Effect of Bending on Selenium Rectifier Disks

BENDING a selenium rectifier disk causes a temporary increase of the current flowing through it in both directions. The effect (discovered in December 1942) is especially pronounced in the reverse direction, where a momentary increase of the current intensity up to 300 per cent and more can be produced through bending by hand, while in the forward direction values exceeding 5–10 per cent have not been observed. With copper oxide rectifiers no trace of a similar effect could be detected. The following, mostly qualitative, observations were made on our own disks, in the reverse direction : (1) The bending causes an increase of the current, whether the selenium layer lies on the convex or on the concave side of the disk. (2) In general, the stronger the bending the greater the effect. (3) The increase of current is, at its maximum, a temporary one. After bending a disk with a constant force, the momentary increased current intensity diminishes in the first few seconds rapidly, then slowly, and reaches its end value after some minutes. The behaviour of the disk is then, within certain narrow limits, that of a biased system : an increase of the bending increases also the current and *vice versa*. (4) Temperature has a pronounced influence ; at 40–50° C., the effect is essentially smaller, and it seems to disappear more rapidly than at room temperature. (5) The effect depends upon the applied voltage. While at small voltages (1–2 volts) no effect is observable, with increasing voltages it increases also rapidly and reaches a maximal value as high as 350 per cent at 15–20 volts with some disks.

Selenium is a typical semi-conductor, its conductivity being due to the faults of the crystalline structure and to the impurities contained in it. Some of these centres are dissociated (into electron holes and negative ions) already in the mechanically finished disks, before forming, and determine the electrical properties of the disk at room temperature and below 1–2 volts. Further ionization—or expressed with modern terminology, transition of electrons to a conductivity-level—can be effected : (*a*) with thermal, (*b*) with electrical, and (*c*) with electrical plus mechanical energy. Thermal ionization goes on with any increase of temperature in the whole selenium layer and causes the temperature coefficient of the conductivity in the forward direction to be positive. Processes (*b*) and (*c*), however, take place only in the blocking layer, where an electrical field strong enough can be produced, thus explaining (*b*) the decrease of reverse resistance with increasing voltages and the phenomenon of 'electrical forming', with respect to (*c*) the bending effect.

In brief, we ascribe the bending effect to the dissociation of the impurity centres under the simultaneous action of electrical field intensity and the shearing stresses, impressed on the selenium layer by the bending. This assumption, together with the phenomenon of plastic relaxation, explains all the observations enumerated above.

Those interested in the new effect are invited to write for free samples of rectifier disks to the address below.

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Transformation of Trichromatic Distribution Curves

The purpose of this communication is to bring to attention a point which does not seem to be generally realized although it is quite simple to prove. If one of a set of three colour-matching stimuli is altered, *the distribution curve for that stimulus is not changed,* though one or both of the other two distribution curves is altered.

Consider a colorimeter in which white is matched by a mixture of one trichromatic unit each of three stimuli X, Y and Z. If some of the stimulus X is transferred from its own beam to the Y beam, we shall have a new primary G; but since the match with white is unaffected, one trichromatic unit each will be present in the new system of X, G and Z. Since one unit of G contains one unit of Y, and also some X, it follows that in matching any colour with a mixture of X, G and Z the same number of units of G will be required as of Y in a mixture of X, Y and Z. The amounts of Z required in the two systems will be the same, though the amounts of X will be different. Therefore, the spectral distribution curve of X will be altered but that of G will remain the same as that of Y.

Let $\bar{x}$, $\bar{y}$ and $\bar{z}$ be the spectral distribution coefficients of stimuli X, Y and Z, and $\bar{r}$, $\bar{g}$ and $\bar{b}$ those of a new set of stimuli, R, G and B, the trichromatic coefficients of which in the X, Y, Z system are u_1, v_1, w_1 ; u_2, v_2, w_2 ; u_3, v_3, w_3 ; where $u + v + w = 1$. Then where

$$\frac{\bar{x}}{\bar{x}+\bar{y}+\bar{z}} = u_1, \quad \frac{\bar{y}}{\bar{x}+\bar{y}+\bar{z}} = v_1 \text{ and } \frac{\bar{z}}{\bar{x}+\bar{y}+\bar{z}} = w_1,$$

the following relations must hold :

$$\frac{\bar{r}}{\bar{r}+\bar{g}+\bar{b}} = 1, \quad \frac{\bar{g}}{\bar{r}+\bar{g}+\bar{b}} = 0, \quad \frac{\bar{b}}{\bar{r}+\bar{g}+\bar{b}} = 0,$$

so that $\bar{g}$ and $\bar{b}$ must both be zero.

$$\text{Similarly, if } \frac{\bar{x}}{u_2} = \frac{\bar{y}}{v_2} = \frac{\bar{z}}{w_2} = \bar{x} + \bar{y} + \bar{z}, \ \bar{r} \text{ and } \bar{b}$$

must both be zero, etc.

If the same white-point is adopted in the two systems, then $\bar{r} = \bar{g} = \bar{b}$ when $\bar{x} = \bar{y} = \bar{z}$; hence we can derive the transformation equations :

$$\bar{r} = \frac{\begin{vmatrix} \bar{x} & \bar{y} & \bar{z} \\ u_2 & v_2 & w_2 \\ u_3 & v_3 & w_3 \end{vmatrix}}{\begin{vmatrix} 1 & 1 & 1 \\ u_2 & v_2 & w_2 \\ u_3 & v_3 & w_3 \end{vmatrix}} ; \quad \bar{g} = \frac{\begin{vmatrix} u_1 & v_1 & w_1 \\ \bar{x} & \bar{y} & \bar{z} \\ u_3 & v_3 & w_3 \end{vmatrix}}{\begin{vmatrix} u_1 & v_1 & w_1 \\ 1 & 1 & 1 \\ u_3 & v_3 & w_3 \end{vmatrix}} ; \quad \bar{b} = \frac{\begin{vmatrix} u_1 & v_1 & w_1 \\ u_2 & v_2 & w_2 \\ \bar{x} & \bar{y} & \bar{z} \end{vmatrix}}{\begin{vmatrix} u_1 & v_1 & w_1 \\ u_2 & v_2 & w_2 \\ 1 & 1 & 1 \end{vmatrix}} .$$

It will be seen that $\bar{r}$ is independent of u_1, v_1 and w_1; that is, of the position of R. If only one, say G of R, G and B, is different from X, Y and Z we have $u_1 = w_3 = 1$, $v_1 = w_1 = u_3 = v_3 = 0$, and the equations reduce to :

$$\bar{r} = \frac{v_2\bar{x} - u_2\bar{y}}{v_2 - u_2} ; \quad \bar{g} = \bar{y} ; \text{ and } \bar{b} = \frac{v\,\bar{z} - w_2\bar{y}}{v_2 - w_2} .$$

Moreover, if G is somewhere on the line XY, so that $w_2 = 0$ and $u_2 = 1 - v_2$, we have :

$$\bar{r} = \frac{v_2\bar{x} - (1-v_2)\bar{y}}{2v_2 - 1} ; \quad \bar{g} = \bar{y} ; \text{ and } \bar{b} = \bar{z}.$$

In other words, altering the green primary alters only the red and blue distribution curves, and if the