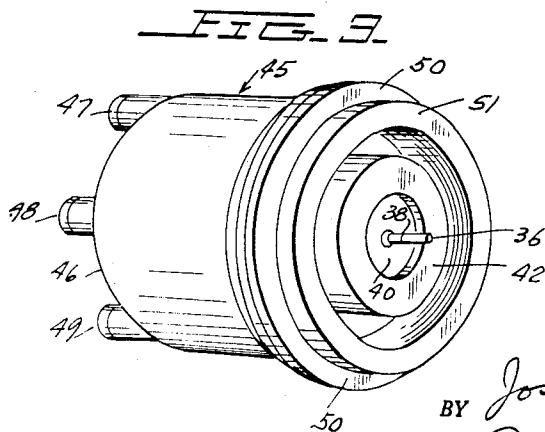
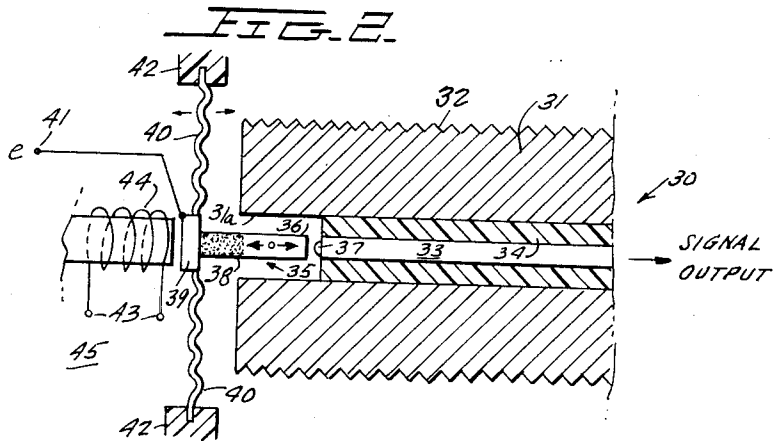
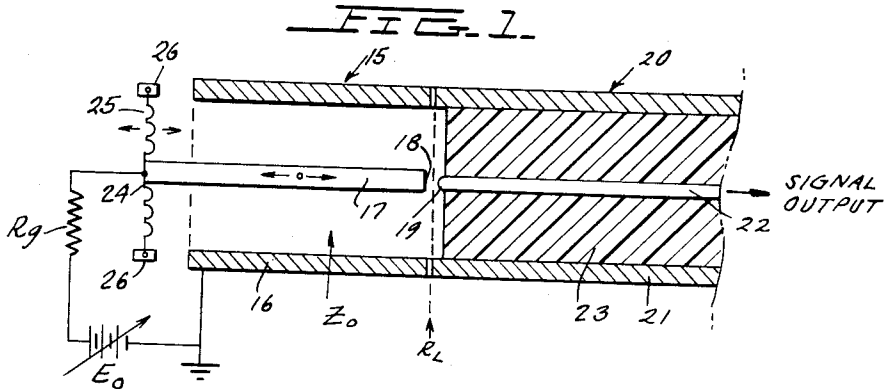


April 12, 1960
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J. LORCH
COAXIAL LINE TYPE IMPULSE GENERATOR WITH
CENTERING MEANS FOR COAXIAL CONDUCTOR

3 Sheets-Sheet 1



INVENTOR.
BY Joseph Forch
Richard A. Marsey

BY

April 12, 1960

COAXIAL LINE TYPE IMPULSE GENERATOR WITH
CENTERING MEANS FOR COAXIAL CONDUCTOR

2,932,802

3 Sheets-Sheet 3

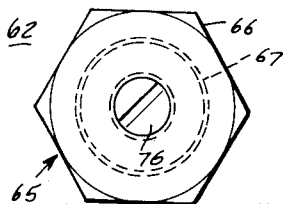
FIG. 8.

FIG. 7.

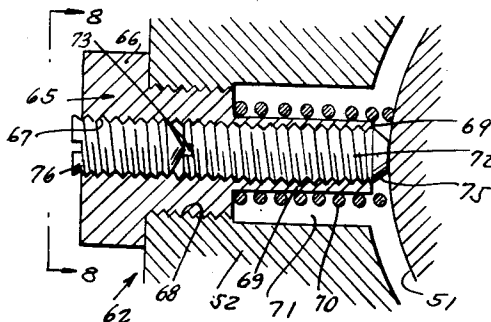


FIG. 10.

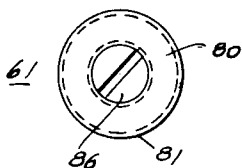


FIG 9

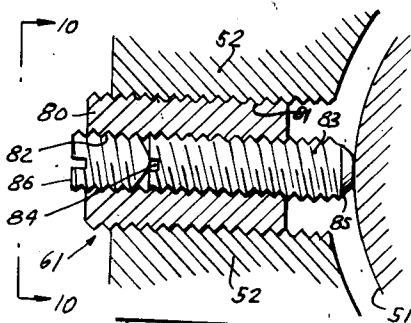


FIG. 11
B (83)

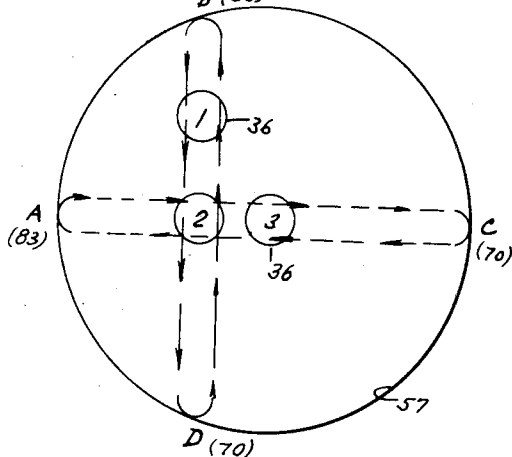
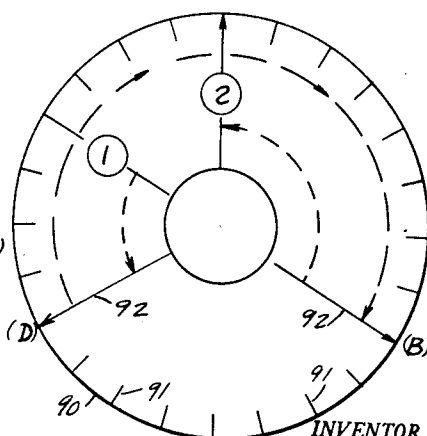


FIG. 12.



INVENTOR.
BY Joseph Lorch
Richard A. Mauer

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2,932,802

COAXIAL LINE TYPE IMPULSE GENERATOR WITH CENTERING MEANS FOR COAXIAL CONDUCTOR

Joseph Lorch, West Hempstead, N.Y., assignor to Empire Devices, Inc., Bayside, N.Y.

Application December 28, 1956, Serial No. 631,363

20 Claims. (Cl. 331-127)

This invention relates to impulse generators, and more particularly relates to improved impulse generator adjusting mechanism for the unit to obtain optimum output and maintain such optimum output over a relatively long period.

An impulse generator is designed with a capability of producing periodic pulses of such shape and duration that they contain energy components from the repetition rate frequency to the order of a high microwave frequency, such as 40 kilomegacycles. The pulses are produced by discharging a small length of charged lossless coaxial transmission line into a resistance through a mechanically vibrating contact. By proper choice of transmission line impedances, it is possible to produce periodic transients having a uniform frequency spectrum out to a predetermined high frequency. This is accomplished by applying a step voltage through a lumped resistance to the coaxial transmission line. U.S. Patent No. 2,722,608 is an example of such impulse generator.

The ratio of the impedance of the charged lossless coaxial transmission line referred to, to that of the output transmission line, determines the nature of the decaying pulses. This ratio is the criteria for determining the output energy at its spectral or frequency distribution. A satisfactory impulse generator has such ratio maintained substantially constant. Towards this end, the supporting member for the charging resistance and the central charged coaxial line must be maintained precisely concentric with respect to its outer line conductor. Otherwise variations in concentricity would produce non-uniformity in the respective decaying pulses, particularly at the high spectrum end. The concentricity of the charged line within its outer conductor must be far better than 0.5 thousandths of an inch, which is the best mechanical positioning heretofore possible in such units, to uniformly extend to high microwave frequencies.

It is the primary purpose of the present invention to provide a novel impulse generator structure and arrangement which is readily centered when assembled; where such centering or coaxial alignment of the charging line with its outer conductor is detectable by the assembler; and which assembly remains centered safely during extended normal operational use of the impulse generator. The centering accuracy is such to maintain uniform results, without the prior art difficulty of even minute eccentricity causing unsteady and uneven results.

The impulse generator transducer of the present invention is mountable in a cylindrical member which contains the outer conductor for the charged line, and the output coaxial transmission line extending therefrom. The mechanical impulse generator transducer has a flange which is locked by a clamping ring coacting with the cylinder, after precise coaxial centering. A pair of spring loaded set-screws are arranged about the transducer, resting within the aforesaid cylindrical member in substantially 90° relation. An additional pair of set-screws are arranged at diametrically opposite positions with respect to the spring loaded set-screws. By a simple procedure,

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the transducer head is precisely positioned with the charged line precisely concentric within the coaxial outer conductor. Further means are provided to lock the set-screws in the adjusted position. The clamping ring locks the transducer within the cylindrical sleeve to maintain the impulse generator as a rigid assembly, with consistent and accurate electrical performance.

It is accordingly an object of the present invention to provide a novel impulse generator with precise centering means for the charging line thereof.

A further object of the present invention is to provide a novel centering means for an impulse generator transducer, wherein the charging line is precisely centered and maintained coaxial with its outer conductor.

Another object of the present invention is to provide an impulse generator centering system embodying a plurality of spring loaded and companion set-screws.

Another object of the present invention is to provide an impulse generator having means for precisely centering the charging line elements thereof, and for maintaining such precise adjustment for extended operating periods.

These and further objects of the present invention will become more apparent in the following description of an exemplary embodiment thereof, taken in connection with the following drawings, in which:

Fig. 1 is a diagrammatic illustration of a basic impulse generator system.

Fig. 2 is a schematic showing of the impulse generator structure used with the present invention.

Fig. 3 is a perspective illustration of the transducer unit of the invention impulse generator.

Fig. 4 is a longitudinal cross-sectional view through the transducer centering and securing structure of the present invention.

Fig. 5 is an enlarged cross-sectional view through the charging transmission line of the impulse generator, taken along the line 5-5 in Fig. 4.

Fig. 6 is a horizontal sectional view, along the line 6-6 of Fig. 4 in the direction of the arrows, used for explaining the centering of the impulse generator in the invention system. (The eccentricity of the respective sections of the Fig. 6 generator being exaggerated for descriptive purposes.)

Fig. 7 is an enlarged cross-sectional view through the line 7-7 of Fig. 6, illustrating the spring loaded set-screw of the invention adjusting system.

Fig. 8 is an end view of the set-screw head, as seen at line 8-8 of Fig. 7.

Fig. 9 is an enlarged cross-sectional view taken along the line 9-9 of Fig. 6, through the fixed set-screw section of the invention adjusting system.

Fig. 10 is an end view of the fixed set-screw of Fig. 9, as seen at line 10-10 thereof.

Figs. 11 and 12 are diagrams used in connection with the exposition of the method and system for centering the impulse generator coaxial line in the invention system.

Fig. 1 is a simplified diagram of an electrical impulse generator. The small length lossless coaxial transmission line 15 is charged through an adjustable voltage E_0 and charging resistor R_g . The charged transmission line 15 is coextensive with output transmission line 20. The output transmission line 20 contains outer cylindrical conductor 21 and coaxial inner conductor 22 centered and spaced from outer conductor 21 with a suitable low-loss insulation cylinder 23. The output transmission line 20 may be gradually tapered until its output coupling is of a standard physical size. In this manner the effective impedance of the transmission line is predetermined at its juxtaposition and connection R_L with the output of charging coaxial line 15. When the output (not shown) of the

output transmission line 20 is properly terminated to a predetermined characteristic impedance load, its input load impedance at R_L is resistive and may be incorporated in the circuitual analysis of the impulse generator action, as will be set forth.

The charging coaxial transmission line 15 comprises a conductive sleeve or cylinder 16, and a central longitudinally displaceable contact plunger 17. Contact plunger 17 in the exemplary embodiment, is of silver. Its free end 18 is arranged to contact the fixed central contact point 19 of the central conductor 22 of output line 20. The output conductor 16 is connected to ground, as is one side of the D.C. supply E_0 . The left end 24 of vibratory plunger 17 is suitably secured to the center of a vibratory diaphragm 25. The charging resistor R_g is connected between the battery E_0 and central point 24. The diaphragm 25 is insulatingly supported by the schematically indicated flanges or end members 26, 26. Thus voltage is impressed upon vibratory contact plunger 17 through charging resistance R_g by the adjustable voltage source E_0 . Diaphragm 25 is insulated with respect to ground potential, and the charge on plunger 17 is established with respect to grounded conductor 16 of the short coaxial cable 15.

For the purposes of analysis, the generator may be considered an initially charged uniform transmission line of characteristic impedance Z_0 , to which a charging voltage e was applied through a resistance R_g . The transient produced is a pulse train with an overall time duration extremely short compared with the time necessary to travel the length of the transmission line. When the ratio of the load termination R_L to the characteristic impedance Z_0 of the transmission line is properly chosen, the spectrum of the pulse train will be essentially flat to a frequency approximately equal to the resonant frequency of the charged transmission line 15. The resulting pulse train will decay exponentially as a function of the reflection coefficient.

For an impulse generator whose resonant frequency is, for example, about 10 kmc., the individual pulse in the train with a width of about 50 microicroseconds (5×10^{-11} seconds), and the effective time duration of the wave train is about 350 micromicroseconds. With a reflection coefficient of -0.1717 , a reasonably flat spectrum is obtained up to a frequency of $0.9 f_0$ (where f_0 is the resonant frequency of the transmission line). If a highly selective circuit is excited by a voltage impulse, the voltage output oscillates at the resonant frequency of the selective circuit. The envelope of the RF oscillation decays in time as a function of the bandwidth of the tuned circuit, and the peak envelope voltage is proportional to the peak impulse input voltage to the tuned circuit.

The magnitude of the voltage spectrum of a generator $A(f)$ in microvolts/megacycle of bandwidth depends, for reasons already mentioned, entirely on the geometry and D.C. charging potential e of the impulse generator. The spectral intensity in microvolts/megacycle is defined for practical purposes as follows: It is equal to the number of R.M.S. sine wave microvolts (unmodulated) applied to the input of the measuring device as its center frequency, which will result in a maximum response at the output equal to that resulting from the pulse being measured, divided by the effective impulse bandwidth of the circuit in megacycles.

The spectrum of an impulse, from the purely mathematical standpoint is considered to extend as far into the negative frequency domain as into the positive, and a physical bandpass filter or amplifier to which the spectrum is applied responds as if it were receiving not only the energy in its actual passband but also that in the corresponding negative frequency band.

Let $A(f)$ represent the magnitude of the mathematical voltage spectrum in v./cycle/sec., and S the effective spectral intensity in v./cycle/D.C. charging voltage on

the transmission line, the discharge of which generates the impulse. Then:

$$S = \frac{2A(f)}{e}$$

where e is the D.C. voltage to which the line is charged. The power output from a filter with a random noise bandwidth $BW(n)$, produced by an impulse generator at its input, is given by the following relation:

$$P_0 = f_r \cdot \frac{e^2 s^2}{R} \cdot A^2_{\max} \cdot BW(n) \quad (1)$$

P_0 = Output power in watts of the filter assuming output R = Input R

$BW(n)$ = Random noise bandwidth of the filter in cycles/sec.

$A_{\max}$ = Maximum voltage gain of the filter in its band-pass.

R = Input impedance of filter

S = Impulse strength into filter in R.M.S. volts/cycle/volt of D.C. charging voltage.

f_r = repetition rate in cycles/sec.

e = charging voltage in volts.

The relation between the impulse strength and the voltage spectrum amplitude is given by definition:

$$S = \frac{2A(f)}{e} \quad (2)$$

There the interference generator's calibration is in N DB above one microvolt/megacycle, with reference to e , as supplied to a 50 ohm load, the following holds:

$$uV \text{ R.M.S./mc.} = e \cdot \int \log_{10} \left(\frac{N}{20} \right) \quad (3)$$

Substitution of (3) into (1) gives:

$$P_0 = f_r \cdot \frac{10^{-24}}{R} \left[\log_{10} \left(\frac{N}{20} \right) \right]^2 \cdot A^2_{\max} \cdot BW(n)$$

The use of the interference generator for noise figure measurements is based on this formula.

Fig. 2 is a schematic drawing of the exemplary impulse generator utilized in the invention system. The output transmission line 30 comprises a cylindrical outer conductor 31. Conductor 31 is threaded at its external surface 32 for mounting within a cylindrical housing, to be described in connection with Fig. 4. The central inner coaxial conductor 33 is secured within the cylindrical conductor 31 through a suitable central bushing 34 of low-loss dielectric material such as "Teflon." "Teflon" is a registered trademark of insulation material made of tetrafluorethylene. However, other equivalent insulation for the transmission line conductors may be used, as may air.

The short charging coaxial transmission line 35 corresponds to the diagrammatic line 15 of Fig. 1. The dielectric material between central vibratory contact or plunger 36 and exterior conductor 31a, is air. It is to be noted that the outer conductor for contact 36 is simply an extension of cylindrical tube 31 of the output transmission line 30, and is integral therewith. The vibratory contact 36 is arranged coaxially with and electrically engageable with contactor 37. Contact 37 is integral with central conductor 33 of output transmission line 30.

The body of vibratory plunger or contact 36 is of silver. It is made integrally coextensive with charging resistor R_g indicated at 38. The resistor R_g is secured to the central portion 39 of the vibratory diaphragm 40. In the exemplary embodiment, charging resistor 38 is 200 megohms, and of course may be of an equivalent high resistance value in this range. The charging voltage e is applied to terminal 41 connected to the central portion 39 of diaphragm 40, and in turn to charging resistor 38 and silver contact-plunger 36. The charging voltage resultant at terminal 41 is equivalent to a predetermined

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adjustment of the D.C. voltage E_0 indicated in Fig. 1, and is applied directly to the charging resistance R_g which is element 38 in Fig. 2.

The vibratory diaphragm 40 is preferably circular and mounted in a suitable insulation retainer ring 42 such as of "Lucite." The exemplary diaphragm 40 is made of Invar, and is .002 inch thick. The diaphragm 40 is arranged to vibrate through suitable electromechanical means. It is noted that diaphragm 40 is well insulated from the remainder of the transducer, transmission lines, and other electrical elements of the system through the substantial insulation retainer ring 42 within which it is mounted. The extent of vibration of the exemplary contact 36 is up to .020 inch. In other words the gap existing between contact plunger 36 and contact 37 is of the order of .020 inch or less in the exemplary design.

The rate of vibration of diaphragm 40 is controlled by a sinusoidal trigger frequency introduced to the terminals 43 of electromagnet 44 of the transducer unit, indicated generally at 45 in Fig. 2 (see also Fig. 3). The rate of vibration or triggering in a practical and an exemplary unit extends from about 25 to 3000 cycles. The transducer 45 is a relatively simple unit, functioning similar to some types of telephone receiver units. It consists basically of a metallic iron flap placed between the poles of permanent magnets (not shown). Around the flap is found a coil which is excited by a suitable voltage (sinusoidal, square or pulse), causing the ends of the flap to assume magnetic poles depending upon the direction of current flow through the coil. Thus the flap is caused to vibrate back and forth between the magnets. The contacts of the generator are connected to this flap by means of a Bakelite rod and a supported diaphragm. Such electromechanical means is schematically indicated at 44 in Fig. 2, and is contained within the cylindrical enclosure 46 of transducer 45 (see Fig. 3). Details of such transducer construction are shown in the art, and are not detailed herein.

In the exemplary impulse generator unit, the characteristic impedance of the charging short coaxial transmission line 35 is 20.5 ohms. The diameter of the vibratory contact 36 is made the same as that of the central conductor 33 of output transmission line 30. Accordingly their common outer cylindrical conductor 31 produces the same inside diameter for the outer electrical portion of the two lines 30, 35. The insulation section between the output transmission conductors 31 and 33, preferably of "Teflon," which is the dielectric filling for the output transmission line, is proportioned to make its characteristic impedance 14.1 ohms. Also in the exemplary units, the longitudinal dimension of the vibratory plunger 36, namely the silver conductor section extending from the charging resistor 38, is 0.187 inch.

The described impulse generator has been found to provide excellent output, with a flat frequency characteristic from 20 kilocycles up to 40 megacycles. Such flat frequency response and extent of spectrum is importantly due to the precisely centering of contact 36 with respect to the fixed contact 37 and within circular outer conductor 31a. The ratio of the impedances of the input at line 35 is important with respect to the flatness of the spectral output, and the extent of its frequency range. A very small eccentricity of the contact or vibratory plunger 36 within and fixed cylindrical outer conductor 31a distorts the impedance relationships and disturbs the optimum flatness of range of the spectral output of the impulse generator. It is an important objective of the present invention to provide for precise central positioning of vibratory plunger 36 with respect to its outer conductor 31a, and to maintain such precise concentricity during extended operating conditions of the unit.

It is to be noted that the proportions and dimensions of the respective elements and components of the impulse generator system, as shown in Fig. 2 and other figures, are intentionally not to scale in order to more clearly

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illustrate and define their features and relationships. It is to be also understood that the invention system, as is further described hereinafter, is applicable to impulse generators of other constructions, and with different parameters and ranges than the exemplary unit described herein for illustrative purposes.

Fig. 3 shows a transducer unit 45 in perspective, which corresponds to the portion of Fig. 2 including central vibratory plunger 36 and all elements illustrated to the left thereof, including the charging resistor 38, vibratory diaphragm 40, and the electromechanical means 44 for controllable vibrating diaphragm 40. The transducer 45 is of cylindrical shape and contains outer enclosure 46 within which the electromechanical vibratory means (corresponding to 44 Fig. 2) is housed. Electrical plug connectors 47, 48, 49 extend from the rear of transducer 45, for suitable electrical connection to the circuit elements therewithin, as will now be understood.

The vibratory diaphragm 40 is seen supported within a thick cylindrical member 42 of "Lucite" or equivalent insulation material. The charging resistor 38 and contactor 36 extend centrally beyond the plane face at the right end of transducer 45. The transducer 45 is secured to the housing of the output transmission line (as is described in connection with Fig. 4), through extending flange 50 and sleeve 51. The transducer unit 45 is essentially a unit for extending charging resistor 38 and contact 36 from vibratory diaphragm 40, and controllably vibrating diaphragm 40 by electromechanical means within the enclosure 46. The electrical charging voltage e is fed to charging resistor 38 and contact 36 through a rear connector, and in the manner already described in connection with Figs. 1 and 2.

Fig. 4 illustrates the transducer 45 assembled with output transmission line 30 by means of solid housing 52. Housing 52 is cylindrical and preferably made of aluminum. The central upper portion of housing 52 is suitably threaded to receive outer conductor 31 threaded at 32. The central portion of housing 52 is made hollow to receive the head 51 of transducer 45. The head-sleeve portion 51 of transducer 45 is parallel to and projects adjacent to the bottom surface 53 of the hollow. The cylindrical flange 50 of transducer 45 rests in undercut 54 of housing 52, which determines the longitudinal or axial position of the transducer 45 with respect to housing 52. The dimensions of transducer 45, including sleeve 51 and flange 50, and that of housing 52 including its central recess portion 53, the location of the charging small transmission line 35 centrally thereof, and the undercut or recessed portion 54, all result in their general arrangement as shown in Fig. 4.

The transducer contact 36 is in the axial position of the housing, and concentric with center conductor 33 of output transmission line 30. A retaining ring 55 is arranged to hold the transducer 45 in housing 52 through threaded section 56. Initially the clamping ring 55 is loosely fitted against the flange 50 until the final centering of the transducer contact 36 is accomplished in a manner hereinafter described. Ring 55 is thereupon turned to press further against flange 52 and assist the set-screws in holding the assembly of the transducer 45 and housing 52 intact after the final precise centering adjustment.

Fig. 5 is an enlarged cross-sectional view along the line 5-5 through the short charging transmission line 35. The central concentric transducer contactor vibratory plunger 36, is shown within the air space of transmission line 35, and is centrally of outer conductor 31 within the housing 52. A slight displacement of central contact 36 with respect to the inner cylindrical surface 57 of outer conductor 31 causes non-uniform spectral and amplitude signal in the output transmission line. It is an important objective of the present invention to provide means for ascertaining the true and precise concentricity for contact 36 within the inner circle 57 of

outer conductor 31 of the charging coaxial transmission line 35.

Fig. 6 is a cross-sectional view through the transducer centering and securing means, taken along the line 6--6 of Fig. 4. The transducer is indicated centrally at 45 with its eccentric position drawn exaggerated for purposes of illustration. The transducer contact 36 is centrally of and projects axially from the transducer 45. The projecting sleeve 51 at the bottom of transducer 45 coacts with two pairs of adjustable mounted set-screws as follows: Spring loaded set-screw assembly 60, with an adjusting set-screw 61 diametrically opposite thereto; and spring loaded set-screw arrangement 62, oriented 90° from set-screw assembly 60, with an adjustable set-screw 63 diametrically opposite thereto.

Fig. 7 is an enlarged cross-sectional view through the set-screw assembly 62 taken along the line 7--7 of Fig. 6; and Fig. 8 is an end view thereof. Fig. 9 is an enlarged cross-sectional view through the adjusting set-screw 61 as taken along the line 9--9 of Fig. 6; and Fig. 10 is an end view thereof. The spring loading and adjusting set-screw assemblies, corresponding to Figs. 7 and 9 respectively, will first be described in detail, and their operation in conjunction with the plunger 36 centering, and the fastening of the transducer, will be thereupon described in connection with Figs. 6, 11 and 12.

The spring loaded set-screw 62 is identical to that of set-screw assembly 60. As shown in Fig. 7, these comprise a screw unit 65 having a head 66, an internally axially threaded opening 67, an externally central threaded section 68, and an extending end rod section 69. The rod section 69 is of the narrowest diameter, and a tension spring 70 is coiled thereabout and extends beyond rod 69. The central section of screw member 65 is of intermediate diameter, and is threaded within housing body 52. The external head 66 of screw member 65 is hexagonal, and is used to turn the screw member 65 into housing 52. The portion of housing 52 surrounding the cylindrical rod end portion 69 is undercut at 71 to admit the helical tension spring 70 which surrounds the rod 69. Thus, a channel is formed for spring 70 between the smooth end rod portion 69, with the channel 71 surrounding it.

A set-screw 72 operates within the central threaded bore 67 of screw member 65, and when sufficiently turned by a screwdriver through slotted head 73, has its front end portion 75 abut sleeve 51 of transducer 45. As will be set forth, in the initial stages of adjustment, set-screw 72 is retracted within bore 67 so that its front end 75 does not contact the transducer sleeve 51. During such condition, the tension spring 70 presses against transducer sleeve 51, and establishes a spring loading contact in tension on the transducer sleeve for the purpose to be detailed.

When the transducer 45 is accurately centered, it is held by a four-contact assembly including the two springs 70, 70 of the screw assemblies 60, 62. Their set-screws 72 are thereupon operated to press firmly against the transducer sleeve 51, and thereby establish a positive four-point engagement of the circular sleeve 51 by the four set-screw assemblies 60 to 63. When the set-screw 72 of each of the assemblies 60 and 62 are thus suitably engaged as aforesaid, it is preferred to have an additional set-screw 76 mounted within the central bore 67 to abut the head 73 of each set-screw 72 therein, and lock the set-screws in position.

In this manner the combination of the spring tension 70, the engaged set-screw 72, as well as the locking set-screw 76, all combine to firmly hold the sleeve 51 at the identical point contact established for it in connection with the centering procedure to be described in connection with Figs. 6, 11 and 12. Fig. 8 illustrates the head 66 of the set-screw assembly 62, as an integral part of the set-screw member 65. The locking set-screw 76 is viewed from the exterior.

As shown in Figs. 9 and 10, the adjusting set-screw assembly 61 is composed of sleeve 80 threaded and secured at 81 into housing 52. The internal bore of sleeve 80 is threaded at 82 to receive threaded set-screw 83. Set-screw 83 has a slot 84 at its head for longitudinal adjustment by an external screwdriver. The internal end 85 of set-screw 83 is arranged to abut cylindrical surface 51 of transducer 45. The action of the set-screw 83 with respect to centering of the contact 36 of the transducer 45 will be more fully described in connection with Figs. 6, 11 and 12. When the set-screw 83 is finally positioned within sleeve 80, it is preferably further locked into position by a locking screw 86 fitting within the unused bore portion 82. The adjusting set-screw 63, oriented 90° from set-screw 61, is identical in construction thereto, and for clarity the identical numerals are used for its components.

Since the spectral output of the impulse generator depends upon the impedance characteristics of the discharge and output lines, it is most important that the vibrating contact 36, which is the center conductor of the discharge line, be absolutely centered within the transmission line 35 as hereinabove set forth. Even slight eccentricity of the contact 36 with respect to the cylindrical outer conductor surface 57 (see Fig. 5) produces disturbance of the flatness of the generator output frequency characteristic, changes the reflection coefficient of the impulse generator circuit, and affects the spectral frequency output thereof.

Before aligning the center contact 36, the discharge resistor of the circuit is removed, and the plunger-contact 36 is, by well known procedure suitably adjusted for optimum axial contact performance to avoid bouncing or contact arcing. In other words the contact 36 should vibrate stably without bouncing or arcing throughout the repetition frequency range, e.g. 25 to 3,000 cycles per second in the exemplary system. Plunger-contact 36 is thereupon concentrically centered as a final procedure for the impulse generator, in the following manner:

(1) The transducer 45 is set into the generator housing 52 so that the contact 36 falls into the transmission line 35, but short of touching the output line's center conductor 37. This condition can be checked by connecting a megohmmeter between the charging voltage terminal (41) of the transducer 45 and the center conductor 33 of the output line 30. If the contact 36 touches the center conductor 37, the meter would read the charging resistance (200 megohms). The transducer's locking ring 55 is screwed into place so that it holds the transducer 45 firmly, yet not so tight as to prevent side motion during the alignment procedure.

(2) The two adjusting set-screws 61, 63 are set into the housing 52 and advanced just enough to separate the transducer's bearing surface 51 from the housing at points where the screws 83 are inserted (see Fig. 9). The purpose for this step is to insure that the insertion of the spring loaded screws 60, 62 will not push the transducer 45 so far to one side as to cause breakage of the contact 36.

(3) The two spring loaded screws 60, 62 are then inserted. These screws are illustrated in Fig. 7. The threaded hole 67 which runs through the screw's center is also seen in Fig. 7. The purpose of this is for the insertion of locking set-screw 72 which fixes the position of the transducer 45 within the housing 52 after the completion of the aligning procedure. In this step (3) the locking set-screws 72 are not engaged with the transducer sleeve 51, but the springs 70 instead engage this sleeve.

(4) The above step (3) fixes the transducer 45 between four bearing points. Two of these result from the setting set-screws 83, and diametrically opposite are those induced by the tension springs 70. It should now be possible to move the transducer 45 in two directions (90° apart) and cause the transducer contact 36 to touch

the inner wall 57 of the transmission line 30 at four points. Such contacting is indicated by connecting the megohmmeter between the housing 52 and the charging voltage terminal *e* of the transducer 45. The setting screws should be turned in and out with a wrench to insure that contact is made at all four points before the adjusting tool is used. (Such adjusting tool is simply one that translates axial movement of the setting screws (and therefore movement of transducer 45 in the same direction) into angular degree-type readings. Fig. 12 shows the graduated circular dial 90 with arbitrary graduations 91 thereon. The adjusting tool has a head like a screw driver which engages the slots 84 of the adjusting set-screws 83. Axial displacement of screws 83 by the tool driver is indicated by corresponding angular positions of indicator 92 on dial 90.)

(5) Referring to Fig. 11, assume that the position of the contact 36 within the transmission line 35 is such that the contact is at an arbitrary position (1). Assume also that the adjusting set-screws 83 are at points A and B, while the tension springs 70 return the pressure from C and D. By means of the adjusting tool, a set-screw 83 is then turned (either of the two). Let us say that the set-screw 83 at B is turned, pushing the contact 36 towards point D. This is continued until contact is just made at D, as indicated by the megohmmeter, at which time the indicated angle D on the tool's dial 90 is noted. The screw is then withdrawn until contact is just made at B. Again the angle for B is noted. The tool is then turned until the pointer indicates an angle exactly half-way on the arc traveled between B to D contacting points (see Fig. 12). The letters and numbers in Fig. 12 correspond to positions indicated in Fig. 11.

(6) Step (5) is repeated for the other set-screw 83 at A. This time the contact 36 moves from position (2) towards C, at which time the angle is noted on tool scale 90. Set-screw 83 is turned to again move back contact 36 to A, where the angle is again noted; and finally to position (3). Position (3) is that resulting by turning with the tool until the angle read on the tool scale 90, is exactly half of that between A and C. Position (3) is the exact center of the transmission line when the alignment is performed carefully.

(7) The locking set-screws 72 are then inserted into the spring-loaded screws 60, 62 until their ends 75 are tight against the transducer 45 (see Fig. 7). Over these locking set-screws 72 are inserted safety set-screws 76, to doubly insure that they will not loosen. This safety locking is also done to set-screws 83 by safety set-screws 86.

In the exemplary embodiment the inside diameter of the surface 57 of outer conductor 31 is .080 inch; the corresponding diameter of the center conductor or contact 36, .062 inch. The spacing between the surface of contact 36 and inner surface 57 is accordingly .010 inch when the concentricity is exact. The impedance of the charging line 35, when the contact 36 is centered within cylindrical surface 57 is 20.5 ohms, resistive. During accurate concentricity of contact 36 within cylinder 57, the spectral frequency range is as high as the design of the unit dictates, namely to 40 kmc. Also the spectrum is flat in that the reflection coefficient was set at the optimum value of -1.1717 .

Eccentricity even of the order of one ten-thousandths of an inch affects the value of the reflection coefficient, and also the spectral content of the output of the impulse generator. The use of the invention centering arrangement permits the contact 36 to be set to an extreme degree of precision, and to maintain such setting under all normal operating conditions. Thus the invention impulse generator is designed for and maintains a flat frequency spectrum, even when made in production quantities, as the adjustments described hereinabove for centering the contact are done individually as a final

assembly operation. Also it is readily performed as a field service function when necessary.

It is to be understood that the invention is applicable to different designs or constructions of, or parameters for the impulse generators. Essentially the invention system establishes the centering of the vibratory plunger-contact 36 within the short charging lossless coaxial line 35, to a precision heretofore unattainable and is arranged to lock such precise setting to insure the high range flat frequency spectrums desirable for impulse generators.

Although the present invention has been described with respect to an exemplary embodiment thereof, it is to be understood that modifications and variations may be made which are within the full intended scope of the invention as set forth in the following claims.

I claim:

1. An impulse generator of the character described comprising a transducer unit having a projecting vibratory contact, a transmission line with a central conductor and an outer conductor coaxial therewith, a housing supporting said transmission line with a portion receiving said transducer unit with its contact extending within an end region of said outer conductor and towards said central conductor, adjusting means for transversely positioning said transducer unit in said housing with said contact into substantially precise coaxial relation with said central conductor, and locking means connected with said position adjusting means for maintaining the said precisely set coaxial relationship.

2. An impulse generator of the character described comprising a transducer unit having a vibratory contact and an enclosure surrounding said transducer unit with said contact projecting at one end thereof, a transmission line with a central conductor and an outer conductor coaxial therewith, a housing supporting said transmission line with a portion receiving said one enclosure end with said contact extending towards said central conductor, adjusting means mounted in said housing adjacent said one enclosure end for transversely positioning said transducer unit in said housing with said contact into substantially precise coaxial relation with said outer conductor inner surface, and locking means connected with said position adjusting means for maintaining the said precisely set coaxial relationship.

3. An impulse generator of the character described comprising a transducer unit having a vibratory contact projecting centrally therefrom and an enclosure surrounding said transducer unit with said contact extending beyond one end thereof, a transmission line with a central conductor and an outer conductor coaxial therewith, a housing supporting said transmission line with a recessed portion to receive said one transducer enclosure end with said contact extending towards said central conductor, adjusting means mounted in said housing adjacent said one transducer enclosure end for transversely positioning precisely said transducer unit in said recessed portion with said contact into substantially precise coaxial relation with said central conductor, and locking means connected with said position adjusting means for maintaining the said precisely set coaxial relationship.

4. An impulse generator of the character described comprising a transducer unit having a vibratory contact projecting centrally therefrom and a cylindrical enclosure surrounding said transducer unit with said contact extending beyond one end of said enclosure, a flange extending about said enclosure coaxially with said contact, a coaxial transmission line having a central conductor and an outer conductor coaxial therewith, a cylindrical housing supporting said transmission line centrally thereof and having a recessed portion to receive said one transducer enclosure end with said contact extending towards said central conductor and said flange engaging said housing, and adjusting means mounted with said housing adjacent said one transducer enclosure end for trans-

versely positioning precisely said transducer unit in said recessed portion with said contact into substantially precise coaxial relation with said outer conductor inner surface, and locking means connected with said position adjusting means for maintaining the said precisely set coaxial relation, whereby optimum operation of the impulse generator is provided with a substantially flat spectral output of extended frequency range.

5. The impulse generator of claim 1, in which said position adjusting means includes a resilient member, and an adjustable element located diametrically opposite said member.

6. The impulse generator of claim 2, in which said position adjusting means includes a resilient member pressed against said one enclosure end, and an adjustable element located diametrically opposite said member and operable on said one enclosure end.

7. The impulse generator of claim 3, in which said position adjusting means includes a first resilient member pressed against said one enclosure end, a first adjustable element located diametrically opposite said first member, a second resilient member located substantially 90° from said first resilient member and pressed against said one enclosure end, and a second adjustable element located diametrically opposite said second member, said adjustable elements coacting to hold said enclosure and transducer unit in position.

8. The impulse generator of claim 4, in which said position adjusting means includes a first resilient member pressed against said one enclosure end, a first adjustable element located diametrically opposite said first member and operable on said one enclosure end, a second resilient member located substantially 90° from said first resilient member and pressed against said one enclosure end substantially in the plane of said first member and first element, and a second adjustable element located diametrically opposite said second member and operable to position said enclosure and transducer unit.

9. The impulse generator of claim 5, in which said resilient member is a helical spring.

10. The impulse generator of claim 6, in which said resilient member is a helical spring, and said adjustable element is a threaded screw.

11. The impulse generator of claim 7, in which said

resilient members are helical springs and said adjustable elements are threaded screws.

12. The impulse generator of claim 5, further including a set-screw associated with said resilient member to secure said enclosure and transducer unit together with said housing.

13. The impulse generator of claim 10, further including a set-screw centrally through said helical spring to secure said enclosure and transducer unit in conjunction with said threaded screw.

14. The impulse generator of claim 11, further including a set-screw centrally through each of said helical springs to secure said enclosure and transducer unit in conjunction with said threaded screws.

15. The impulse generator of claim 12, in which said locking means includes a locking screw settable against said set-screw.

16. The impulse generator of claim 14, in which said locking means includes locking screws settable against said set-screws and said threaded screws.

17. The impulse generator of claim 3, further including a clamping ring engageable with said housing for locking said enclosure therewith.

18. The impulse generator of claim 4, further including a clamping ring engageable with said housing for locking said transducer enclosure therewith across said flange.

19. The impulse generator of claim 8, further including a set-screw centrally through each of said helical springs to secure said transducer unit, and a clamping ring engageable with said housing for locking said transducer enclosure therewith across said flange.

20. The impulse generator of claim 15, further including a clamping ring engageable with said housing for locking said transducer enclosure therewith across said flange.

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