRONN.