

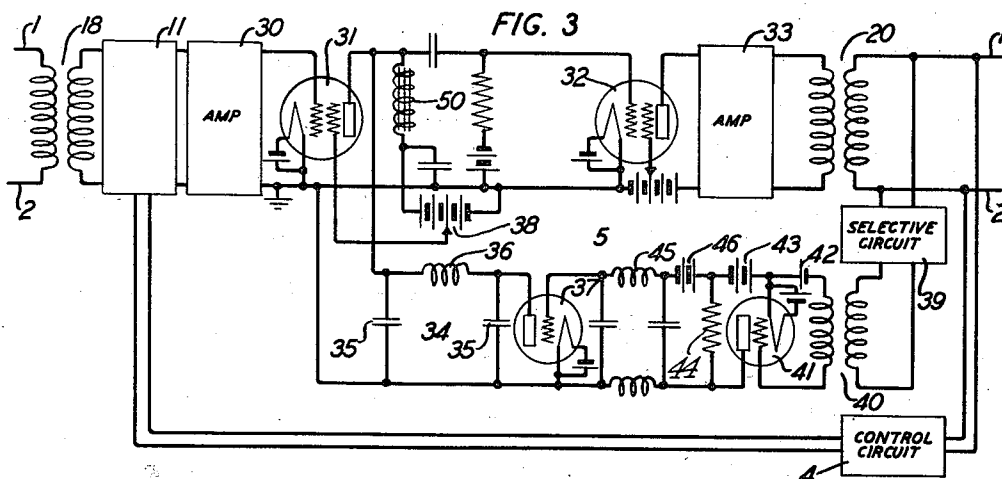
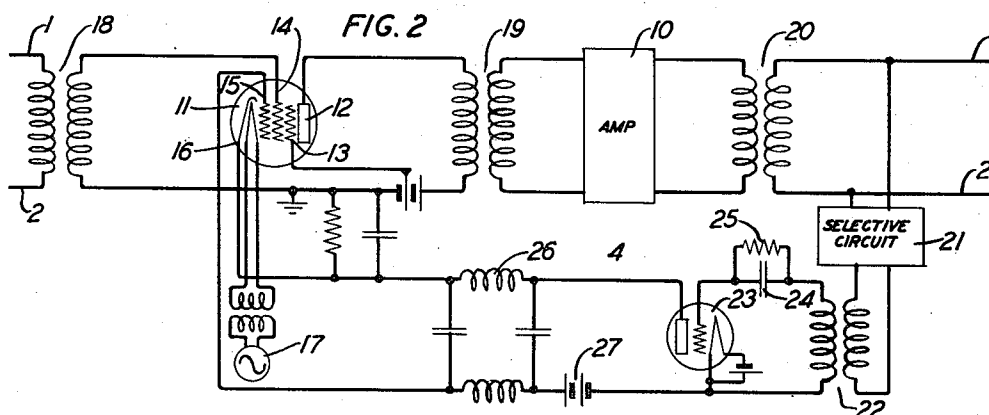
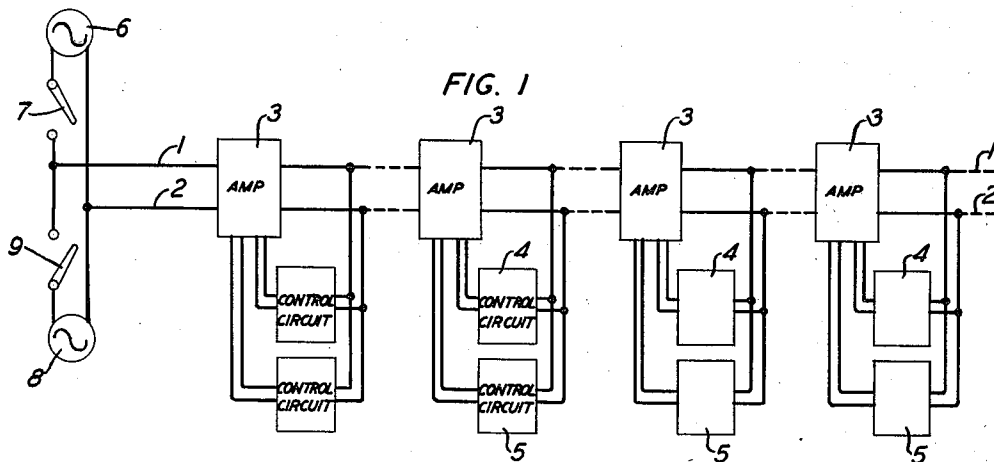
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SIGNAL TRANSMISSION SYSTEM

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SIGNAL TRANSMISSION SYSTEM

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This invention relates to high frequency signal transmission systems and particularly to gain control circuits for high frequency transmission systems.

5 One object of the invention is to provide a high frequency transmission system that shall control the gain at repeater stations and that shall equalize the energy levels of the currents of different frequencies.

10 Another object of the invention is to provide a high frequency transmission system for transmitting a plurality of signals by carrier currents of different frequencies that shall control the gain at a repeater station in accordance with the energy level of one pilot current and that shall
15 equalize the energy levels of the carrier currents of different frequencies in accordance with the energy level of a second pilot current.

20 A further object of the invention is to provide a high frequency transmission system of the above indicated character that shall control the gain at a repeater station in accordance with the energy level of a pilot current having a frequency adjoining the lower part of the frequency range
25 of the carrier currents and that shall equalize the energy levels of the currents of different frequencies by a pilot current having a frequency adjoining the upper part of the frequency range of the carrier currents.

30 In a system where a plurality of signals are transmitted simultaneously over a transmission line by means of carrier currents of different frequencies it is desirable that the attenuation of the carrier currents of different frequencies be
35 maintained constant regardless of changes in line conditions. The changes in attenuation may be due to changes in temperature or to changes in leakage conditions which may be caused by weather variations. In most high frequency
40 transmission systems, the variations in attenuation with temperature are greater for high frequency currents than for low frequency currents.

45 In the present invention means are provided for controlling the gain at repeater stations along a transmission line in accordance with the energy level at the repeater stations of a pilot current transmitted over the line. At the repeater stations equalizing means are provided under the control of a second pilot current for so compensating the gain at the repeater stations as to
50 correct for the attenuation of the carrier currents of different frequencies.

55 The gain at a repeater station on a transmission line is preferably controlled by varying the positive potential impressed on the space-charge

grid of a pentode tube. If so desired other types of tubes may be employed for controlling the gain. The potential on the space-charge grid is controlled in accordance with the energy level of a pilot current transmitted over the line. Preferably the control circuits which govern the potential on the space-charge grid are governed in accordance with energy level of the pilot frequency at a point on the line beyond the repeater station. The frequency of the pilot current which controls the gain at the repeater station is preferably close to the lower frequency range of the carrier currents which are employed to transmit the signals. If so desired the pilot current controlling the gain may have a frequency located at other positions in the frequency range of the carrier currents.

In the control of the potential impressed on the space-charge grid, a selective circuit is connected to the transmission line beyond the repeater. The selective circuit is tuned to the frequency of the pilot current employed to control the gain. This selective circuit is connected to a detector tube and the output circuit of the detector tube is connected by a filter to the space-charge grid. The filter in the output circuit of the detector tube serves to eliminate any alternating current which may be present. The detector tube has a rectifying action and serves to decrease the current in the output circuit upon an increased energy level of the pilot frequency on the line. Thus, if the energy level of the pilot current on the line is raised, the positive potential on the space-charge grid is lowered to lower the gain effected at the repeater station.

55 In a transmission system wherein signals are transmitted by carrier currents of relatively high frequency, it is desirable to equalize the energy level of the carrier currents of different frequencies as well as to control the gain of the carrier currents. The attenuation for the higher frequency carrier currents is greater than the attenuation for the lower frequency carrier currents. Moreover, the variations in attenuation with changes in outside factors such as temperature is greater for the higher frequency currents than for the lower frequency currents. A section of a high frequency carrier current line and its associated repeater properly equalized by fixed networks at one temperature would no longer be properly equalized at any other temperature, even though the gain at one frequency was corrected by an automatic gain control as mentioned above. In order to provide the additional correction in the characteristic at the repeater station for the

changes in attenuation at different frequencies by temperature changes, a second pilot current is transmitted over the line. The pilot current which controls the equalization of the carrier currents preferably has a frequency close to the upper frequency in the frequency range of the carrier currents. However, the pilot current controlling the equalization of the carrier currents may have a frequency located at other positions in the carrier frequency range.

A repeater station in a system controlled in accordance with the invention preferably has a number of amplifier tubes. The first tube preferably is the pentode tube which is governed to control the repeater station gain according to the energy level of the pilot current of lower frequency. A low pass network is connected across the line beyond the pentode tube and between any of the amplifier tubes for equalizing the energy levels of the carrier currents of different frequencies. The low pass network or filter has a cut-off point above the useful frequency range of the repeater so as to transmit the full frequency range of the carrier currents and the two pilot currents. The impedance of the low pass network or filter when terminated with a proper impedance is substantially constant over the frequency band of carrier currents transmitted over the line. The terminating impedance of this filter may be changed from its normal value so that the impedance of the filter as a whole may be made approximately proportional or inversely proportional to the frequencies of the transmitted currents, depending on the value of the terminating impedance. The terminating impedance of the filter is controlled to equalize the energy levels of the currents of different frequencies transmitted over the line.

In controlling the terminating impedance of the low pass filter, a selective circuit tuned to the frequency of the pilot current of higher frequency is connected across the line beyond the repeater station. The selective circuit is connected to a detector tube having a negative bias so that when the energy level of the pilot current of the higher frequency is raised, the output from the detector tube is raised. This detector tube has an opposite action with respect to the action of the detector tube in the control circuits governed by the pilot current of lower frequency. A filter is connected between the detector tube and a three-element space discharge tube which serves as the terminating impedance for the low pass filter. The filter connected between the detector tube and the control tube serves to eliminate any alternating current that may be in the output circuit of the detector tube. The impedance of the control tube which serves as the terminating impedance for the low pass filter is governed in accordance with the potential impressed on the grid thereof. The potential impressed upon the grid is controlled in accordance with the energy level of the pilot current of higher frequency.

In a low pass filter of the type shown on the drawing, a change in the value of the terminating impedance will not only affect the shape of the gain characteristic curve, but will modify, in general, the gain of the repeater at the frequency of the gain control pilot channel. The change in the gain of the low frequency pilot current will effect operation of the gain control circuits to change the gain of the repeater as a whole. This will, in general, cause the attenuation equalizer circuit to operate again. This reaction of one control on another will continue, each succes-

sive change being smaller until simultaneously the gain of the repeater and the shape of its characteristic are correct. Actually the changes of the control circuits will not be in a step-by-step manner, but will be effected almost instantaneously.

If the energy level of the pilot current of the higher frequency is raised above normal, the output from the detector tube is raised and the negative potential impressed upon the grid of the control tube is raised to increase the terminating impedance of the low pass filter. Increasing the terminating impedance of the low pass filter serves to attenuate the carrier currents approximately inversely in accordance with the frequency. If the energy level of the pilot current of higher frequency falls below normal, the impedance of the control tube is raised to attenuate the currents of higher frequency approximately proportionate to the frequency. In this manner the energy level of the carrier currents of different frequencies are equalized at the repeater station. The number of repeater stations on a transmission line which are equipped with gain control circuits and equalization control circuits of the type disclosed may vary according to the conditions on the line. In the case of an open air line it would be necessary to equip each of the repeater stations with gain control and equalization control circuits.

In the accompanying drawing:

Fig. 1 is a diagrammatic view of a signal transmission system having gain control circuits constructed in accordance with the invention;

Fig. 2 is a diagrammatic view of a repeater station provided with circuits for controlling the gain at a repeater station by governing the space-charge grid of a pentode tube; and

Fig. 3 is a diagrammatic view of a repeater station provided with circuits for controlling the gain and for equalizing the energy levels of the different carrier currents.

Referring to Fig. 1 of the drawing a transmission line comprising conductors 1 and 2 is shown provided with a number of repeater stations 3. Means, not shown, are provided for transmitting signals over the line by means of carrier currents. The repeater stations are each provided with control circuits 4 for controlling the gain at a repeater station and control circuits 5 for equalizing the energy levels of the carrier currents of different frequencies. The control circuits 4 at each repeater station are preferably governed according to the energy level of a pilot current having a frequency close to the carrier current of lowest frequency transmitted over the line. The control circuits 5, which equalize the energy levels of the different carrier currents, are preferably controlled by a pilot current having a frequency close to the carrier current having the highest frequency. A source of oscillations 6 is connected to the conductors 1 and 2 by the switch 7 for impressing the pilot current of higher frequency on the line. A source of oscillations 8 is connected to the conductors 1 and 2 by a switch 9 for impressing the pilot current of lower frequency on the line.

In Fig. 2 of the drawing the control circuits 4 for governing the gain at a repeater station are shown in detail. An amplifier 10 and a pentode tube 11 are shown connected in the transmission line. The pentode tube 11 comprises a plate 12, a screen grid 13, a control grid 14, a space-charge grid 15 and cathode 16. The cathode 16 is heated from a source of alternating current 17. The

positive potential impressed on the space-charge grid 15 is varied in accordance with the energy level of the pilot current of lower frequency on the line beyond the amplifier 10. The input circuit of the pentode tube is connected to a transformer 18 and the output circuit of the pentode tube is connected by a transformer 19 to the amplifier 10. A transformer 20 is provided in the output circuit of the amplifier 10.

The control circuit 4 for governing the positive potential impressed on the space-charge grid 15 to govern the gain at the repeater station comprises a selective circuit 21 which is tuned to the frequency of the pilot current of lower frequency and is connected across the line circuit. The selective circuit 21 is connected by a transformer 22 to the input circuit of a three-element detector tube 23 having a capacity 24 and a resistance 25 in the input circuit for providing a grid leak. The output circuit of the detector tube 23 is connected to a filter 26 which serves to eliminate alternating currents. The filter 26 is connected to the space-charge grid 15 and the cathode 16 of the pentode tube 11. A battery 27 which is connected between the detector tube 23 and the filter 26 furnishes positive potential to the space-charge grid 15 of the pentode tube and plate potential for the detector tube.

If the energy level of the pilot current of lower frequency at a repeater station is above normal value, the negative potential on the grid of the detector tube 23 is increased and the impedance of the detector tube is increased. Accordingly, the potential drop across the detector tube 23 is increased and the potential drop from the space charge-grid 15 of the pentode tube 11 to ground is decreased. The sum of the voltage drop across the detector tube 23 and the potential drop from the space-charge grid 15 to ground must equal the constant voltage supplied by the battery 27. This lowers the gain at the repeater station. If the energy level of the pilot current of lower frequency falls below normal value, the negative bias on the detector tube 23 is lowered to decrease the impedance of the tube and thus increase the positive potential impressed on the space-charge grid 15 of the pentode tube 11. The increase in the positive potential on the space-charge grid 15 serves to decrease the impedance of the pentode tube and thus increase the gain at the repeater station.

Referring to Fig. 3 of the drawing a repeater station for the transmission line is shown provided with control circuits 4 for controlling the gain at the repeater station and control circuits 5 for equalizing the energy levels of the carrier currents of different frequencies. The control circuit 4 in Fig. 3 of the drawing is similar in construction and operation to the control circuit 4 shown in Fig. 2 of the drawing and like parts in Fig. 3 will be indicated by similar reference characters. The repeater station shown in Fig. 3 of the drawing is provided with four amplifier devices 30, 31, 32 and 33. The amplifier devices are each preferably of the space discharge type provided with screen grids. Across the output circuit of the amplifier tube 31 is connected a low pass network or filter 34. The filter 34 comprises capacity elements 35 and an inductive element 36. The terminating impedance of the filter comprises the impedance of a three-element space discharge device 37. A battery 38 is provided for supplying plate potential to the amplifier tube 31 and to the tube 37. The battery 38 is connected to the anode of the tube 31 by means of a choke coil

50. The terminal impedance of the filter 34 comprising the impedance of the space discharge tube 37 is varied to equalize the energy levels of the carrier currents of different frequencies.

The control circuits 5 for governing the terminal impedance of the low pass filter 34 comprise a selective circuit 39 connected across the line beyond the amplifier 33 and tuned to the frequency of the pilot current of higher frequency. The selective circuit 39 is connected by a transformer 40 to the input circuit of a detector tube 41. A battery 42 is provided for impressing a negative bias on the grid of the detector tube 41 and a battery 43 is provided in series with the potentiometer 44 for impressing potential on the plate of the detector tube 41. The input circuit of the space discharge tube 37 is connected through the filter 45 across the potentiometer 44 in the output circuit of the detector tube 41. A battery 46 is provided for impressing the negative bias on the grid of the space discharge tube 37.

The detector tube 41 in the control circuit 5 acts in an opposite manner to the detector tube 23 in the control circuit 4. The output from the detector tube 41 increases when the energy level of the pilot current of higher frequency is raised and decreases when the energy level of the pilot current of higher frequency is lowered. The output from the detector tube 23 decreases when the energy level of the pilot current of lower frequency is raised and increases when the energy level of such pilot current is lowered.

If the energy level of the pilot current of higher frequency rises above normal value, the output from the detector tube 41 increases to increase the negative potential on the grid of the space discharge tube 37. This increases the impedance of the tube 37 and accordingly the terminating impedance of the filter 34. Increasing the impedance of the filter 34 which is connected across the line serves to make the impedance on the line to carrier currents of the higher frequencies less than the impedance to lower frequencies. The filter 34 produces substantially constant impedance to the carrier currents of all frequencies when the pilot current of higher frequency has a normal energy level. If the energy level of the pilot current of higher frequency rises, the impedance of the line caused by the filter 34 is less for the higher frequency currents than for the lower frequency currents. If the energy level of the pilot current of higher frequency falls below normal, the impedance of the filter 34 is greater for the higher frequency currents than for the lower frequency currents.

In repeater stations having control circuits constructed as above set forth, the gain at the repeater station is controlled by a pilot current of a low frequency. The losses are different for the carrier currents of different frequencies and means must be provided for insuring that the carrier currents of different frequencies are raised to the same energy level beyond the repeater station. The pilot current having the higher frequency controls an equalizing filter which compensates for the different variations in line attenuation at different frequencies caused by variations in external physical conditions.

Modifications in the circuits and in the arrangement and location of parts may be made within the spirit and scope of the invention, and such modifications are intended to be covered by the appended claims.

What is claimed is:

1. In a transmission system, a line transmitting signals by carrier currents of different frequencies, means for transmitting two pilot currents over said line having frequencies respectively near the upper and lower limits of the frequency range of said carrier currents, a signal station on said line, a low-pass filter at said station connected across said line and having a cut-off point above the highest carrier current frequency, a gain control impedance at said station, means controlled by one of said pilot currents for governing said impedance to control the gain at the station, and means controlled by the other pilot current for governing said filter to equalize the energy levels of the different carrier currents.

2. In a transmission system, a line transmitting signals by carrier currents of different frequencies, means for transmitting two pilot currents over said line having frequencies respectively near the upper and lower limits of the frequency range of said carrier currents, a repeater station on said line, means for controlling the gain at the repeater station according to the energy level of one of said pilot currents, a low pass filter connected across the line and having a cut-off point above the highest carrier current frequency, a variable terminating impedance for said filter, and means governed according to the energy level of the other pilot current for governing said terminating impedance to equalize the energy levels of the different carrier currents.

3. In a transmission system, a line transmitting signals by carrier currents of different frequencies, means for transmitting two pilot currents over said line having frequencies respectively near the upper and lower limits of the frequency range of said carrier currents, a repeater station on said line, means for controlling the gain at the repeater station according to the energy level of the pilot current having the lower frequency, and means controlled according to the energy level of the higher frequency pilot current for equalizing the energy levels of the different carrier currents.

4. In a transmission system, a line transmitting signals by carrier currents of different frequencies, means for transmitting two pilot currents over said line having frequencies respectively near the upper and lower limits of the frequency range of said carrier currents, a repeater station on said line, a space discharge device in series with the line at the repeater station, means for controlling the impedance of said device according to the energy level of the pilot current having the lower frequency to control the gain at the repeater station, and means controlled according to the energy level of the higher frequency pilot current for equalizing the energy levels of the different carrier currents.

5. In a transmission system, a line transmitting signals by carrier currents of different frequencies, a repeater station on said line comprising a control space discharge tube and an amplifier, means for transmitting two pilot currents over said line having frequencies respectively near the upper and lower limits of the frequency range of said carrier currents, means for controlling the impedance of said tube according to the energy level beyond said amplifier of said low frequency pilot current to govern the gain at the repeater station, and means controlled according to the energy level beyond said amplifier of the higher frequency pilot current

for equalizing the energy levels of the different carrier currents.

6. In a transmission system, a line transmitting signals by carrier currents of different frequencies, means for transmitting two pilot currents over said line having frequencies respectively near the upper and lower limits of the frequency range of said carrier currents, a repeater station on said line, a space discharge tube in series with the line at the repeater station, means for controlling the impedance of said tube according to the energy level of the pilot current having the lower frequency to control the gain at the repeater station, an impedance network connected across the line at the repeater station, and means controlled according to the energy level of the pilot current having the higher frequency for governing said network to equalize the energy levels of the different carrier currents.

7. In a transmission system, a line transmitting signals by carrier currents of different frequencies, a repeater station on said line, means for transmitting a pilot current over said line, a low pass filter having a cut-off point above the highest carrier current frequency and connected across the line at the repeater station, a space discharge tube forming the terminal impedance of said filter, and means for controlling the impedance of said tube according to the energy level of said pilot current to equalize the energy levels of the different carrier currents.

8. In a transmission system, a line transmitting signals by carrier currents of different frequencies, a repeater station on said line, means for transmitting a pilot current having a frequency near the upper limit of the frequency range of said carrier currents, a low pass filter connected across the line and having a cut-off point above the highest carrier current frequency, a three-element space discharge device with the plate circuit impedance forming the terminal impedance of said filter, a circuit connected to the line beyond the repeater and selective of said pilot current frequency, and a detector tube connected to said circuit for controlling said device according to the energy level of the pilot current on the line to govern said filter and equalize the energy levels of the different carrier currents.

9. In a transmission system, a line transmitting signals by carrier currents of different frequencies, a repeater station on said line, means for transmitting two pilot currents over said line having frequencies respectively near the upper and lower limits of the frequency range of said carrier currents, means for controlling the gain at the repeater station according to the energy level of the pilot current having the lower frequency, a low pass filter connected across the line and having a cut-off point above the highest carrier current frequency, a space discharge tube forming the terminal impedance of said filter, and means for controlling the impedance of said tube according to the energy level of the pilot current having the higher frequency to equalize the energy levels of the different carrier currents.

10. In a transmission system, a line transmitting signals by carrier currents of different frequencies, a repeater station on said line, a pentode tube having an anode, a cathode, a control grid governed by the signal currents, a screen grid and a space-charge grid, said tube being connected in series with the line at the repeater station for controlling the gain, means for impressing potential on said screen grid which is positive

with respect to the cathode potential, means for impressing a pilot current on said line, and means for impressing a varying potential on said space-charge grid according to the energy level of the pilot current beyond the repeater station.

11. In a transmission system, a line transmitting signals by currents of different frequencies, a repeater station on said line, a pentode tube having an anode, a cathode, a control grid governed by the signal currents, a screen grid and a space-charge grid, said tube being connected in series with the line at the repeater station for controlling the gain, means for impressing potential on said screen grid which is positive with respect to the cathode potential, means for impressing a pilot current on the line having a frequency different from the frequencies of the currents transmitting the signals, and means controlled according to the energy level of the pilot frequency for governing said space-charge grid to control the gain effected at the repeater station.

12. In a transmission system, a line transmitting signals by carrier currents of different frequencies, a repeater station on said line comprising tandem connected amplifier space discharge devices and a pentode tube having a

space-charge grid, means for impressing a pilot current on the line having a frequency near the lowest frequency of said carrier currents, a filter connected across said line beyond the amplifier devices and highly selective to the frequency of said pilot current, a rectifier circuit connected between said filter and the space-charge grid of said tube to vary the impedance of said tube and the gain at the repeater station according to energy level of the pilot current on the line beyond said amplifier devices, means for impressing a second pilot current on the line having a frequency near the upper limit of the frequency range of said carrier currents, a low pass filter connected across the line beyond said tube and having a cut-off above the frequencies of the carrier currents and the second pilot current, and means for varying the terminating impedance of said low pass filter according to the energy level of said second pilot current on the line beyond the amplifiers to compensate for changes in attenuation on the line for the different frequencies of the carrier currents and to maintain the gain constant for the different carrier currents.

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