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AN AUTOMATIC FOUR-POSITION SPOT BRIGHTENER

by

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Abstract

An automatic 4-position spot brightener is designed for a short-periodic seismograph to increase the recording efficiency. The degree of the brightening effect depends on the spot velocity. The device is stable in operation and comparatively simple in construction.

Introduction

The difficulties experienced in photographic recording are well-known in seismology. The beam of light deflected by the galvanometer has a wide range of deflection velocities, and the times during which the area elements of the photo-sensitive recording paper are illuminated vary accordingly. In a typical short-periodic seismograph installation an under-exposure during an earthquake may be a hundredfold or more. The whole record will be rendered invisible except occasionally at the turning points.

A specially shaped slit, placed into the path of the beam of light, is often used to increase the intensity. A spot brightener with one brightening step has been also designed (DE BREMAECKER, MICHEL [1]). Systematic overexposure, largely used, might prevent the failure, but the scatter effects arising in the light projecting system will become visible and cause a very broad trace masking the smaller deflections. A perfect record could only be achieved by varying the light flux of the recording lamp in the correct proportion to the instantaneous spot velocity.

However, the range of light fluxes available from any incandescent lamp is not likely to satisfy all the conditions incident to seismic recording. The lower limit of the filament temperature of the lamp is set to a certain permissible minimum value of radiation over the photographic band of light wavelengths, while the upper limit is determined by the permissible filament evaporation. The lower the working temperature of the filament, the wider the range.

Most earthquakes are not large, and considerable improvement is obtainable with the arrangement described in this paper, which gives a brightening ratio of the order of 1:30.

Description of the equipment

A relatively large-wattage lamp is taken to serve as the recording lamp. It is a standard 6V 15W automobile bulb, but must have a symmetrical spiral. With the aid of a slit, adjustable in width and position, a very satisfactory focusing is conveniently achieved.

Because the recording is done close to the lower limit of the exposure, any unwanted changes in the lamp power would be harmful. To decrease these effects, a current regulator is used in series with the lamp transformer, as can be seen in the circuit diagram in Fig. 1.

The presence of this constant-current device in the circuit means that any wanted changes in the lamp current must be produced by shunt arrangements. The coupling of the shunt resistors to the other winding of the transformer is accomplished by thyratrons, which can conduct during the positive half-cycles. The grids of the thyratrons are connected

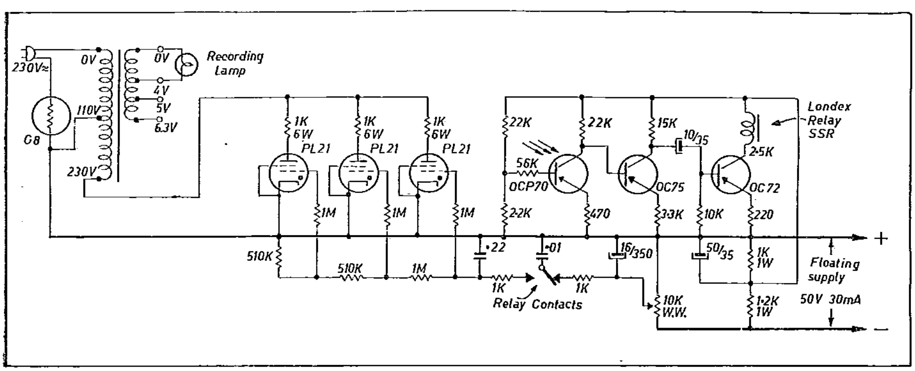

Fig. 1. The circuit diagram of the automatic spot brightener.

to a voltage divider, and the magnitude of the negative bias voltage across the input of the divider network determines the number of cut-off tubes. A gradual change of the thyratron firing angle between 0 and 90° also occurs, causing some gliding effect between the steps.

To produce a voltage proportional to the velocity of the galvanometer deflection, an auxiliary light source is directed to the galvanometer mirror. The vertical image of the spiral filament of the auxiliary lamp is then projected onto a grid with opaque and transparent vertical lines 3 mm in width (RIDER, BRADLEY [2]). Behind the grid, two standard rectangular magnifiers focus the light onto a phototransistor. Red light is used to reduce the stray light effects in the recording room. The phototransistor works well in the red light owing to its spectral response. The set-up is sketched in Fig. 2. The auxiliary light source and receiver are at a distance of approximately 0.5 m from the galvanometer.

As the image of the filament moves across the grid, the relay operates, counting the lines traversed, and the voltage building up across the bias circuit capacitor will be roughly proportional to the spot velocity. The value of the total shunt current decreases if one or more thyratrons are cut off, and the lamp current increases.

The lamp voltage vs. line voltage at the four positions is given in Fig. 3. Three of the four curves turn almost vertical because of the increasing thyratron conduction angle with increasing A.C. plate voltage. The

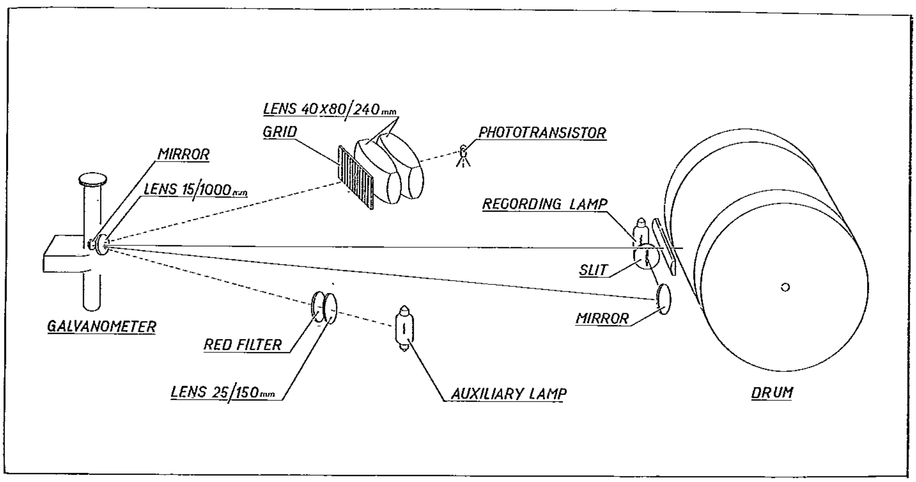

Fig. 2. The set-up of the auxiliary equipment used with the automatic spot brightener.

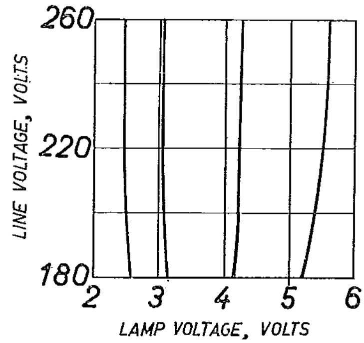

Fig. 3. The lamp voltage vs. line voltage at the four positions.

lamp voltage in the quiescent condition is about 2.5 volts, and the power dissipation of the current regulator is at a maximum. If the line voltage is normal, the voltage across C8 is 85 % of the rated maximum value. A life of more than 2 500 hours has been experienced in such conditions. The regulating range of 80 to 200 volts is completely used for such line voltage variations, as illustrated in the graph.

The maximum attack rate depends on the thermal time constants, while the decay rate is mostly determined by the time constant of the bias circuit.

The grid line spacings, capacitors and D.C. voltage should be in the right proportions. The values given are for a short-periodic installation with a seismometer period of approximately 1 second.

Discussion

This system has been working entirely satisfactorily with the four operational steps which are in good accord with the speed-sensing device. It is improbable that any continuous method of power control could deliver similar stability with such a minimum of components.

Test patterns are shown in Fig. 4, with the spot brightener in and out of operation. The almost complete disappearance was evident in the case when the spot brightener was disengaged.

The system was designed for one 15W recording lamp. Probably three smaller lamps could be operated in parallel in the 3-component seismograph station, or additional power sources used, controlled in parallel. For seismographs of longer periods, the values of the bias circuit capa-

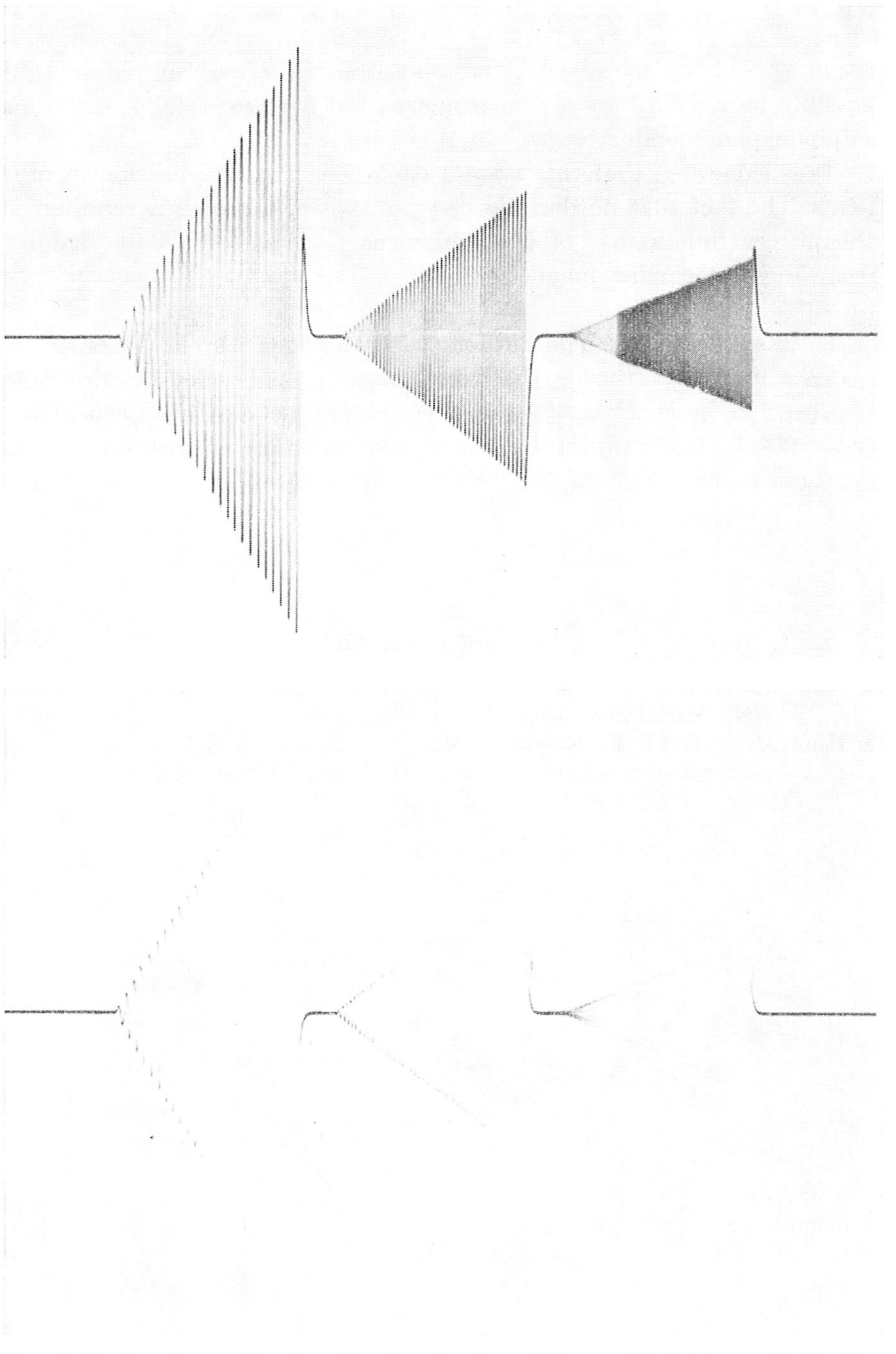

Fig. 4. Test patterns showing the functioning of the spot brightener. Deflection frequencies are 1, 2 and 5 c/s, with maximum excursions of 80, 40 and 20 mm, respectively. The lower set of patterns is achieved with the spot brightener disengaged.

citors should be increased. The phototransistor and amplifier could possibly be replaced by a slow-response, but high-sensitivity, cadmium-sulphide photoconductive cell in this case.

It is suggested that this system could also find application in other fields. The fact that no definite rest position of the spot is required for the proper functioning of the apparatus may also make it useful in recording the earth's magnetic field.

Acknowledgements: The authors wish to thank Dr. E. Vesanen for his encouragement during the work. Also the assistance by Mr. Risto Karttunen in constructing the experimental set-ups has been greatly appreciated. The support by the *State Committee of Natural Sciences* (Valtion Luonnontieteellinen Toimikunta) is gratefully acknowledged.

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