volts on the signal grid

Ia be the mean value of the anode current over a positive half cycle of anode volts

μ be the amplification factor of the valve

Ra be the anode A.C. resistance of the value

Now, referring to Figure 2, let ABCDE represent a positive half sinusoid of applied anode voltage extending from $\omega t=0$ to $\omega t=\pi$ radians.

Due to the D.C. fixed negative bias it is obvious that anode current will not flow during the cycle until the instantaneous anode voltage exceeds μeg. Let $\omega t=\theta$ be the point at which anode current starts to flow. Then the anode current will be a function of the curve BCD which is the portion of the cycle during which the anode voltage exceeds μeg.

The average anode current during the half cycle is then given by:—

$$2\times\frac{1}{Ra}\times\left[\frac{\omega}{\pi/2}\int_{t=\frac{\theta}{\omega}}^{t=\frac{\pi}{2\omega}}\hat{\mathcal{E}}\sin\omega t\,dt-(\text{area GBHJ})\right]$$

$$=\frac{2}{Ra}\times\left\{\frac{2\omega}{\pi}\cdot\frac{\hat{\mathcal{E}}}{\omega}\left[-\cos\omega t\right]_{\frac{\theta}{\omega}}^{\frac{\pi}{2\omega}}-(\text{area GBHJ})\right\}$$

$$=\frac{2}{Ra}\left\{\frac{2\hat{\mathcal{E}}}{\pi}(\cos\theta)-(BG\times JH)\right\}$$

$$=\frac{2}{Ra}\left\{\frac{2\hat{\mathcal{E}}}{\pi}\sqrt{1-\sin^2\theta}+\mu Eg\times\left(\frac{\pi}{2}-\theta\right)\right\}$$

$$=\frac{4}{\pi Ra}\times\sqrt{1-\sin^2\theta}\times\hat{\mathcal{E}}+\left(\frac{\pi}{2}-\theta\right)\mu Eg\times\frac{2}{Ra}$$

$$=K_1\hat{\mathcal{E}}\sqrt{1-\left(\frac{\mu\mathcal{E}g}{\hat{\mathcal{E}}}\right)^2}+K_2\mu\mathcal{E}g\left(\cos^{-1}\frac{\mu Eg}{\hat{\mathcal{E}}}\right)$$

It will be seen that the expression for anode current so obtained is diminished in a non-linear manner from the general form:—

$$Ia=\frac{f(Va+Vg)}{Ra}$$

by the introduction of further terms dependant on the ratio of applied anode and grid voltages, and the general relationship can only hold at zero grid bias. It is thus obvious that with a steady D.C. applied to the grid, and with alternating voltage on the anode, due to the fixed cut-off that occurs at the ends of the sinusoidal anode current cycle it is impossible for the valve anode current to follow the general Ia/Vg characteristic.

To overcome this deficiency, and again presuming a linear valve characteristic, it is obvious that for anode current to flow throughout the anode voltage cycle the grid voltage and anode voltage must pass through zero and maximum at similar times. In other words, with a sinusoidal applied anode voltage the grid voltage must also be sinusoidal and since it is to represent a negative grid voltage it must be in exact anti-phase to the anode voltage. To overcome the previously mentioned drawback of the effect of the positive half cycle on the grid, when the anode is taking no current, some means must be obtained to procure a grid voltage which is sinusoidal during the negative half cycle and zero during the positive half cycle. This obviously gives rise to the provision of a half-wave rectified signal to which no smoothing has been applied to destroy the sinusoidal nature of the signal during its operative half cycle. This is the system which is adopted in accordance with the present invention, namely, the provision of alternative voltage to the anode, screen and/or other high voltage electrodes together with the application of a half-wave unsmoothed rectified signal in counter-phase to the anode voltage and of a suitable magnitude to replace the D.C. voltage conditions desired.

The magnitude of the A.C. anode voltage and the half-wave rectified grid voltages required to simulate D.C. conditions are obtained as follows and referring to Figures 3 and 4 of the accompanying drawings in which Figure 3 represents a set of idealised Ia/Va curves for the valve under consideration and Figure 4 represents a half sinusoid of anode voltage for the valve. Adopting the same notation as in the previous case with the exception that eg now represents the negative peak value of the grid volts, it will be seen that since the grid voltage varies sinusoidally in phase with the anode voltage, both starting from zero, the instantaneous anode current at $\omega t=\alpha$ can be taken as f.GH = f.(FH − FG)

$$=f\hat{\mathcal{E}}\sin\alpha-\mu\hat{\mathcal{E}}g\sin\alpha$$

Then average anode current over the half cycle

$$Ia=K\frac{1}{Ra}\cdot\frac{\omega}{\pi}\left\{\int_{\omega t=0}^{\omega t=\pi}\hat{\mathcal{E}}\sin\omega t+\int_{\omega t=0}^{\omega t=\pi}\hat{\mathcal{E}}g\sin\omega t\right\}$$

$$=K\frac{\omega}{\pi Ra}\left\{\hat{\mathcal{E}}\times\frac{1}{\omega}\left[-\cos\omega t\right]_{\omega t=0}^{\omega t=\pi}+\mu\hat{\mathcal{E}}g\times\frac{1}{\omega}\left[-\cos\omega t\right]\right\}$$

$$=\frac{K}{\pi Ra}\left\{2\hat{\mathcal{E}}+2\mu\hat{\mathcal{E}}g\right\}$$

$$=\frac{2K}{\pi}\left(\frac{\hat{\mathcal{E}}+\mu\hat{\mathcal{E}}g}{Ra}\right)$$

where K is a constant depending on the physical constants of the valve.

Deriving this in terms of the actual