

Oct. 28, 1941.

E. HUDEC

2,260,906

SYSTEM FOR PRODUCING TELEGRAPH SIGNALS

Filed Dec. 16, 1937

4 Sheets-Sheet 1

Fig. 1

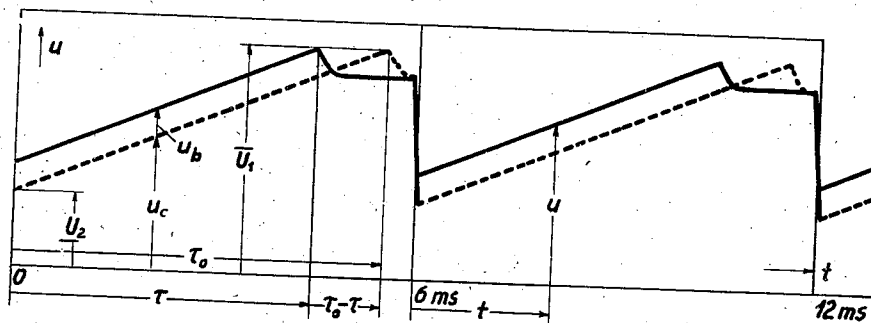
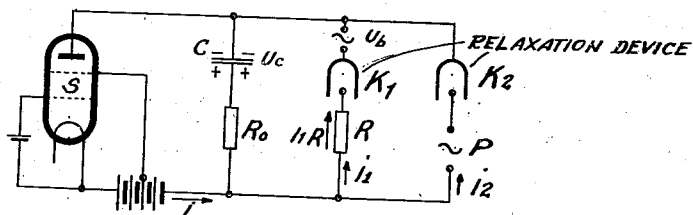


Fig. 2a

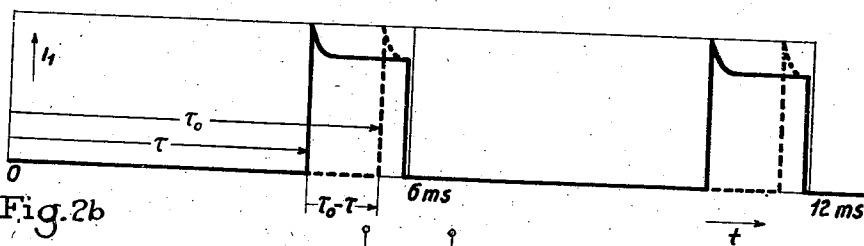


Fig. 2b

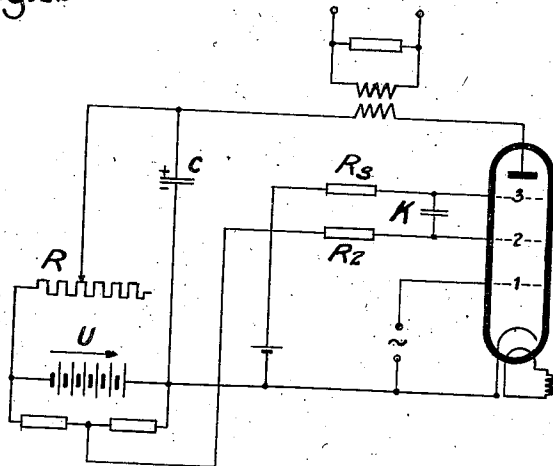


Fig. 4

Inventor:

Erich Hudec

Oct. 28, 1941.

E. HUDEC

2,260,906

SYSTEM FOR PRODUCING TELEGRAPH SIGNALS

Filed Dec. 16, 1937

4 Sheets-Sheet 2

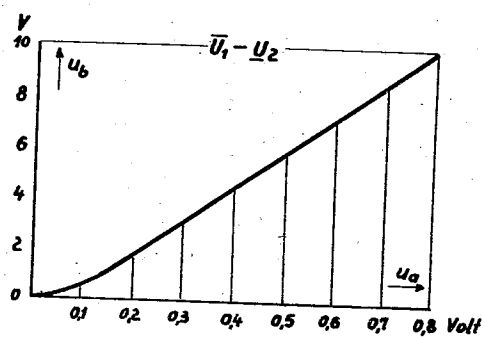


Fig. 3a

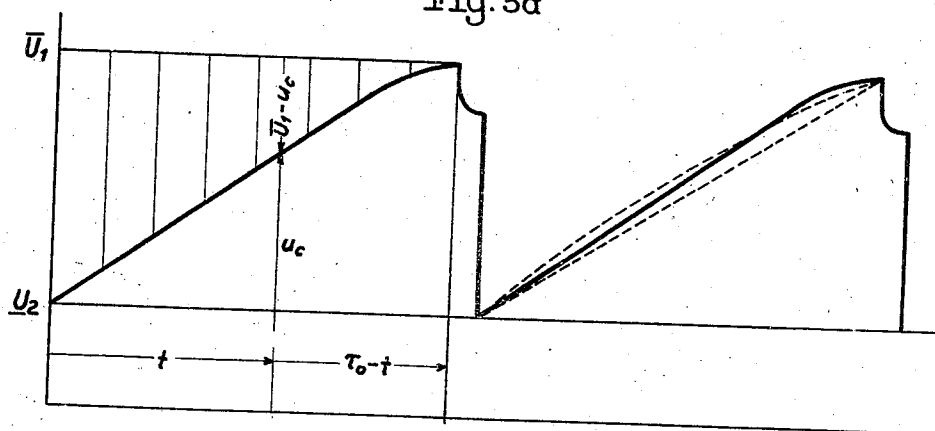


Fig. 3b

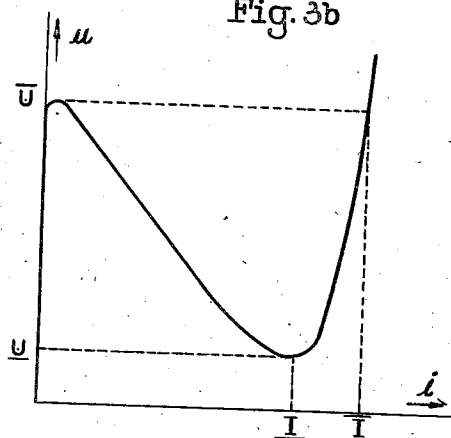


Fig. 9

Inventor:

Erich Hudec

Oct. 28, 1941.

E. HUDEC,

2,260,906

SYSTEM FOR PRODUCING TELEGRAPH SIGNALS

Filed Dec. 16, 1937

4 Sheets-Sheet 3

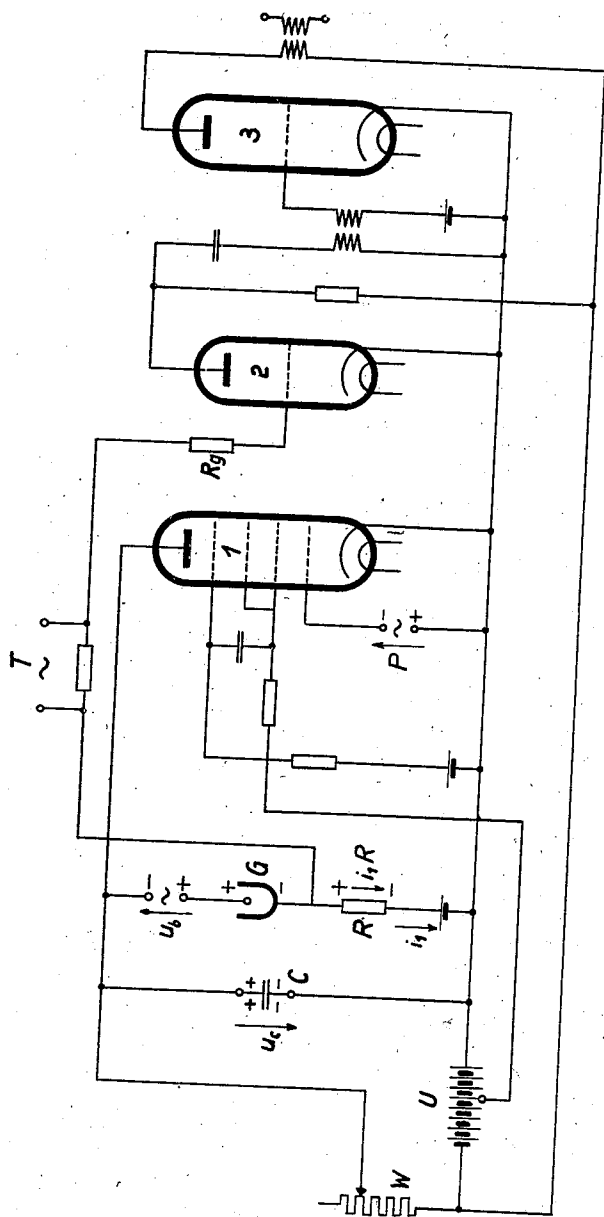


Fig. 5

Inventor:

Erich Hunter

Oct. 28, 1941.

E. HUDEC

2,260,906

SYSTEM FOR PRODUCING TELEGRAPH SIGNALS

Filed Dec. 16, 1937

4 Sheets-Sheet 4

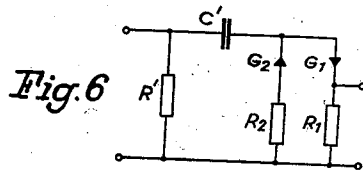


Fig. 7a

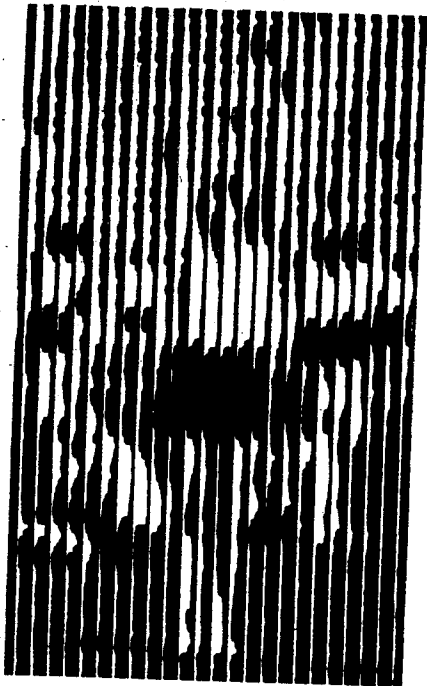


Fig. 7b



Fig. 8a

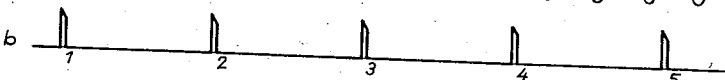
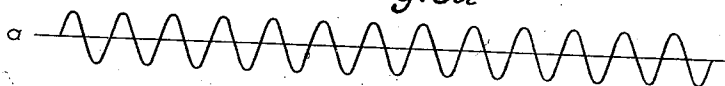


Fig. 8b



Fig. 8c

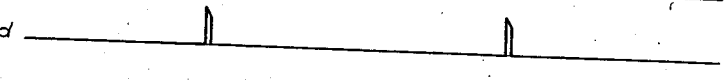


Fig. 8d

Inventor:

Eric Hudec

UNITED STATES PATENT OFFICE

2,260,906

SYSTEM FOR PRODUCING TELEGRAPH SIGNALS

Erich Hudec, Berlin, Germany

Application December 16, 1937, Serial No. 180,146
In Germany December 23, 1936

6 Claims. (Cl. 178—7.1)

This invention relates to telegraphy, phototelegraphy and more especially to photoradio methods and apparatus.

For photoradio transmission on short waves the pictures are screened, i. e. are made up of black dashes of different length dependent on the light intensity of the original picture.

According to the Ranger "Shore and Whitaker" method dashes of different length are produced electrically at the transmitting station by a regenerative resistance amplifier which is controlled by a saw tooth wave form voltage. At a certain value U_1 of this control voltage the amplified current increases suddenly to a high value and retains almost this value as long as the control voltage exceeds the value U_1 . When the voltage becomes smaller than U_1 , the amplified current decreases suddenly to the small value at the outset.

In this way telegraph signals are produced the length of which depends on the value U_1 and the amplitude of the control voltage. By adjustment of a suitable bias the length of the telegraph signals can be altered. If the bias becomes more positive, the telegraph signal begins earlier and ceases later. As the control voltage has a saw tooth wave form the length of the signals is proportional to this bias.

If the image voltage produced in the phototube is employed as a bias the length of the telegraph signals is proportional to the image voltage. If the light intensity of the original picture increases, the telegraph signals become shorter by beginning later and ceasing earlier.

An object of my invention is to produce telegraph signals the length of which is only varied by altering the beginning or the end.

Another object of my invention is to produce telegraph signals the length of which is exactly proportional to the light intensity reflected from the picture or to the light intensity absorbed by the picture.

Another object of my invention is to provide means for producing a crossed pattern as is generally used for the printing of pictures in newspapers.

The term "relaxation device" used in this specification refers to any device having a characteristic according to Fig. 9. If the voltage u acting on such a device is increased, the current i will be zero or at least very small until the voltage exceeds the upper relaxation potential $\bar{U}$. At this moment the current will increase suddenly to the value $\bar{I}$.

If the voltage is now decreased, the current remains rather large until the voltage becomes smaller than the lower relaxation potential $\underline{U}$. At this moment the current $\underline{I}$ will be cut off or at least be diminished to a much smaller value.

According to my invention telegraph signals are produced by means of a control potential in proportion to the length of the signals. This control potential and the potential of a condenser, being charged by a direct current source by way of a resistance or an electronic tube, are acting on a relaxation device which becomes conductive whenever the total of the condenser potential and the control potential exceeds the upper relaxation potential. The condenser is discharged at equal intervals of time either by the said relaxation device the resistance of which can be decreased by altering the potential of a grid or by another parallel connected relaxation device. The current flowing through the first relaxation device is interrupted whenever the condenser is discharged by way of the second relaxation device which is caused to relax by screen impulses at equal intervals of time. The screen impulses are controlled by the same constant frequency as the drum of the picture scanning machine. The screen frequency is selected to be so great that for one revolution of the drum there are n complete $\pm$ one half screen periods. In another feature of my invention the screen frequency is equal to an integral multiple of the number of revolutions/sec. of the drum. In this case the second relaxation device is controlled by screen impulses which are displaced to the extent of one-half of a screen period whenever a new line of the picture commences to be scanned.

In the accompanying drawings, embodiments of my invention are illustrated diagrammatically.

Fig. 1 shows a diagram of the device for producing the telegraph signals.

Fig. 2 shows the voltage at the condenser C and at the resistance R_0 .

Fig. 3 shows the demodulated image voltage as produced in the phototube and the voltage of the condenser C for compensating the demodulation error.

Fig. 4 shows a device for producing the screen impulses.

Fig. 5 shows the device for producing telegraph signals for transmitting pictures on short waves.

Fig. 6 shows a device for decreasing the duration of the screen impulses.

Fig. 7a shows an enlarged picture with a line structure produced by a device according to Fig. 5.

Fig. 7b shows the same picture having a dotted structure.

Fig. 8a shows the synchronizing frequency.

Figs. 8b-d show screen impulses for producing pictures having a dotted structure.

Fig. 9 shows the characteristic of a relaxation device adapted for use in a system in accordance with the invention.

Referring to Fig. 1 of the drawings, C is a condenser charged with constant current by way of the screening grid tube S; its potential increases proportional to the time.

In parallel with the condenser there are two relaxation devices K₁ and K₂. The upper relaxation potential ($\bar{U}_2$) of K₂ is greater than the upper relaxation potential ($\bar{U}_1$) of K₁; the lower relaxation potential ($\underline{U}_2$) of K₂ is smaller than the lower relaxation potential ($\underline{U}_1$) of K₁: $\bar{U}_2 > \bar{U}_1$, $\underline{U}_2 < \underline{U}_1$.

The relaxation device K₂ is caused to relax at equal intervals (6 ms.) by short screen impulses p. In this way the condenser C is rapidly discharged down to the lower relaxation potential $\underline{U}_2$.

In the next screen period the condenser is charged in proportion to the time from the lower relaxation potential $\underline{U}_2$ of K₂ until its potential reaches the upper relaxation potential $\bar{U}_1$ (compare the broken-line curve in Fig. 2a). K₁ is then suddenly traversed by a current, and the potential at the condenser C drops until the current i_1 flowing by way of K₁ is equal to the charging current i (compare Fig. 1). The charging current, the dimensions of the relaxation device K₁ and the resistance R are accordingly so chosen that the condenser C cannot be discharged by way of K₁ down to the lower relaxation potential of K₁.

The current i_1 traversing the relaxation device K₁ produces at the resistance R a drop of potential $i_1 R$. It occurs at the moment of relaxation of K₁, and endures for such time until the condenser C at the end of the screen period has been discharged by way of K₂ to the lower relaxation potential of K₂. $i_1 R$ then suddenly returns to zero. This drop of potential supplies the rectangular telegraph signals which are necessary for image transmission on short waves (compare Fig. 2b, the broken-line curve for i_1).

The charging current i is so adjusted by a suitable grid bias of the tube S that the upper relaxation potential of K₁ is reached just prior to the end of the screen period. The duration of the drop of potential $i_1 R$ at the resistance R then amounts for example to 5% of the screen period. This case is illustrated by the broken-line curve in Fig. 2.

The photo telegraph signals, in accordance with Fig. 1, are varied in their length (at the resistance R) by the image potential u_b acting in series with the condenser potential u_c on the relaxation device K₁. The total potential u at K₁ (compare Fig. 2, the full-line curve) is accordingly

$$\begin{aligned} u &= u_b + u_c \\ &= u_b + \underline{U}_2 + \frac{1}{C} \int_0^t i \, dt \\ &= u_b + \underline{U}_2 + \frac{1}{C} I \cdot t \end{aligned}$$

The potential u at K₁ is shown in Fig. 2a by the full line curvature. u begins with the potential $\underline{U}_2 + u_b$, where $\underline{U}_2$ is the lower relaxation potential of K₂ and increases proportionally to

time (t) until the upper relaxation potential $\bar{U}_1$ of K₁. Then a current i_1 according to Fig. 2b begins to flow through K₁ and the resistance R, so that the potential u in Fig. 2a decreases. As soon as the current i_1 is equal to the current i in Fig. 1, the potential u remains constant till the end of the screen period ($t=6$ ms. in Fig. 2a), when the condenser C is discharged to the lower relaxation potential $\underline{U}_2$ of K₂.

If the time required for reaching the upper relaxation potential $\bar{U}_1$ of K₁ is designated τ , there results

$$\bar{U}_1 = u_b + \underline{U}_2 + \frac{1}{C} I \cdot \tau$$

or

$$\tau = \frac{(\bar{U}_1 - \underline{U}_2) \cdot C}{I} - \frac{C}{I} u_b$$

for $u_b=0$ there is

$$\tau_0 = \frac{(\bar{U}_1 - \underline{U}_2) \cdot C}{I}$$

This time τ_0 is illustrated by the broken line curve in Fig. 2a. According to the last two equations:

$$\tau_0 - \tau = \frac{I}{C} u_b$$

$\tau_0 - \tau$ in accordance with Fig. 2 is the increase in the duration of the drop of potential at R. This increase is proportional to the image current. The drop of potential at R is accordingly the desired photo telegraph potential.

In Fig. 3a there is shown the error occurring when the output of the picture scanning device is demodulated. u_a is the carrier output of the picture scanning device modulated by the image voltage produced in the phototube, u_b is the demodulated image voltage. As a result of this curvature the differences of light intensity in the dark parts of the picture are reproduced too weakly or are not reproduced at all.

This error is completely compensated if, according to Fig. 3b, the condenser potential is allowed to increase. In the black parts of the picture a very small image potential u_b will cause the photo telegraph signals to increase on a relatively large scale, so that the length of these signals is always proportional to the carrier output of the picture scanning device. This curvature can be approximately realised if the condenser is charged through a suitable electronic tube or, more simply, through a resistance. The course of the potential of the condenser when charged through a resistance is indicated in broken lines in Fig. 3b.

This curvature corresponds still more to the ideal course shown by the full line in Fig. 3b if the control range of the rectifier characteristic is suitably adjusted.

In Fig. 3b there is also shown in the dotted line the curvature of the condenser potential increasing proportionally to time according to Fig. 2.

In order that the screen dashes will have the same position in every line the screen frequency must be synchronous with the synchronizing frequency by which the drum of the picture scanning machine is controlled. The synchronizing frequency is e. g. 1000 cycles/sec. By this frequency or by a subharmonic of it the motor (tone wheel) of the drum is controlled. The screen frequency is a subharmonic of 1000 cycles/sec. or of a multiple of 1000 cycles/sec., e. g.

125 c./s. = 1/8.1000 c./s. or 150 c./s. = 1/20.3000 c./s.

The screen frequency is preferably produced with the aid of enforced relaxation oscillations.

A relaxation device for generating the screen impulses is illustrated in Fig. 4. The condenser K is charged by the battery U through the resistance R up to the upper relaxation potential of the single-tube relaxation device which comprises the valve with three grids 1, 2, 3, two resistances R₂ and R₃ and a condenser K, and is then rapidly discharged through its anode circuit. As long as the potential of the condenser K is smaller than the upper relaxation potential, a constant current i_2 is flowing across the space charge grid 2 in Fig. 4, while the plate current is zero. When the potential of the condenser exceeds the upper relaxation potential, a very small current begins to flow and therefore the space current i_2 and the negative potential $i_2 R_2$ at the resistance begin to decrease and the grid 3 coupled to this potential by the condenser K and the resistance R₃ becomes more positive. Therefore the current i_2 and the potential $i_2 R_2$ decrease further, the grid becomes more positive, etc.

By this reaction the current i_2 is suddenly reduced to a much smaller value and the plate current is suddenly cut in. The condenser K will be discharged by this current down to the lower relaxation potential. At this moment the plate current will be cut out, the condenser K will be charged again and the whole process will be repeated periodically.

The grid in Fig. 4 is controlled by the synchronizing frequency, which is e. g. 1000 cycles/second. Whenever the condenser K is discharged, an impulse is produced at the output of the transformer in Fig. 4.

In Fig. 5 there is shown an embodiment of my invention for generating telegraph signals from an amplitude-modulated image current. The first part of Fig. 5, including the tube 1, corresponds to Fig. 1, with the exception that the tube S in Fig. 1 is replaced by the resistance W in Fig. 5, in order to decrease the demodulation error. As K₁ there is employed a glow lamp G, as second relaxation device the single-tube relaxation device according to Fig. 4. When the total of the condenser potential u_c and the demodulated image potential u_b is equal to the ignition potential of the glow lamp,

$$u_c + u_b = \bar{U}_1$$

a current suddenly commences to traverse the same, and there results at the resistance R a drop in potential $i_1 R$ of several volts, dependent on its size. This drop in potential continues to endure for such time until the single-tube relaxation device becomes transmissive by the screen impulses p at the end of the screen period and suddenly discharges the condenser C down to its lower relaxation potential U_2 . The glow lamp is then extinguished, $i_1 R$ returns to zero and retains this value for such time until the glow lamp again ignites.

The impulses generated by the device according to Fig. 4 can be directly employed as screen impulses for controlling the single-tube relaxation device. It is to be observed, however, that not only the upper relaxation potential but also, to a smaller extent, the lower relaxation potential is dependent on the potential of the control grid. The condenser C in Fig. 5 would accordingly be discharged to varying extent dependent on the particular size of the screen impulses. Therefore the duration of the screen impulses is so decreased that they merely initiate the discharge of the

condenser C, i. e., they merely affect the upper relaxation potential and not the lower relaxation potential.

This can be realised according to Fig. 6 by charging a condenser C' by the screen impulses through a sufficiently small resistance R'. By suitable selection of the time constant R'C' very short impulses can be produced at the resistance. As however the condenser is again discharged at the end of the control impulse a short negative current impulse, which is opposed to the short impulse at the beginning of the control impulse, passes through the resistance R'.

This reaction impulse is rendered ineffective by charging the condenser C' through a resistance R₁ and a plate rectifier G₁, and discharging it through another resistance R₂ and another plate rectifier G₂. The impulses at the resistance R₁ are very short and very well suited for controlling the relaxation device according to Fig. 5.

Since the telegraph signals cannot be directly transmitted over a line, the carrier frequency T is modulated by the telegraph signals with the aid of the modulation tube 2 in Fig. 5. For the duration of the telegraph signal amplified carrier frequency is transmitted over the line by the amplifying tube 3; during the interval it is interrupted.

The pictures obtained by the device according to Fig. 5 are made up by a line screen according to Fig. 7a. In order to produce a crossed screen according to Fig. 7b, such as generally employed for stereotype plates in the printing art, it is necessary to select the number of screen periods for one revolution of the drum to be equal to an integral number $n \pm \frac{1}{2}$.

This screen frequency must be synchronous to the synchronizing frequency (e. g. 1000 cycles/sec.) and can be obtained by frequency division and multiplication.

If the synchronizing frequency is e. g. $f_1 = 1000$ cycles/sec., by means of forced relaxation oscillations a lower frequency is produced which is an odd number and synchronous with the synchronizing frequency, e. g. $f_2 = 1000/8 = 125$ c./s. There is selected a higher harmonic of this partial frequency, which is nearest the index cooperation, for example $f_3 = 7 \times 125 = 875$ c./s. From this frequency the screen frequencies are produced by means of forced relaxation oscillations. If the number of revolutions per second is $1/n$ (e. g.: $1/2, 1/3$) the screen frequency is $875/2n$ (e. g. $218 \frac{3}{4}, 145 \frac{5}{6}$) c./s.

The screen frequency is preferably so selected that the dot pattern of the transmitted picture is quadratic when the light intensity amounts to 50 pc. (See Fig. 7b left upper corner.) Therefore the frequency f_3 must be so selected that it is nearest the index of cooperation. If e. g. the circumference of the drum is 8.5 inches and the number of lines 100 per inch, the index of cooperation is $8.5 \times 100 = 850$.

Another method of producing a crossed screen consists in controlling the tube relaxation device in Fig. 5 by screen impulses which are displaced to the extent of one-half of a screen period between one image line and the next as shown in Fig. 8c and d. This can be realised by the relaxation device according to Fig. 4 controlling a second completely similar relaxation device so that it oscillates with one-half of the frequency of the first device. For controlling the single-tube relaxation device in Fig. 5 there are employed alternately the screen impulses of this second relaxation device alone as shown in Fig. 8c and a counter-connection made up of these screen im-

pulses (Fig. 8c) and the screen impulses of the first relaxation device as shown in Fig. 8b.

The method described is not limited to photo telegraphy, but can be employed for other purposes, for example for high-speed telegraphy on short waves.

I claim as my invention:

1. A system for producing telegraph signals comprising a condenser; a direct-current source for charging said condenser; a first relaxation device, a resistance, and a source of control potential all connected in series with said condenser; a second relaxation device connected in parallel relation to said condenser; the upper relaxation potential of said first relaxation device being smaller than the upper relaxation potential of said second relaxation device, and the lower relaxation potential of said first relaxation device being greater than that of said second relaxation device; and means coupled to said second relaxation device for producing impulses at substantially equal intervals of time, said impulses causing said second relaxation device to relax, thereby to discharge said condenser.

2. A system for producing telegraph signals comprising a condenser; a direct-current source for charging said condenser; a first relaxation device, a resistance, and a source of control potential all connected in series relation with said condenser; a second relaxation device connected in parallel relation to said condenser; the upper relaxation potential of said first relaxation device being smaller than the upper relaxation potential of said second relaxation device, and the lower relaxation potential of said first relaxation device being greater than that of said second relaxation device; and a third relaxation device coupled to said second relaxation device and adapted to be controlled by a constant-frequency signal for producing impulses at substantially equal intervals of time, said impulses causing said second relaxation device to relax, thereby to discharge said condenser.

3. A system for producing telegraph signals comprising a condenser; a resistance; a direct-current source for charging said condenser by way of said resistance; a first relaxation device, a resistance, and a source of control potential all connected in series relation with said condenser; a second relaxation device connected in parallel relation to said condenser; the upper relaxation potential of said first relaxation device being smaller than the upper relaxation potential of said second relaxation device, and the lower relaxation potential of said first relaxation device being greater than that of said second relaxation

device; and means coupled to said second relaxation device for producing impulses at substantially equal intervals of time, said impulses causing said second relaxation device to relax, thereby to discharge said condenser.

4. A system for producing telegraph signals comprising a condenser; a direct-current source for charging said condenser; a first relaxation device, a resistance, and a source of image potential corresponding to the light intensity of an elemental area of an image, all connected in series relation to said condenser; and a second relaxation device connected in parallel relation to said condenser for discharging said condenser at substantially equal intervals of time; the upper relaxation potential of said first relaxation device being smaller than the upper relaxation potential of said second relaxation device, and the lower relaxation potential of said first relaxation device being greater than that of said second relaxation device.

5. A system for producing telegraph signals comprising a condenser; a direct-current source for charging said condenser; a first relaxation device, a resistance, and a source of image potential corresponding to the light intensity of an elemental area of an image, all connected in series relation to said condenser; a second relaxation device connected in parallel relation to said condenser; the upper relaxation potential of said first relaxation device being smaller than the upper relaxation potential of said second relaxation device, and the lower relaxation potential of said first relaxation device being greater than that of said second relaxation device; and a third relaxation device coupled to said second relaxation device and adapted to be controlled by a constant frequency signal for producing impulses at substantially equal intervals of time, said impulses causing said second relaxation device to relax, thereby to discharge said condenser.

6. A system for producing telegraph signals comprising a condenser; a direct-current source for charging said condenser; a first relaxation device, a resistance, and a source of control potential all connected in series with said condenser; and a second relaxation device connected in parallel relation to said condenser for discharging said condenser at substantially equal intervals of time; the upper relaxation potential of said first relaxation device being smaller than the upper relaxation potential of said second relaxation device, and the lower relaxation potential of said first relaxation device being greater than that of said second relaxation device.

ERICH HUDEC.