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AUDIOMETER

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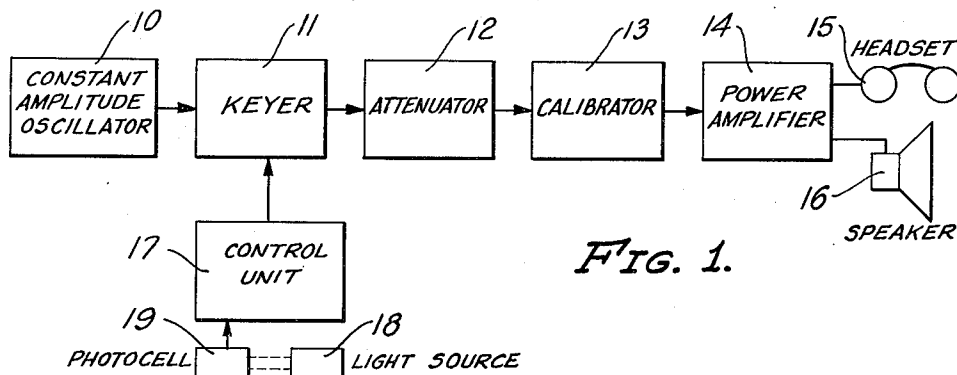


FIG. 1.

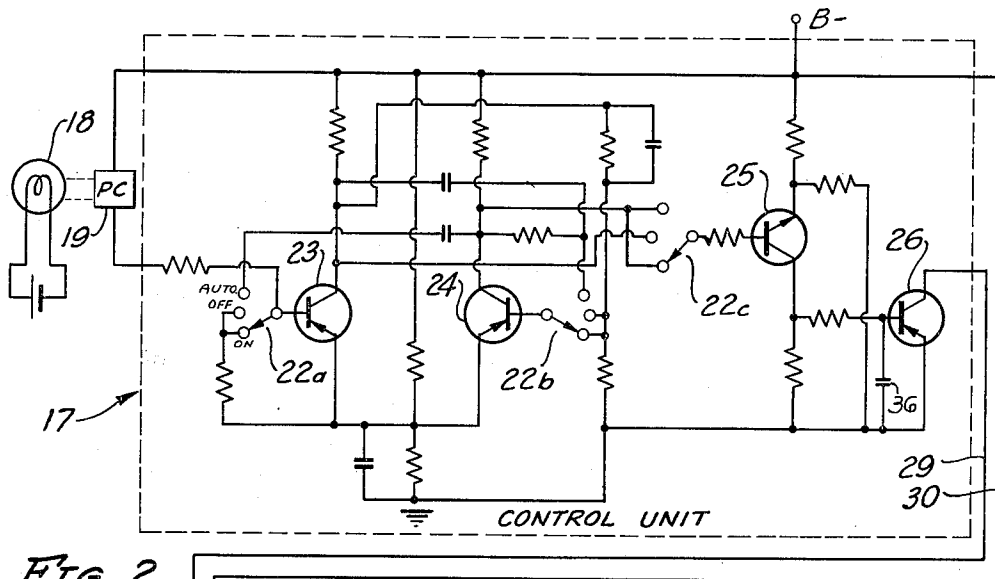
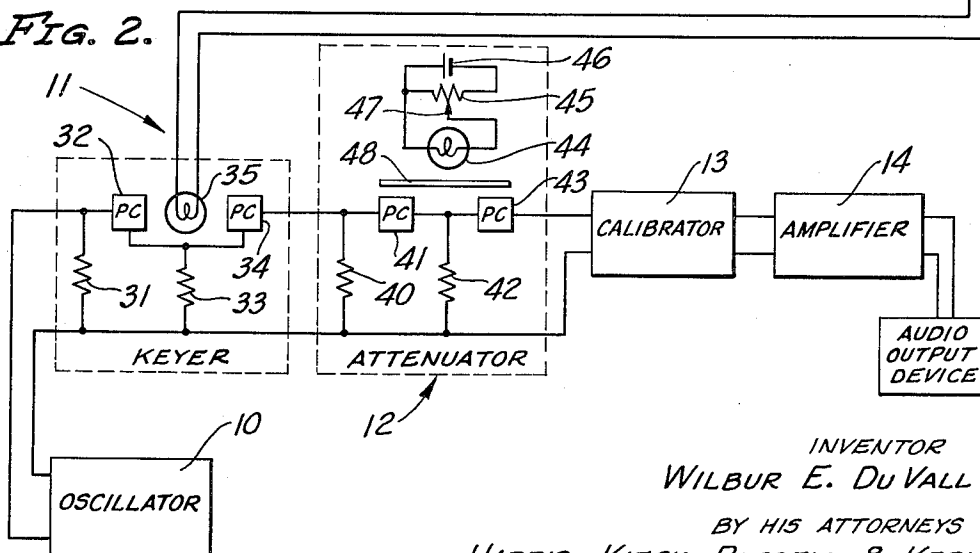


FIG. 2.



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1

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AUDIOMETER

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This invention relates to audiometers and, in particular, to new and improved means for controlling the signal level in audiometers and the like.

It is an object of the invention to provide an audiometer in which extraneous noise, such as key clicks due to switching, is eliminated during the hearing-testing operation. A further object is to provide such an audiometer which can utilize low noise, dependable solid state devices rather than vacuum tubes and the like, resulting in a simple, durable and economical instrument.

It is an object of the invention to provide an audiometer which may utilize a continuous running oscillator as a signal source rather than requiring the oscillator to be turned off and on. The oscillator, not being subjected to constant switching off and on, may be designed for low distortion, constant amplitude and stability of performance. A further object is to provide means for connecting and disconnecting the oscillator output to the audio output system wherein the rise and decay of the signal is controlled in accordance with A.S.A. specifications or any other desired characteristics.

It is an object of the invention to provide a nonmechanical tone interrupter for use with an audiometer, which tone interrupter does not generate any audible noises for direct hearing by the patient or any electrical noises for transmission through the instrument. A further object is to provide a tone interrupter comprising a light source and a photocell with the path between the source and cell being manually interruptible by the instrument operator and with the photocell functioning as a variable impedance to vary the control current of the keyer. Another object is to provide a control unit having the tone interrupter photocell as an element thereof and having means for generating a keyer on or a keyer off output as desired when the light path to the photocell is interrupted. Another object is to provide such a control unit wherein the amplifier stages which generate the control currents may be interconnected to the function as an oscillator providing a continuously keyed output from the audiometer.

It is an object of the invention to provide a keyer for controlling signal transmission between a source such as an oscillator and an output system such as an audio transducer. Another object is to provide such a keyer having a variable impedance photocell as a network element thereof for changing the keyer between the off and on conditions or high and low impedance states. Another object is to provide such a keyer having a light source for exciting the photocell with the intensity of light from the source serving as a control for the keyer. Another object is to provide such an apparatus wherein the intensity of the light source is controlled by the magnitude of current from the control unit which, in turn, is switched between maximum and minimum values by a tone interrupter. A further object is to provide such a photocell controlled unit which can function as an off-on device or as a variable attenuation device by suitably controlling the intensity of light impinging on the photocell.

In general, the invention contemplates an audiometer having a first light source and photocell functioning as a tone interrupter to provide a control current for a second light source and photocell which function as a keyer for the audio oscillator, and a third light source and

2

photocell and means for varying the light energy falling on the cell to function as an attenuator for the signal coupled from the oscillator to the output system.

The invention also comprises novel details of construction and novel combinations and arrangements of parts which will more fully appear in the course of the following description. The drawing merely shows and the description merely describes a preferred embodiment of the present invention which is given by way of illustration or example.

In the drawing:

FIG. 1 is a block diagram of a preferred form of the audiometer of the invention; and

FIG. 2 is a schematic diagram showing the details of a number of the elements of the instrument of FIG. 1.

The audiometer shown in FIG. 1 includes a constant amplitude oscillator 10, a keyer 11, an attenuator 12, a calibrator 13, a power amplifier 14, audio output transducers such as a headset 15 and a speaker 16, a control unit 17 for the keyer, and a manually operable tone interrupter comprising a light source 18 and a photocell 19. This instrument may be used in the same manner as the conventional audiometer for testing hearing. The sound is turned off and on by manual operation of the tone interrupter as will be described below. The sound level is controlled by varying the attenuator to determine the hearing threshold. The calibrator provides for calibration of the instrument at a particular frequency and is changed only when the oscillator is switched to a new frequency. The present invention relates to the oscillator, keyer and attenuator portion of the instrument and the calibrator, power amplifier, head set and/or speaker, which normally comprise the output system, may be identical to those used in conventional instruments.

In the instrument of the invention, the oscillator 10 is designed to have substantially constant amplitude and low distortion and may be of any standard design. However, it is significant to note that the oscillator may be a continuous running unit rather than being turned off and on with each operation of the tone interrupter.

FIG. 2 shows a preferred form of the control unit 17, the keyer 11 and the attenuator 12 in greater detail. The control unit 17 energizes the keyer 11 as a function of the magnitude of light directed to the photocell 19 and the position of a three-position switch 22a, 22b, 22c. When the switch 22 is in the lower position, as seen in FIG. 2, and light from the source 18 is directed to the photocell 19, the control unit will maintain the keyer 11 in the on or signal passing condition. When the switch 22 is in the intermediate position and light from the source 18 impinges on the cell 19, the control unit will maintain the keyer in the off or signal blocking condition. These two switch positions correspond to the normally on and normally off modes for the audiometer. When the switch 22 is in the upper position, the keyer is periodically switched between the off and on conditions while light from the source 18 falls on the cell 19. This condition is usually referred to as the automatic mode. When the light is interrupted in the automatic mode, the tone is shut off as in the normally on mode.

The control unit 17 includes a Schmidt trigger circuit with transistors 23, 24, and a two-stage amplifier with transistors 25, 26. When light is impinging on the photocell 19, it is in the low impedance state producing a relatively large base current to the transistor 23. Heavy conduction of the transistor 23 will prevent collector current flow in the transistor 24, through the switch 22a. The transistor 24 is cut off, producing no current to the base of the transistor 25, through the switch 22c. Then the transistor 26 will not conduct and there will be no current in the lines 29, 30 leading to the keyer 11. Con-

versely, when the light path between the source 18 and the photocell 19 is interrupted, as by placing the operator's hand or a piece of card or the like therebetween, the photocell is in the high impedance state which virtually eliminates base current to the transistor 23. When the transistor 23 is not conducting, its collector voltage goes toward the supply voltage, producing a relatively large base current in the transistor 24, through the switch 22b. With the transistor 24 heavily conducting, its collector voltage will be low, causing a relatively high base current in the transistor 25, through the switch 22c, resulting in heavy conduction of the transistor 26 and current in the lines 29, 30. This manually operable tone interrupter requires no mechanical movements and generates no audible or electrical noise while producing a current and a no current condition for actuation of the keyer.

The collector voltage of the transistor 24 is always the inverse of that of the transistor 23. Then when the switch 22 is moved to the intermediate or normally off position, the transistor 25 is driven from the transistor 23 rather than from the transistor 24 so that interruption of the light path between the source 18 and the cell 19 will result in no current in the lines 29, 30 to turn the keyer to the on or passing condition.

With the switch 22 in the upper position, the transistors 23, 24 are connected in a conventional flip-flop circuit providing an output on the lines 29, 30 continuously changing between the current and no current conditions. The photocell 19 is connected in the base bias circuit of the transistor 23 so that when light to the cell is interrupted, the flip-flop circuit stops operating and remains in the signal blocking condition.

The preferred circuitry for the control unit described above is simple, dependable and utilizes all solid state devices. It is understood, of course, that other circuit arrangements, including vacuum tubes and the like, may be utilized to provide the same control function between the tone interrupter and the keyer.

The preferred form of the keyer 11 is shown in FIG. 2 and includes a network having a shunt resistor 31, a series photocell 32, another shunt resistor 33, and another series photocell 34. The photocells 32, 34 are variable impedance devices having a relatively low resistance when exposed to light and a relatively high resistance when no light is impinging thereon. The resistance values of the photocells and the shunt resistors are selected so that when the photocells are in their high resistance state, the impedance of the network will be sufficiently high to prevent signal transmission from the oscillator 10 to the attenuator and beyond.

A lamp 35 is mounted in the keyer adjacent the photocells so that light from the lamp will fall on the photocells, the components ordinarily being enclosed in a light tight case so that stray light will not affect the operation of the unit. The lamp 35 is energized from the control unit 17 through the lines 29, 30 so that when there is a current output from the control unit the lamp will produce a large amount of light directed onto the photocells which, in turn, will be in their low impedance condition passing signal transmission from the oscillator. Conversely, when there is no current output from the control unit, the lamp will be extinguished and the photocells will be in their high impedance condition, blocking signal transmission from the oscillator to the attenuator and the output system.

The rise and decay characteristics of the audio signals are of significance in many hearing tests and, therefore, it is desirable that these be controlled in an audiometer. The impedance of the keyer and, hence, the signal magnitude is directly related to the intensity of light falling on the photocells in the keyer. The increase and decrease characteristic of the current to the lamp 35 may be controlled by varying the time constant of the output amplifier with the transistor 26, as by insertion of a capacitor 36 of a particular capacitance between the emitter and

base of the transistor 26. Also, the rise and decay of the audio signal can be controlled by selecting a lamp having a particular heating and cooling characteristic of the filament, the light intensity of the lamp being a function of the filament temperature. Since the desired audio rise and decay characteristics have relatively large time constants, it has been found that the use of an incandescent filament lamp in the keyer eliminates the requirement for a large capacitance in the control unit, so that the lamp serves both as an on-off control for the keyer and also provides the desired rise and decay characteristics for the audio signal.

It is understood that only a single photocell or more than two cells may be used in the keyer where the impedance requirements of the circuit so dictate.

The attenuator 12 is similar in design and operation to the keyer 11, but is operated as a variable impedance device rather than as an on-off device. The attenuator may have a network including a shunt resistor 40, a series photocell 41, a shunt resistor 42 and a series photocell 43 similar to that of the keyer. A lamp 44 serves as a light source for exciting the photocells and means may be provided for varying the intensity of radiation from the lamp to the photocells. Two possible controls are shown in the figure. A potentiometer 45 may be coupled across a battery 46 which provides the power for energizing the lamp, the arm 47 of the potentiometer serving as a control for the lamp current and, therefore, the radiation intensity. Alternatively, a moving vane 48 may be positioned between the lamp and the photocells with the vane being movable from a position blocking all light from the lamp to the photocells for the maximum attenuation condition to a position permitting minimum radiation from the lamp to the photocells for the maximum attenuation condition. Other means for controlling the intensity of light impinging on the photocells may be used if desired. The potentiometer arm 47 or the vane 48 may be provided with detents over the movable range to provide fixed amounts of attenuation for use by the operator during the hearing examination.

The audiometer of the invention is operated as follows: the instrument is turned on, the oscillator is switched to the frequency at which the test is to be carried out and the calibrator is adjusted for this particular frequency. The switch 22 is moved to the desired position, say the intermediate or normally off position and the headset is adjusted on the patient. Then the operator turns the sound off and on as desired by moving his hand or a card between the light source 18 and the photocell 19 of the tone interrupter. The operator also varies the magnitude of the sound by varying the attenuator as desired. Both the off-on and the attenuation are controlled without producing any audible clicks and without switching of circuitry which would introduce electrical noise into the instrument. Such noises are uncomfortable to the patient and also provide hints as to when the instrument settings are being changed and, for these reasons, are highly undesirable. Furthermore, there being no mechanically moving parts or switch contacts, wear with normal use is not a factor in the accuracy of the instrument.

Although an exemplary embodiment of the invention has been disclosed and discussed, it will be understood that other applications of the invention are possible and that the embodiment disclosed may be subjected to various changes, modifications and substitutions without necessarily departing from the spirit of the invention.

I claim as my invention:

1. In an audiometer, the combination of: a continuously running audio oscillator having substantially constant amplitude output; an audio output circuit including a calibrator unit, a power amplifier and an audio transducer; a keyer unit and a variable attenuator unit connected in series between said oscillator and output circuit for controlling signal transmission therebetween,

said keyer unit having a high impedance condition for blocking signal transmission and a low impedance condition permitting signal transmission, said keyer unit including a first variable impedance photocell for controlling the impedance of said unit, said attenuator unit including a second variable impedance photocell for varying the impedance of said unit; a first light source directed to said first photocell; a second light source directed to said second photocell; a keyer control unit coupled to said first light source for energizing same, said control unit including a third photocell having an impedance which varies as a function of the light directed thereon to vary the output of said control unit; a third source of light directed to said third photocell along a manually interruptible path to vary the impedance of said third photocell for varying the output of said control unit and changing the impedance of said keyer unit between said high and low impedance conditions; and means for varying the intensity of light from said second source impinging upon said second photocell to vary the magnitude of signal transmitted between said oscillator and output circuit.

2. In an audiometer, the combination of: a continuous running audio oscillator having substantially constant amplitude output; an audio output system including a calibrator unit, a power amplifier and an audio transducer; an output keyer and a variable attenuator serially connected between said oscillator and said output system, said keyer having a high impedance condition for blocking signal transmission between said oscillator and output system and a low impedance condition permitting signal transmission between said oscillator and output system, said keyer including a first variable impedance photocell for controlling the impedance of said keyer; a light source directed to said first photocell; a keyer control unit for energizing said source, said control unit including a second photocell having an impedance which varies as a function of the light directed thereon to switch the output of said control unit between current and no current states; and means for directing light onto said second photocell.

3. In an audiometer, the combination of: a continuous running audio oscillator having substantially constant amplitude output; an audio output circuit including a calibrator unit, a power amplifier and an audio transducer; a keyer unit and a variable attenuator serially connected between said oscillator and said output circuit, said keyer having an off condition for blocking signal transmission between said oscillator and output circuit and an on condition permitting signal transmission between said oscillator and output circuit; a keyer control unit coupled to said keyer unit for changing said keyer to said off and on conditions, said control unit including a photocell having an impedance which varies as a function of the light directed thereon to vary the output of said control unit; and means for directing light onto said photocell.

4. In an audiometer, the combination of: an audio oscillator; an audio output system; an output keyer connected between said oscillator and output system, said keyer having a high impedance condition for blocking signal transmission between said oscillator and output system and a low impedance condition for permitting signal transmission between said oscillator and output system, said keyer including a first variable impedance photocell for controlling the impedance of said keyer; a light source directed to said first photocell; a keyer control unit for energizing said source, said control unit including a second photocell having an impedance which varies as a function of the light directed thereon to switch the output of said control unit between current and no current states; and means for directing light onto said second photocell.

5. In an audiometer, the combination of: an audio oscillator; an audio output circuit; a keyer unit and

a variable attenuator unit connected in series between said oscillator and output circuit for controlling signal transmission therebetween, said keyer unit having a high impedance condition for blocking signal transmission and a low impedance condition permitting signal transmission, said keyer unit including a first variable impedance photocell for controlling the impedance of said unit, said attenuator unit including a second variable impedance photocell for varying the impedance of said unit; a first light source directed to said first photocell; a second light source directed to said second photocell; a keyer control unit coupled to said first light source for energizing same, said control unit including a third photocell having an impedance which varies as a function of the light directed thereon to vary the output of said control unit; means for directing light onto said third photocell; and means for varying the intensity of light from said second source impinging on said second photocell.

6. In an audiometer, the combination of: an audio oscillator; an audio output circuit; a keyer unit connected between said oscillator and said output circuit, said keyer unit having an off condition for blocking signal transmission between said oscillator and output circuit and an on condition for permitting signal transmission between said oscillator and output circuit; a keyer control unit for changing said keyer to said off and on conditions, said control unit including a photocell having an impedance which varies as a function of the light directed thereon to vary the output of said control units; and means for directing light onto said photocell.

7. In an audiometer, the combination of: an audio oscillator; an audio output circuit; a keyer unit connected between said oscillator and said output circuit, said keyer unit having an off condition for blocking signal transmission between said oscillator and output circuit and an on condition permitting signal transmission between said oscillator and output circuit; a keyer control unit coupled to said keyer unit for changing said keyer unit to said off and on conditions, said control unit including a photocell having an impedance which varies with the function of the light directed thereon to vary the output of said control unit, said control unit having a first possible output which changes said keyer unit to the off condition when the impedance of said photocell increases and a second possible output which changes said keyer unit to the on condition when said impedance increases, said control unit including selector means for selecting one of said outputs for coupling to said keyer unit; and means for directing light onto said photocell.

8. In an audiometer, the combination of: an audio oscillator; an audio output circuit; a keyer unit connected between said oscillator and said output circuit, said keyer unit having an off condition for blocking signal transmission between said oscillator and output circuit and an on condition permitting signal transmission between said oscillator and output circuit; a control unit coupled to said keyer unit providing a current and a no current output for changing said keyer unit to said off and on conditions, said control unit including a photocell having an impedance which varies as a function of the light directed thereon to switch said output of said control unit between current and no current states; and means for directing light onto said photocell.

9. In an audiometer, the combination of: an audio oscillator; an audio output system; a variable impedance circuit connected between said oscillator and said output system for controlling signal transmission from said oscillator to said output system, said circuit including a variable impedance photocell; a source of light directed to said photocell; and means for controlling the intensity of light impinging on said cell and thereby

controlling signal transmission between said oscillator and output system.

10. In an audiometer, the combination of: an audio oscillator; an audio output system; an output keyer connected between said oscillator and said output system, said keyer having a high impedance condition for blocking signal transmission between said oscillator and output system and a low impedance condition permitting signal transmission between said oscillator and output system, said keyer including a variable impedance photocell for controlling the impedance of said keyer; a light source directed to said photocell; and a control unit for energizing said source.

11. In an audiometer, the combination of: an audio oscillator; an audio output system; an output keyer connected between said oscillator and output system, said keyer having a high impedance condition for blocking signal transmission between said oscillator and output system, and a low impedance condition permitting signal transmission between said oscillator and output system, said keyer including a variable impedance photocell for controlling the impedance of said keyer; an incandescent filament lamp directed to said photocell, said filament having a heating characteristic such that the light output of said lamp increases following application of current substantially the same as a predetermined time constant; and a control unit for switching the current to said lamp between off and on conditions.

12. In a control circuit for an audiometer or the like having an electrical signal source and an output system, the combination of: an output keyer connected between the electrical signal source and the output system, said keyer including a pair of L sections, each with an arm connected in series with said signal and an arm connected in shunt with said signal and with a variable resistance photocell in each series arm and a resistor in each shunt arm; a light source directed to said photocells; and means for energizing said light source.

13. In a control circuit for an audiometer or the like having an electrical signal source and an output system, the combination of: a signal attenuator for connecting between the electrical signal source and the output system, said signal attenuator including a variable impedance photocell for varying the impedance of said attenuator and thereby the signal transmitted from the source to the output system; a light source directed to said photocell; and means for varying the intensity of light impinging on said photocell.

14. In a control circuit for an audiometer or the like having an electrical signal source and an output

system, the combination of: an impedance network for connecting between the electrical signal source and the output system, said network including a photocell having an impedance variable between maximum and minimum values for varying the impedance of said network between maximum and minimum values thereby varying the signal transmission from the source to the output system between a maximum and substantially zero; a light source directed onto said photocell; and means for controlling said light source to direct zero and a maximum light value on said photocell.

15. In an audiometer, the combination of: an audio oscillator; an audio output circuit; a keyer unit and a variable attenuator unit connected in series between said oscillator and output circuit for controlling signal transmission therebetween, said keyer unit having a high impedance condition for blocking signal transmission and a low impedance condition permitting signal transmission, said keyer unit including a first variable impedance photocell for controlling the impedance of said unit, said attenuator unit including a second variable impedance photocell for varying the impedance of said unit; a first light source directed to said first photocell; a second light source directed to said second photocell; and means for varying the intensity of light from each of said sources impinging on the corresponding photocell.

16. In a control circuit for an audiometer or the like having a source and an output system, the combination of: an output keyer connected between the source and output system, said keyer having off and on conditions for blocking and permitting signal transmission between the source and output system; and a keyer actuator unit coupled to said output keyer in driving relationship, said actuator unit having first and second amplifier stages interconnected to provide an output from said second stage inverse to the output from said first stage and having means for connecting a variable input to said first stage and selecting the outputs of said first and second stages for driving said keyer between said off and on conditions as a function of said variable input and for connecting the output of said second stage as an input of said first stage to provide an oscillating output for driving said keyer between said off and on conditions.

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