5.10. In a two-color printing press, two pairs of large printing drums are rotated from a single drive shaft as shown in Fig. 5.29. Each drum pair has total rotary inertia J, and is supported in bearings with a linear rotational drag coefficient B. The drive-shaft sections each have a torsional stiffness K. The system is driven by a motor that may be considered as an angular velocity source. Derive a set of state equations for this system.

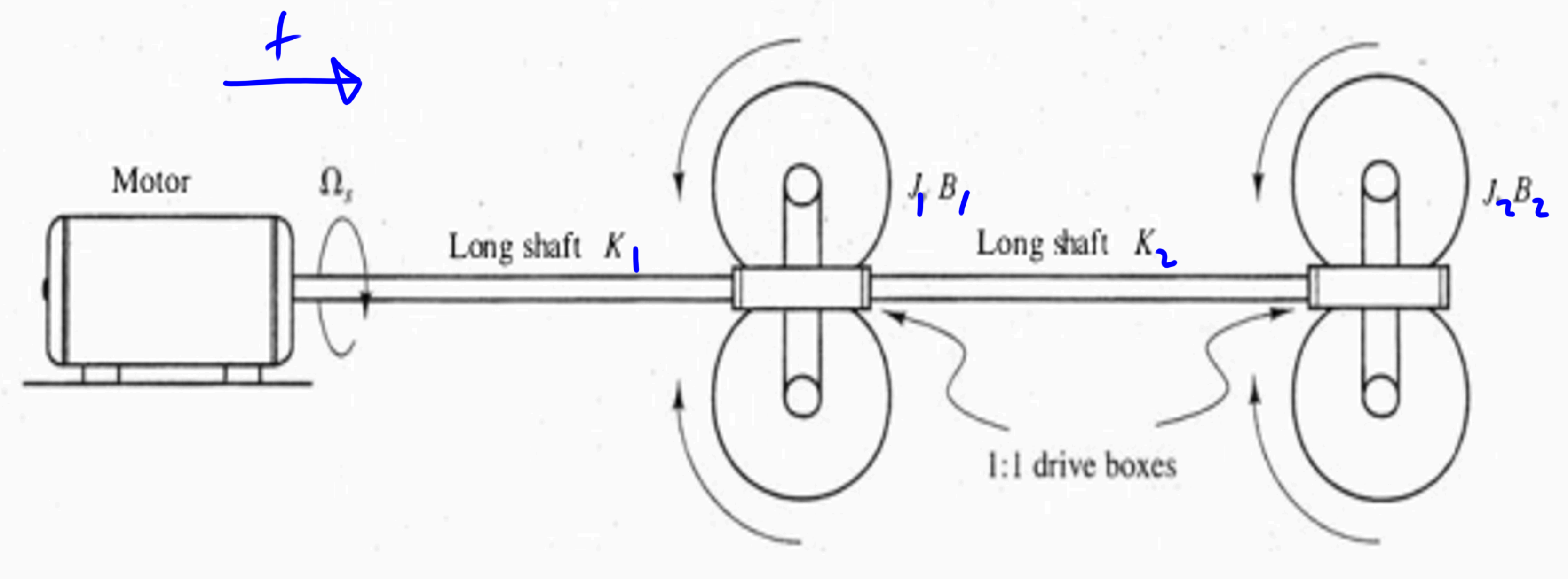
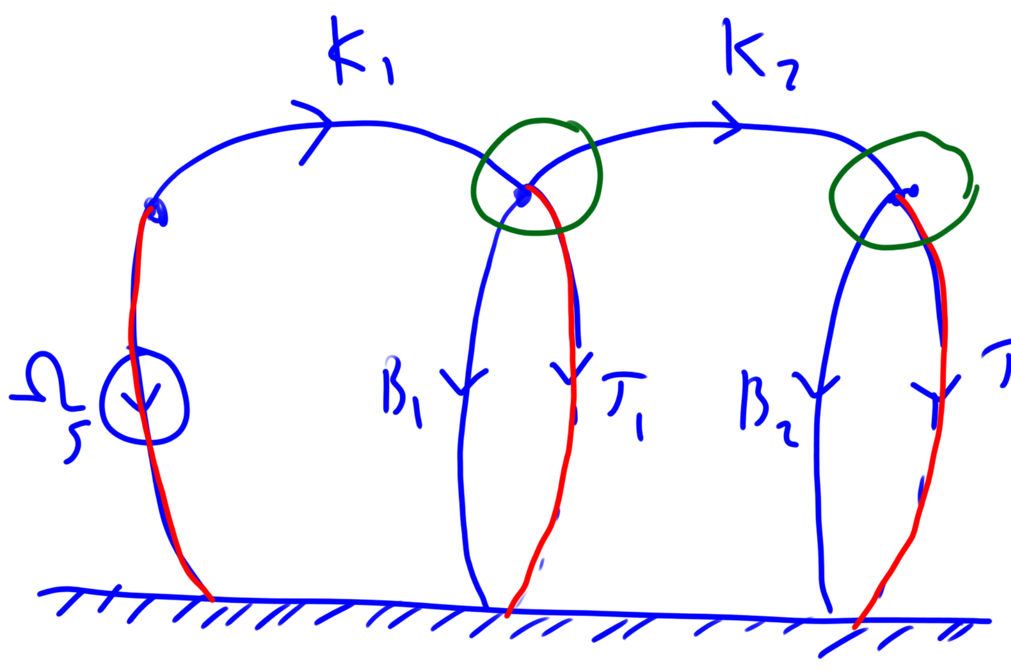


Figure 5.29: A rotary drive system.



primary: $\Omega_s \quad \omega_{J_1} \quad \omega_{J_2} \quad \tau_{K_1} \quad \tau_{K_2} \quad \tau_{B_1} \quad \tau_{B_2}$

secondary: $T_s \quad \tau_{J_1} \quad \tau_{J_2} \quad \omega_{K_1} \quad \omega_{K_2} \quad \omega_{B_1} \quad \omega_{B_2}$

State: $\omega_{J_1} \quad \omega_{J_2} \quad \tau_{K_1} \quad \tau_{K_2}$

$$\left.\begin{aligned}
\frac{d\omega_{J_1}}{dt} &= \frac{1}{J_1}\tau_{J_1} \\
\frac{d\omega_{J_2}}{dt} &= \frac{1}{J_2}\tau_{J_2} \\
\frac{d\tau_{K_1}}{dt} &= K_1\,\omega_{K_1} \\
\frac{d\tau_{K_2}}{dt} &= K_2\,\omega_{K_2}
\end{aligned}\right\} \text{State var elemental eq'ns}$$

$$\left.\begin{aligned}
\tau_{B_1} &= B_1\,\omega_{B_1} \\
\tau_{B_2} &= B_2\,\omega_{B_2}
\end{aligned}\right\} \text{other elemental eq'ns}$$

$$\left.\begin{aligned}
\tau_{J_2} &= \tau_{K_2} - \tau_{B_2} \\
\tau_{J_1} &= \tau_{K_1} - \tau_{K_2} - \tau_{B_1} \\
\omega_{B_2} &= \omega_{J_2} \\
\omega_{B_1} &= \omega_{J_1} \\
\omega_{K_2} &= \omega_{J_1} - \omega_{J_2} \\
\omega_{K_1} &= \Omega_s - \omega_{J_1}
\end{aligned}\right\} \text{Constraints}$$