April 4, 1939. H. H. BENNING 2,153,528

BROAD BAND TRANSMISSION SYSTEM

Filed April 22, 1938

FIG. 4

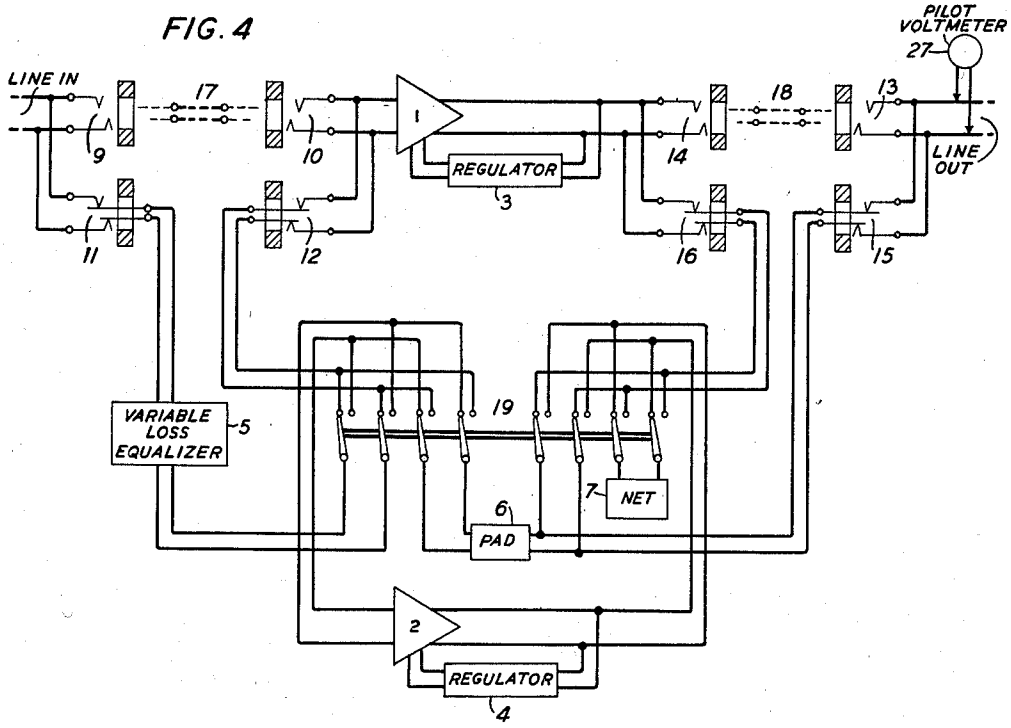


FIG. 1

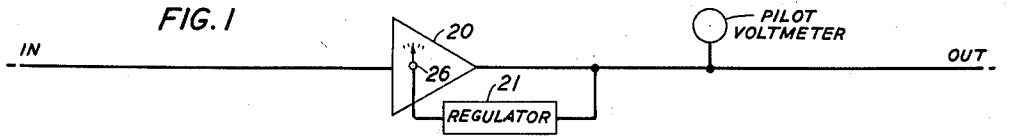


FIG. 2

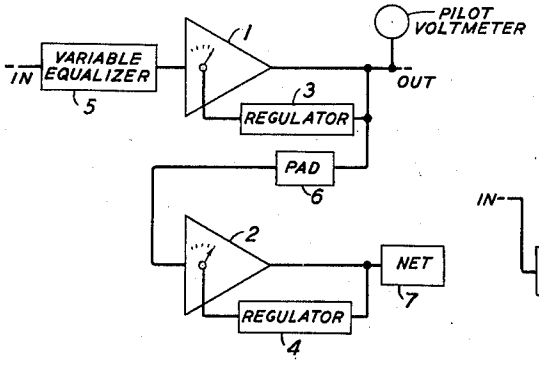
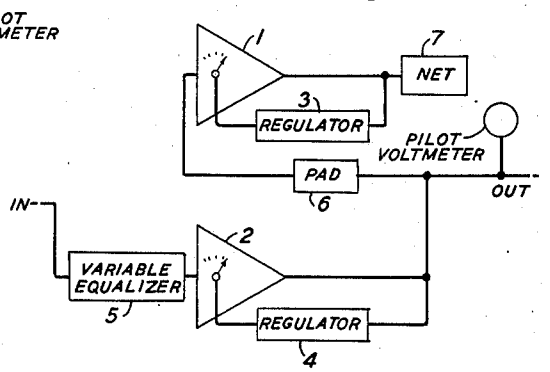


FIG. 3



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BROAD BAND TRANSMISSION SYSTEM

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10 Claims. (Cl. 178—44)

This invention relates to transmission circuits and more particularly to a broad band system employing a plurality of one-way repeaters.

It is the object of the invention to provide means whereby an active repeater may be replaced without circuit disturbance.

In a broad band transmission system it is the practice to use a large number of repeaters spaced at rather close intervals. In general, these repeaters transmit in one direction only, an additional circuit being provided for the transmission in the opposite direction. With a large number of repeaters thus connected in tandem it is necessary to hold the amplification produced by any one repeater within very close limits. A satisfactory method of accomplishing this result is provided by the pilot frequency regulator. The pilot frequency may be any convenient frequency within the band of transmission of the system. The regulator may consist of a form of amplifier-rectifier bridged across a repeater output. As it will usually be sensitive only to the pilot frequency it may provide a direct current potential which is proportional to the level of the pilot frequency at the repeater output which potential, being (in one type of regulator) applied to the grid of a variable mu tube which forms a part of the amplification system of the repeater, will serve to increase or decrease the gain of the repeater if required until the level of the pilot frequency transmission at the repeater output shall reach its designed value. Thus the output level of the repeater as judged by the pilot frequency is held within very close limits.

A broad band system such as that under consideration will ordinarily carry a very large number of channels and it is, therefore, of great importance that no interruption of service over it occurs. Particularly, means must be provided for the adequate maintenance of repeaters without appreciable interruption or change in transmission characteristic. It is proposed to provide spare repeaters which may be quickly substituted for those in active service but due to the feature of automatic gain control the spare repeaters will ordinarily not immediately provide the proper output level. In a specific disclosure of my invention as described below, I provide a method for insuring against this contingency. This disclosure is based upon the presumption, which is a matter of properly controlled design and manufacture, that the amplification of all repeaters at maximum gain setting will be identical.

For a more complete understanding of the invention, reference is made to the drawing in which:

Fig. 1 shows in simplified diagram a single repeater in service;

Fig. 2 is a schematic of an active and a spare repeater in condition to be interchanged;

Fig. 3 shows a schematic of connection after a spare repeater has been substituted for an active repeater; and

Fig. 4 is a general layout of the arrangement of apparatus for making repeater substitution.

In Figs. 1, 2 and 3 transmission circuits are shown by a single line for the sake of simplicity. In Fig. 1 a repeater 20 receives energy from line "in", amplifies it and transmits it to line "out". The regulator 21 is shown connected across the repeater at its output and it is presumed that under the conditions of normal operation the regulator has set the gain of the repeater at a position midway between minimum and maximum. According to the convention adopted in the drawing this is indicated by the indicator 26. It should be understood that this convention has been adopted in the drawing to aid in explaining the operation of the invention. It has no counterpart in the actual repeater and under ordinary circumstances it would not be possible to determine by inspection what gain was being produced by any particular repeater. The pilot voltmeter of Fig. 1 might consist of an amplifier-rectifier with input tuned to the pilot frequency and having an output meter calibrated to indicate the pilot frequency voltage at the line position at which the pilot voltmeter may be connected in a manner known in the art.

Referring now to Fig. 4, the normal active repeater 1, equipped with regulator 3 under normal operating conditions is connected directly between line "in" and line "out", the patching cord 17 being used to bridge jack 9 to jack 10 and the patching cord 18 being used to bridge jack 14 to jack 13. Under the conditions shown in Fig. 4, however, it is assumed to have been decided that repeater 1 should be removed from the line for inspection. Without removing patching cords 17 and 18 the spare repeater circuit is set up. This circuit may be traced from jack 11 which is in multiple with jack 9 through the variable loss equalizer 5, thence through normally closed contacts of the quick-acting switch 19 back to jack 12 which is in multiple with jack 10, also from jack 16 in multiple with jack 14 through normally closed contacts of the quick-acting switch and back to jack 15 which is in multiple

with jack 13. The variable loss equalizer is a network which has been designed to have the same transmission frequency characteristic as the actual line and to be variable in attenuation upwards from zero. It is assumed that under the conditions just described, that is, with patching cords 17 and 18 still in place, the variable loss equalizer has been set for zero attenuation. It will be noted that the pad 6 is shown bridged across the strap between jacks 16 and 15. This is assumed to be a bridging pad whose impedance is so high as to cause no appreciable attenuation or distortion when bridged across a transmission line such as that under consideration. It will now be apparent that with the variable loss equalizer 5 set at zero and with the pad 6 assumed to cause no appreciable loss or distortion, the patching cords 17 and 18 may be removed, so long as the quick-acting switch 19 is in the position shown, without any disturbance to the line circuit. The conditions shown in Fig. 4 are equivalent to those of Fig. 1 so far as line transmission is concerned. There is in Fig. 4, however, an auxiliary circuit which may be traced from the output of repeater 1 through pad 6, normally closed contacts of switch 19, and thence to the input of repeater 2 which is equipped with regulator 4. The output of repeater 2 is traced through normally closed contacts of switch 19 to network 7. The function of high impedance bridging pad 6 is two-fold. It not only picks pilot frequency off the line for transmission to the input of repeater 2 but it also so attenuates the level of that pilot frequency that the pilot frequency level after amplification by repeater 2 is still well below the level which repeater 2 and regulator 4 are designed to maintain. In the effort to achieve this designed level, therefore, the regulator 4 steps up repeater 2 to its maximum gain.

Pilot voltmeter 21 may then be employed to check the satisfactory operation of repeater 2. It is apparent that repeater 2 may be a regulator controlled repeater equivalent to repeater 1 or it may be any suitable repeater set to have a gain equivalent to the maximum gain of repeater 1.

Returning now to the main transmission circuit, in the condition shown in Fig. 4, with patching cords 17 and 18 removed, if attenuation is slowly cut into the variable loss equalizer 5 thus decreasing the level of pilot frequency and, of course, all other transmitted frequencies into repeater 1, regulator 3 will step up the gain of repeater 1 thus keeping the pilot frequency output level constant. This operation is continued until repeater 1 reaches the point of maximum gain as evidenced by the fact that for a further small increase of attenuation the voltage as measured by the pilot voltmeter will decrease slightly. The condition of Fig. 2 has now been reached in which both active and spare repeaters are set at maximum gain and are, therefore, set for equal amplification. If now the quick-acting switch 19 is thrown to its alternate position the conditions become those of Fig. 3 in which 2 is now the active repeater and 1 is out of active service and may be serviced or replaced without disturbance to the line transmission system. When service of repeater 1 has been completed the quick-acting switch 19 may be thrown back to its normal position as shown in Fig. 4. The variable equalizer is then gradually cut down to zero, the patching cords 17 and 18 are replaced, and normal operating conditions are thus restored.

It is to be understood that the various structures and circuit arrangements are merely illustrative and that many modifications may be made without departing from the spirit of the invention as defined by the claims.

What is claimed is:

1. In a transmission system, a transmission line, a repeater having an input and an output connected in said line, a spare repeater, an automatic gain regulator for each repeater adapted to be controlled in accordance with current on said line for adjusting the gain setting of said repeaters, means to connect the input of said spare repeater to receive highly attenuated currents from said line, whereby its regulator is caused to adjust its gain to maximum setting, means for attenuating the current to said repeater in said line to cause its regulator to adjust its gain to maximum setting, and a switch for substituting said spare repeater in place of said repeater in said line.

2. The method of servicing a repeater in a transmission line self-regulated by line current which consists in attenuating the line current at the repeater input to cause said line repeater to regulate its gain to maximum, impressing highly attenuated line current on a spare repeater to cause said spare repeater to regulate its gain to maximum and substituting said spare repeater for said line repeater.

3. The method of making a service replacement of a self-regulated repeater in a transmission line which comprises increasing the attenuation of said line to the point at which the said repeater is self-regulated to a condition of maximum gain, and quickly substituting a spare repeater preadjusted to the same gain for said repeater in said transmission line.

4. The method of replacing in a transmission line, an active line repeater having an automatic gain regulator adapted to be controlled in accordance with current in said line by a similarly controlled spare repeater, comprising the introduction of attenuation into said transmission line to cause said active repeater to be regulated to maximum gain setting, the eduction of highly attenuated currents from said transmission line to cause said spare repeater to be regulated to maximum gain setting and rapid substitution of said spare repeater for said active repeater.

5. In a transmission system, a transmission line, an amplifier in said line, a spare amplifier arranged to receive input current from said line and having its output connected to a dummy load, means for adjusting said line amplifier to a predetermined gain above the normal gain of said line amplifier without change in net system gain means for adjusting said spare amplifier to said predetermined gain, and a multicontact switch adapted to interchange respectively the inputs of said amplifiers and simultaneously to interchange respectively the outputs of said amplifiers.

6. In a transmission system employing self-adjustable amplifiers having a margin of available gain above normal operating gain, replacement means for an active amplifier comprising in combination an equivalent spare amplifier, means for causing said active amplifier to cancel its normal operating margin so as to adjust its gain to maximum while maintaining constant system gain, auxiliary means causing said spare amplifier to regulate its gain into equivalence with said active amplifier, and a quick-acting switch adapted to substitute said spare amplifier for said active amplifier.

7. In a transmission system employing con-

stant output amplifiers, replacement means for an active amplifier comprising in combination an equivalent spare amplifier, means including a variable attenuator for causing said active amplifier to adjust its gain to a maximum while maintaining constant system gain, auxiliary means including an input loss pad and a terminating network causing said spare amplifier to regulate its gain into equivalence with said active amplifier, and a quick-acting switch adapted to interchange said amplifiers.

8. In a transmission system designed to maintain constant output level by the employment of self-regulatory amplifiers, replacement means for an active amplifier comprising a similar spare amplifier, means for causing said active amplifier to adjust its gain to a predetermined level, means for causing said spare amplifier to adjust its gain to a level equal to that of said active amplifier, and a hand operated switch for interchanging said amplifiers.

9. In a transmission system arranged to automatically maintain a constant output level by the employment of self-adjustable amplifiers, replacement means for an active amplifier comprising a similar spare amplifier, means for causing said active amplifier to increase its gain to a predetermined level without change in system level, independent means causing said spare amplifier to adjust its gain to equivalence with said active amplifier, and a quick-acting switch for interchanging said amplifiers.

10. In a transmission system designed to automatically compensate for changes in system attenuation by the employment of self-adjustable amplifiers, replacement means for an active amplifier comprising a spare amplifier of identical design, hand operated means for increasing the system attenuation preceding said active amplifier whereby it is caused to increase its gain to maximum without change in the transmission equivalent of the said system, input means causing said spare amplifier to adjust its gain to maximum, and a switch adapted to quickly interchange the input and the output connections respectively of said amplifiers.

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