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The Equations Obtained for Voltage Dividers and Current Dividers for n Resistors in Electrical Systems and Equations for The Velocity Dividers and Force Dividers for n Dampers in Mechanical Dynamic Systems

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ABSTRACT: *In present work the electrical voltage and current dividers for* ***n*** *resistors in parallel and series are obtained. In this work also the mechanical analogous to electrical dynamic system for* ***n*** *dampers for velocity dividers and force dividers are obtained.*

Key Words: Voltage dividers, current dividers, Mechanical dynamic system, voltage dividers, force dividers, **n** resistors, **n** dampers.

INTRODUCTION

This book[1] which is about scientific instrumentation has one chapter on electronics. Present work can be continuation to the chapter of this book which is about electronics.

While I was teaching basics of scientific electronics,2,3, I realized that the book has a section on voltage and current divider for manuscripts. The voltage divider was obtained for two resistors in series. We already published four manuscripts4-7 concerning n and nxn resistors in global journal of physics.4-7

As it is shown in Fig.1

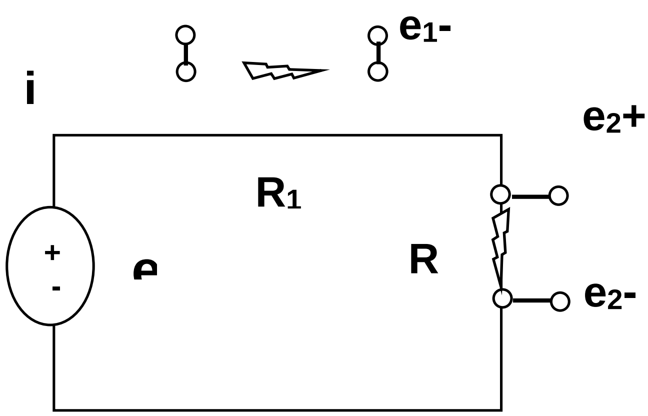


Fig.1

From the equal resistors in series and ohm's law we can write:

i = $\frac{e}{R_1 + R_2}$ **(eq.1)**

eq.3 is obtained according to ohm's law. And substituting for **i** from **eq.1** into **eq.2**.

$\mathbf{e_1} = R_1 i$ **(eq.2)**

$\mathbf{e_1} = \frac{R_1 e}{R_1 + R_2}$ **(eq.3)**

With the same logical reasoning, one can obtain,

$\mathbf{e_2} = \frac{R_2 e}{R_1 + R_2}$ **(eq.4)**

For **n** resistors in series as shown in Fig.2

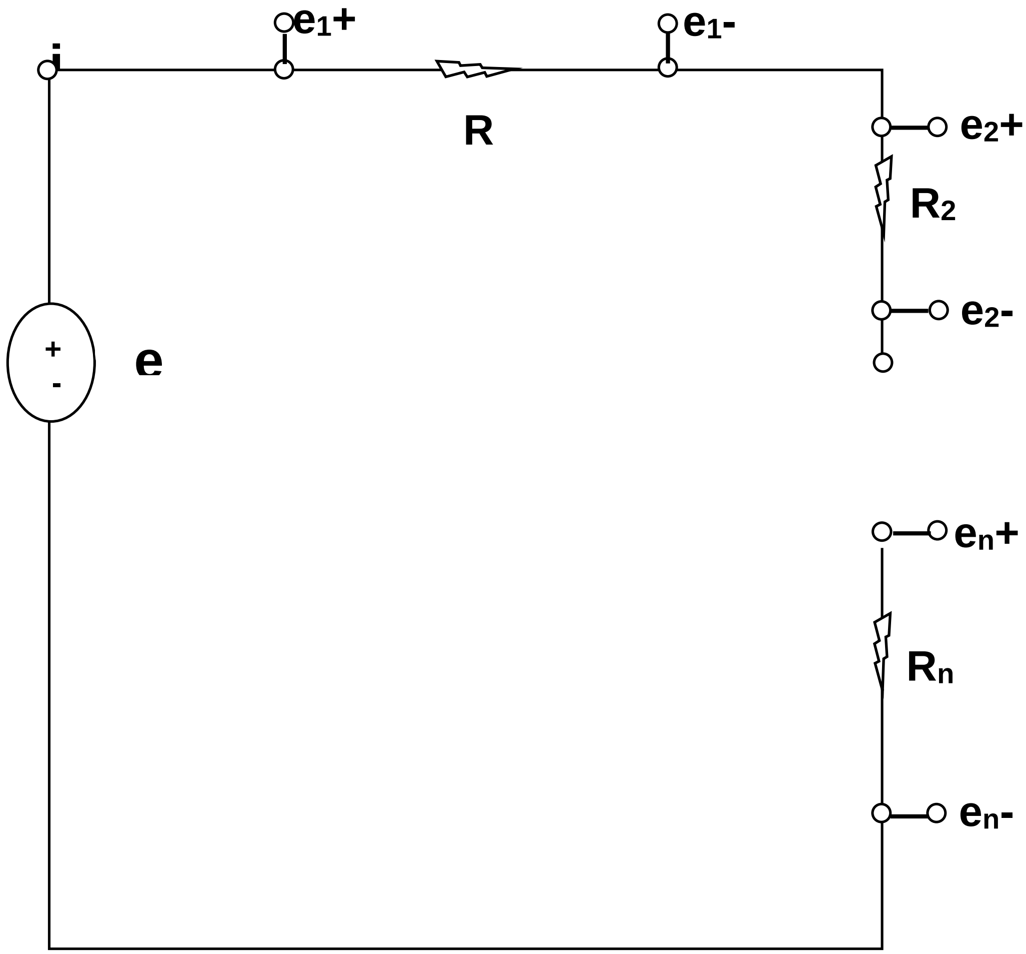


Fig.2

$$e_1 = \frac{R_1 e}{R_1+R_2+\cdots+R_n} \quad \textbf{(eq.5)}$$

$$e_2 = \frac{R_2 e}{R_1+R_2+\cdots+R_n} \quad \textbf{(eq.6)}$$

$$e_n = \frac{R_n e}{R_1+R_2+\cdots+R_n} \quad \textbf{(eq.7)}$$

ANALOGOUSE ELECTRICAL and MECHANICHAL SYSTEMS[8,9] FOR VELOCITY DIVIDER

The mechanical **i** analog stipulates that **e** voltage is replaced by velocity **V**, current, **i** by force, **f** and resistance, **R** by inverse of damper constant, $^{\mathbf{1}}/_{\boldsymbol{B}}$ which yields **V=** $^{\boldsymbol{f}}/_{\boldsymbol{B}}$. The damper is shown schematically as follow.

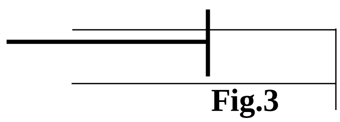
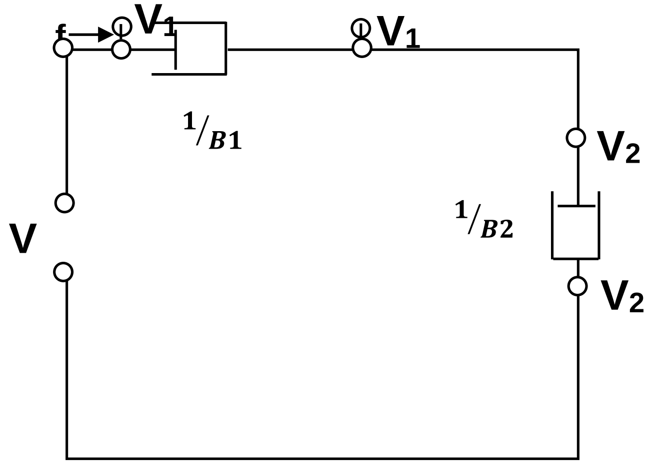


Fig.3

In the – electrical system ohm's law is **e= Ri**. Analog of ohm's law.

In mechanical system is **V=** $^{\boldsymbol{f}}/_{\boldsymbol{B}}$

The velocity divider was obtained for two dampers in series. As it is shown in Fig.4



From the equal damper implant and in series and mechanical ohm's law we can write equations of 1 to 4 which is electrical for voltage divider could be changed to equations for 8 to 13 for velocity divider for mechanical systems.

For velocity divider for the mechanical system Fig.4 is

$$\mathbf{f} = \frac{V}{\frac{1}{B_1} + \frac{1}{B_2}} \qquad \textbf{(eq.8)}$$

$$\mathbf{V_1} = \frac{1}{B_1}\,\mathbf{f} \qquad \textbf{(eq.9)}$$

$$\mathbf{V_1} = \frac{1}{B_1}\cdot\frac{V}{\frac{1}{B_1}+\frac{1}{B_2}} \qquad \textbf{(eq.10)}$$

$$\mathbf{V_2} = \frac{1}{B_2}\cdot\frac{V}{\frac{1}{B_1}+\frac{1}{B_2}} \qquad \textbf{(eq.11)}$$

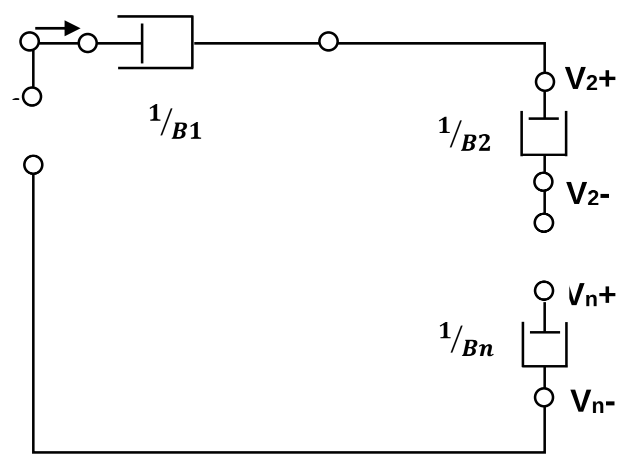
$$\mathbf{V_1} = \frac{1}{B_1} \quad \frac{V}{\frac{B_2+B_1}{B_1B_2}} = \frac{B_2}{B_2+B_1}\,.\,\mathbf{V} \qquad \textbf{(eq.12)}$$

$$\mathbf{V_2} = \frac{1}{B_2} \quad \frac{V}{\frac{B_2+B_1}{B_1B_2}} = \frac{B_1}{B_2+B_1}\,.\,\mathbf{V} \qquad \textbf{(eq.13)}$$

For velocity divider by 2 from equation (12) and (13) $\mathbf{B_1 = B_2}$

We conclude $\mathbf{V_1} = \frac{V}{2}$ and $\mathbf{V_2} = \frac{V}{2}$

Fig.5 the analogous from electrical Fig.2 to mechanical for **n** dampers are shown in Fig.5



For finding analogous from electrical to mechanical for **n** damper Fig.5 equations 5 to 7 are converted to mechanical system.

$$\mathbf{V_1} = \frac{\frac{1}{B_1}V}{\frac{1}{B_1}+\frac{1}{B_2}+\cdots+\frac{1}{B_n}} \qquad \textbf{(eq.14)}$$

$$V_2 = \frac{\frac{1}{B_2}V}{\frac{1}{B_1}+\frac{1}{B_2}+\dots+\frac{1}{B_n}} \qquad \textbf{(eq.15)}$$

$$V_n = \frac{\frac{1}{B_n}V}{\frac{1}{B_1}+\frac{1}{B_2}+\dots+\frac{1}{B_n}} \qquad \textbf{(eq.16)}$$

CURRENT DIVIDER IN ELECTRICAL SYSTEM [2,9]

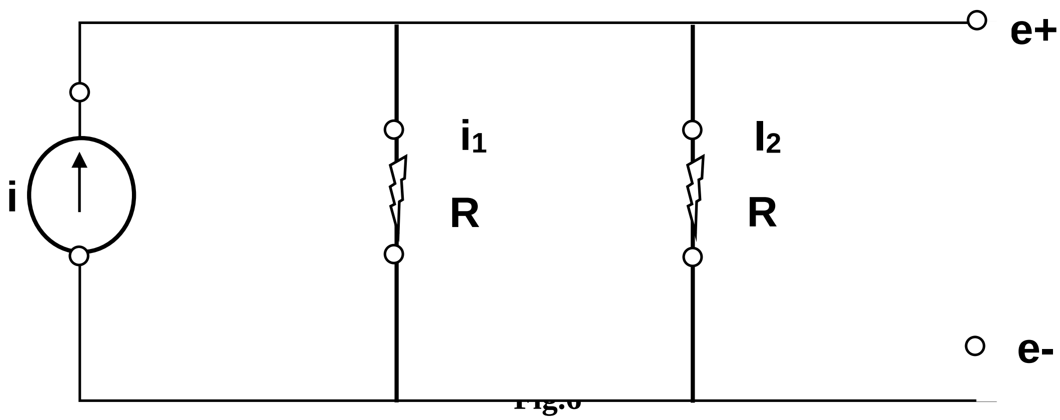


Fig.6

$$i_1 R_1 = e \qquad \textbf{(eq.17)}$$

$$i_2 R_2 = e \qquad \textbf{(eq.18)}$$

The equal resistance for two resistors shown in Fig.6 is as followed

$$\frac{1}{Req} = \frac{1}{R_1} + \frac{1}{R_2} = \frac{B_2 + B_1}{R_1\, R_2} \qquad \textbf{(eq.19)}$$

$$\mathbf{Req} = \frac{R_1\, R_2}{R_1 + R_2} \qquad \textbf{(eq.20)}$$

$$\mathbf{iReq} = \frac{i\, R_1\, R_2}{R_1 + R_2} = \mathbf{e} \qquad \textbf{(eq.21)}$$

By setting **eq.21** and **eq.17** equal.

We obtain:

$$i_1 R_1 = \frac{i\, R_1\, R_2}{R_1 + R_2} = \mathbf{e} \qquad \textbf{(eq.22)}$$

By simplifying **eq.22** from both side $\mathbf{R_1}$ is eliminated and one gets

$$i_1 = \frac{i\,R_2}{R_1 + R_2} \qquad \textbf{(eq.23)}$$

With similar logic $\mathbf{i_2}$ is obtained by setting **eq.21** and **eq.18** equal and simplifying $\mathbf{R_2}$ from both sides.

$$i_2 = \frac{i\,R_1}{R_1 + R_2} \qquad \textbf{(eq.24)}$$

The book[3] has not gone further to obtained the current dividers for **n** resistors in parallel. That is at the goals of this manuscript for electrical and mechanical systems.

THEORY FOR CURRENT DIVIDER FORCE DIVIDER

First we obtain the equation for a current divider for three resistors in parallel as shown in Fig.7

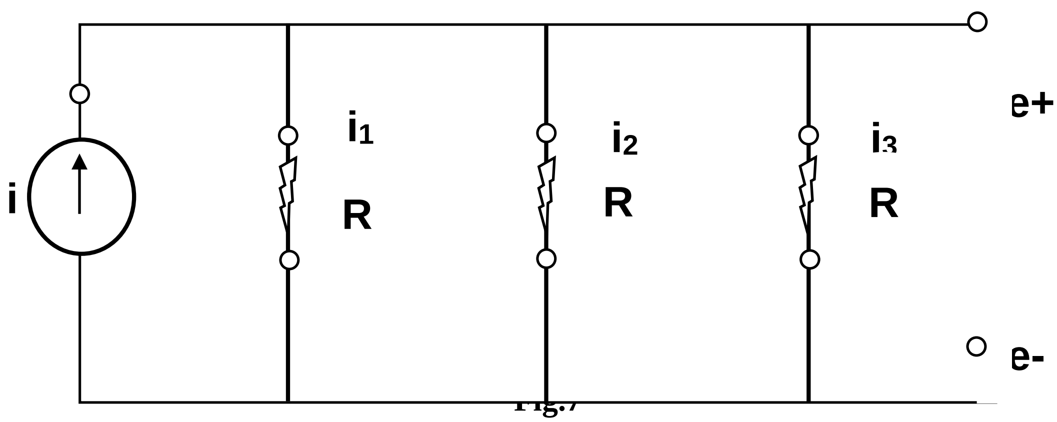


Fig.7

We find the current divider with the same strategy. The first step is finding **Req** for three resistors in parallel.

$$\frac{1}{Req} = \frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3} \qquad \textbf{(eq.25)}$$

$$\frac{1}{Req} = \frac{R_2\,R_3 + R_1 R_3 + R_1 R_2}{R_1\,R_2\,R_3} \qquad \textbf{(eq.26)}$$

$$\text{Req} = \frac{R_1\,R_2\,R_3}{R_2\,R_3 + R_1 R_3 + R_1 R_2} \qquad \textbf{(eq.27)}$$

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From Fig.7 according to ohm's law we can write

$$\mathbf{e = i_1 R_1} \qquad \textbf{(eq.28)}$$

$$\mathbf{e = i_2 R_2} \qquad \textbf{(eq.29)}$$

$$\mathbf{e = i_3 R_3} \qquad \textbf{(eq.30)}$$

$$\mathbf{e = Req\ i} = \frac{R_1 R_2 R_3}{R_2 R_3 + R_1 R_3 + R_1 R_2}\ \mathbf{i} \qquad \textbf{(eq.31)}$$

By setting **eq.28** and **eq.31** equal and simplify $\mathbf{R_1}$ from both sides one can get,

$$\mathbf{i_1} = \frac{R_2 R_3}{R_2 R_3 + R_1 R_3 + R_1 R_2}\ \mathbf{i} \qquad \textbf{(eq.32)}$$

With similar approach by setting **eq.29** and **eq.31** equal and simplify **R** from both sides one can get

$$\mathbf{i_2} = \frac{R_1 R_3}{R_2 R_3 + R_1 R_3 + R_1 R_2}\ \mathbf{i} \qquad \textbf{(eq.33)}$$

For $\mathbf{i_3}$ with similar strategy setting **eq.30** and **eq.31** equal and simplifying from both sides one can obtain

$$\mathbf{i_3} = \frac{R_1 R_2}{R_2 R_3 + R_1 R_3 + R_1 R_2}\ i \qquad \textbf{(eq.34)}$$

For four resistors in parallel. The current dividers become what is seen in Fig.8. By similar strategies which was used for Fig.8.

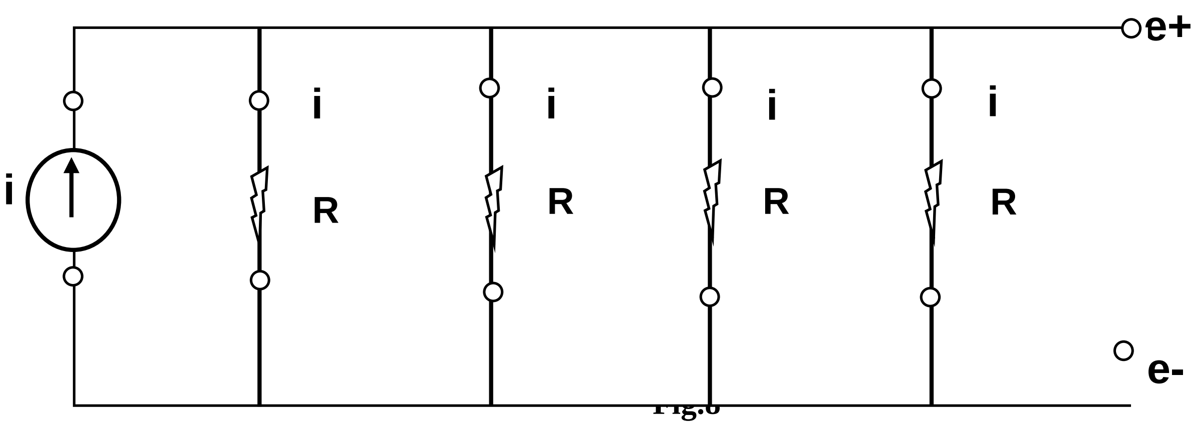

Fig.8

i1 = $\frac{R_2\, R_3 R_4}{R_2\, R_3 R_4 + R_1 R_3 R_4 + R_1 R_2 R_4 + R_1 R_2 R_3}\, i$ **(eq.35)**

i2 = $\frac{R_1\, R_3 R_4}{R_2\, R_3 R_4 + R_1 R_3 R_4 + R_1 R_2 R_4 + R_1 R_2 R_3}\, i$ **(eq.36)**

i3 = $\frac{R_1\, R_2 R_4}{R_2\, R_3 R_4 + R_1 R_3 R_4 + R_1 R_2 R_4 + R_1 R_2 R_3}\, i$ **(eq.37)**

i4 = $\frac{R_1\, R_2 R_3}{R_2\, R_3 R_4 + R_1 R_3 R_4 + R_1 R_2 R_4 + R_1 R_2 R_3}\, i$ **(eq.38)**

For **n** resistors in parallel. The dividers become what is seen in Fig.9. in Fig.13 the conversion is done from current dividers to force divider for **n** dampers.

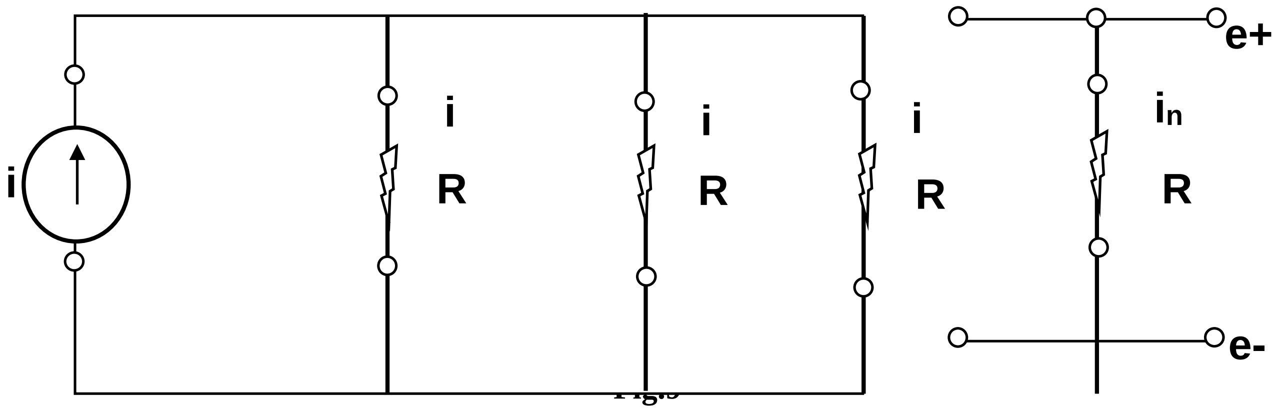

Fig.9

With similar approach

i1 = $\frac{R_2\, R_3 \ldots R_{n-1}\, R_n}{R_2\, R_3 \ldots R_{n-1}\, R_n + R_1\, R_3 \ldots R_{n-1}\, R_n + R_2\, R_3 \ldots R_{n-1}\, R_n + R_1\, R_2\, R_3 \ldots R_{n-1}\, R_n + R_1\, R_2\, R_3 \ldots R_{n-1}} \,.\, i$ **(eq.39)**

i2 = $\frac{R_1\, R_3 \ldots R_{n-1}\, R_n}{R_2\, R_3 \ldots R_{n-1}\, R_n + R_1\, R_3 \ldots R_{n-1}\, R_n + R_2\, R_3 \ldots R_{n-1}\, R_n + R_1\, R_2\, R_3 \ldots R_{n-1}\, R_n + R_1\, R_2\, R_3 \ldots R_{n-1}} \,.\, i$ **(eq.40)**

i3 = $\frac{R_1\, R_2\, R_4 \ldots R_{n-1}\, R_n}{R_2\, R_3 \ldots R_{n-1}\, R_n + R_1\, R_3 \ldots R_{n-1}\, R_n + R_1\, R_2 \ldots R_{n-1}\, R_n + R_1\, R_2\, R_3 \ldots R_{n-1}\, R_n} \,.\, i$ **(eq.41)**

in = $\frac{R_1\, R_2 \ldots R_{n-1}}{R_2\, R_3 \ldots R_{n-1}\, R_n + R_1\, R_3 \ldots R_{n-1}\, R_n + R_1\, R_2 \ldots R_{n-1}\, R_n + R_1\, R_2\, R_3 \ldots R_{n-1}\, R_n} \,.\, i$ **(eq.42)**

ANALOGOUS ELECTRICAL AND MECHANICAL SYSTEM FOR FORCE DIVIDER

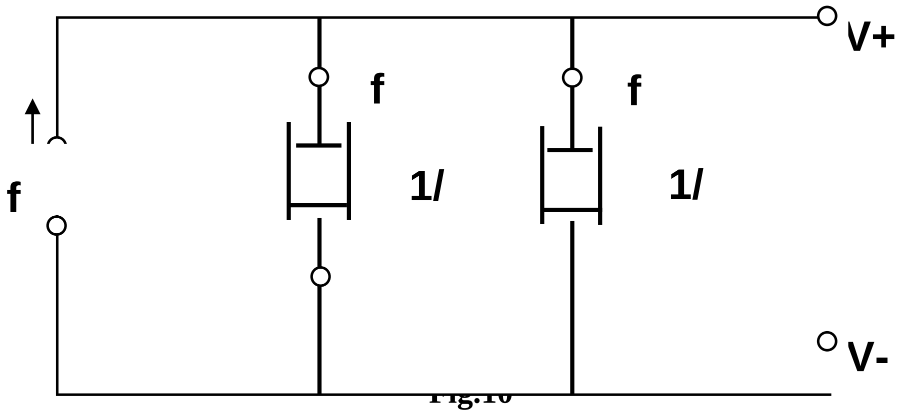

Fig.10

Its shown by converting electrical current divider equations **23** and **24** to their analog in mechanical system

f1 = $\frac{f\ ^{1}/_{B_2}}{\frac{1}{B_1}+\frac{1}{B_2}}$ **(eq.43)**

f1 = $\frac{f\ B_1}{B_2+B_1}$ **(eq.44)**

f2 = $\frac{f\ ^{1}/_{B_1}}{\frac{1}{B_2}+\frac{1}{B_2}}$ **(eq.45)**

f2 = $\frac{f\ B_2}{B_2+B_1}$ **(eq.46)**

It is shown the force, **f**, divider for three dampers in parallel. It is converted mechanical analog from electrical current divider Fig.7

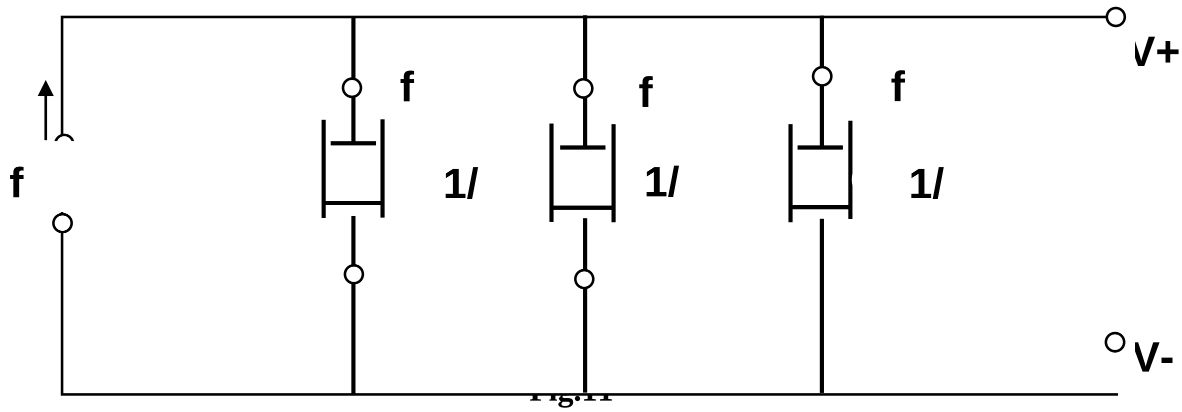

Fig.11

By converting equation of **32**, **33** and **34** the electrical current dividers for three resistors are converted to and force divider for three dampers shown in Fig.11. from **eq.32**, **33** and **34** converted to mechanical system.

$$\mathbf{f_1} = \frac{\frac{1}{B_2}\frac{1}{B_3}}{\frac{1}{B_2}\frac{1}{B_3} + \frac{1}{B_1}\frac{1}{B_3} + \frac{1}{B_1}\frac{1}{B_2}}\,\mathbf{f} \qquad \textbf{(eq.47)}$$

$$\mathbf{f_1} = \frac{B_1}{B_1 + B_2 + B_3}\,\mathbf{f} \qquad \textbf{(eq.48)}$$

$$\mathbf{f_2} = \frac{\frac{1}{B_1}\frac{1}{B_3}}{\frac{1}{B_2}\frac{1}{B_3} + \frac{1}{B_1}\frac{1}{B_3} + \frac{1}{B_1}\frac{1}{B_2}}\,\mathbf{f} \qquad \textbf{(eq.49)}$$

$$\mathbf{f_2} = \frac{B_2}{B_1 + B_2 + B_3}\,f \qquad \textbf{(eq.50)}$$

$$\mathbf{f_3} = \frac{\frac{1}{B_1}\frac{1}{B_2}}{\frac{1}{B_2}\frac{1}{B_3} + \frac{1}{B_2}\frac{1}{B_3} + \frac{1}{B_1}\frac{1}{B_2}}\,\mathbf{f} \qquad \textbf{(eq.51)}$$

$$\mathbf{f_3} = \frac{B_3}{B_1 + B_2 + B_3}\,\mathbf{f} \qquad \textbf{(eq.52)}$$

For four resistors in parallel the current dividers become what is seen in Fig.8. we convert electrical system shown in Fig.8 to mechanical system shown in Fig.12.

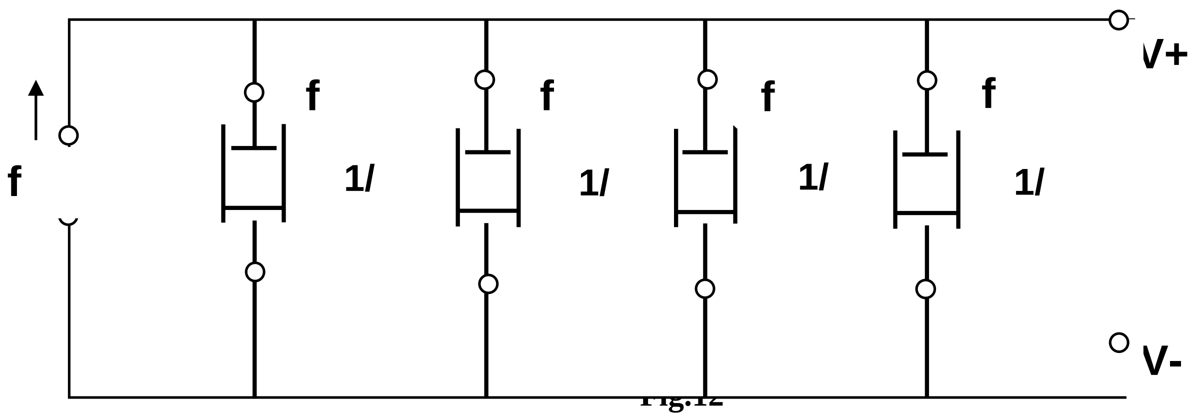

Fig.12

By converting **eq.35** to **eq.38**, to equations 53 to 60 the force. **f**, dividers for four dampers are obtained.

$$\mathbf{f_1} = \frac{\frac{1}{B_2}\frac{1}{B_3}\frac{1}{B_4}}{\frac{1}{B_2}\frac{1}{B_3}\frac{1}{B_4}+\frac{1}{B_1}\frac{1}{B_3}\frac{1}{B_4}+\frac{1}{B_1}\frac{1}{B_2}\frac{1}{B_4}+\frac{1}{B_1}\frac{1}{B_2}\frac{1}{B_3}}\,\mathbf{f} \qquad \textbf{(eq.53)}$$

$$\mathbf{f_1} = \frac{B_1}{B_1+B_2+B_3\,B_4}\,\mathbf{f} \qquad \textbf{(eq.54)}$$

$$\mathbf{f_2} = \frac{\frac{1}{B_2}\frac{1}{B_3}\frac{1}{B_4}}{\frac{1}{B_2}\frac{1}{B_3}\frac{1}{B_4}+\frac{1}{B_1}\frac{1}{B_3}\frac{1}{B_4}+\frac{1}{B_1}\frac{1}{B_2}\frac{1}{B_4}+\frac{1}{B_1}\frac{1}{B_2}\frac{1}{B_3}}\,\mathbf{f} \qquad \textbf{(eq.55)}$$

$$\mathbf{f_2} = \frac{B_2}{B_1+B_2+B_3+B_4}\,\mathbf{f} \qquad \textbf{(eq.56)}$$

$$\mathbf{f_3} = \frac{\frac{1}{B_1}\frac{1}{B_2}\frac{1}{B_4}}{\frac{1}{B_2}\frac{1}{B_3}\frac{1}{B_4}+\frac{1}{B_1}\frac{1}{B_3}\frac{1}{B_4}+\frac{1}{B_1}\frac{1}{B_2}\frac{1}{B_4}+\frac{1}{B_1}\frac{1}{B_2}\frac{1}{B_3}}\,f \qquad \textbf{(eq.57)}$$

$$\mathbf{f_3} = \frac{B_3}{B_1+B_2+B_3+B_4}\,f \qquad \textbf{(eq.58)}$$

$$\mathbf{f_4} = \frac{\frac{1}{B_1}\frac{1}{B_2}\frac{1}{B_3}}{\frac{1}{B_2}\frac{1}{B_3}\frac{1}{B_4}+\frac{1}{B_1}\frac{1}{B_3}\frac{1}{B_4}+\frac{1}{B_1}\frac{1}{B_2}\frac{1}{B_4}+\frac{1}{B_1}\frac{1}{B_2}\frac{1}{B_3}}\,f \qquad \textbf{(eq.59)}$$

$$\mathbf{f_4} = \frac{B_4}{B_1+B_2+B_3+B_4}\,f \qquad \textbf{(eq.60)}$$

For **n** resistors in parallel. The dividers become what is seen in Fig.9. in Fig.13 the conversion is done from current dividers to force divider for **n** dampers.

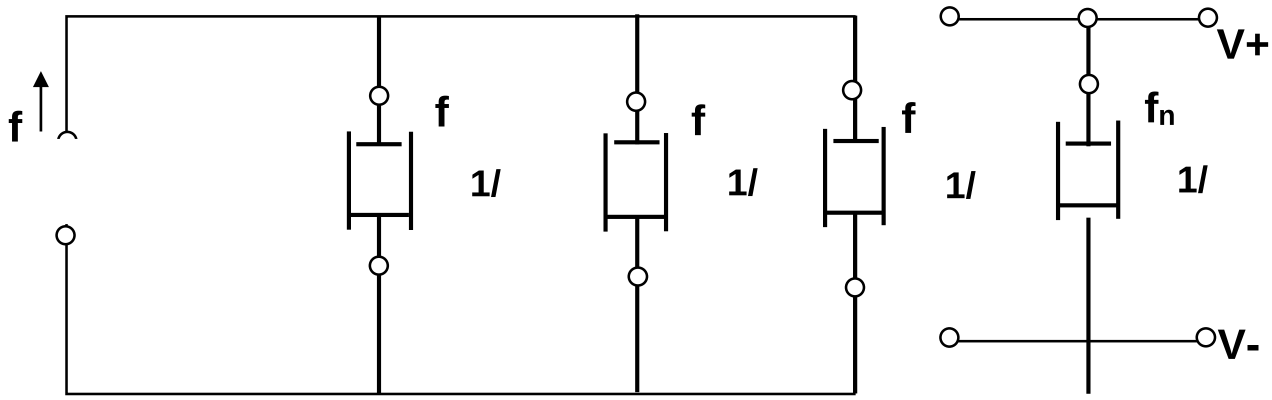

Fig.13

Equation **39** to **42** are the current dividers for **n** resistors in parallel. The Fig.13 is the conversion of mechanical force dividers for **n** dampers. The equations **39** to **42** are converted to equations **61** to **68**.

$$f_1 = \frac{\frac{1}{B_2}\frac{1}{B_3}\cdots\frac{1}{B_{n-1}}\frac{1}{B_n}}{\frac{1}{B_2}\frac{1}{B_3}\cdots\frac{1}{B_{n-1}}\frac{1}{B_n}+\frac{1}{B_1}\frac{1}{B_3}\cdots\frac{1}{B_{n-1}}\frac{1}{B_n}+\frac{1}{B_1}\frac{1}{B_2}\frac{1}{B_3}\cdots\frac{1}{B_{n-1}}\frac{1}{B_n}}\,f \qquad \textbf{(eq.61)}$$

$$f_1 = \frac{B_1}{B_1+B_2+\cdots+B_n}\,f \qquad \textbf{(eq.62)}$$

$$f_2 = \frac{\frac{1}{B_1}\frac{1}{B_3}\cdots\frac{1}{B_{n-1}}\frac{1}{B_n}}{\frac{1}{B_2}\frac{1}{B_3}\cdots\frac{1}{B_{n-1}}\frac{1}{B_n}+\frac{1}{B_1}\frac{1}{B_2}\cdots\frac{1}{B_{n-1}}\frac{1}{B_n}+\frac{1}{B_1}\frac{1}{B_2}\frac{1}{B_3}\cdots\frac{1}{B_{n-1}}\frac{1}{B_n}}\,f \qquad \textbf{(eq.63)}$$

$$f_2 = \frac{B_2}{B_1+B_2+\cdots+B_n}\,f \qquad \textbf{(eq.64)}$$

$$f_3 = \frac{\frac{1}{B_1}\frac{1}{B_2}\cdots\frac{1}{B_{n-1}}\frac{1}{B_n}}{\frac{1}{B_2}\frac{1}{B_3}\cdots\frac{1}{B_{n-1}}\frac{1}{B_n}+\frac{1}{B_1}\frac{1}{B_3}\cdots\frac{1}{B_{n-1}}\frac{1}{B_n}+\frac{1}{B_1}\frac{1}{B_2}\cdots\frac{1}{B_{n-1}}\frac{1}{B_n}+\frac{1}{B_1}\frac{1}{B_2}\frac{1}{B_3}\cdots\frac{1}{B_{n-1}}\frac{1}{B_n}}\,f \qquad \textbf{(eq.65)}$$

$$f_3 = \frac{B_3}{B_1+B_2+B_3+\ldots+B_n}\,f \qquad \textbf{(eq.66)}$$

$$f_n = \frac{\frac{1}{B_1}\frac{1}{B_2}\cdots\frac{1}{B_{n-1}}\frac{1}{B_n}}{\frac{1}{B_2}\frac{1}{B_3}\cdots\frac{1}{B_{n-1}}\frac{1}{B_n}+\frac{1}{B_1}\frac{1}{B_3}\cdots\frac{1}{B_{n-1}}\frac{1}{B_n}+\frac{1}{B_1}\frac{1}{B_2}\cdots\frac{1}{B_{n-1}}\frac{1}{B_n}+\frac{1}{B_1}\frac{1}{B_2}\frac{1}{B_3}\cdots\frac{1}{B_{n-1}}\frac{1}{B_n}}\,f \qquad \textbf{(eq.67)}$$

$$f_n = \frac{B_n}{B_1+B_2+B_3+\ldots+B_n}\,f \qquad \textbf{(eq.68)}$$

CONCLUSION

We obtain the voltage dividers in series for 2 resistors to **n** resistors. The analogous mechanical dynamic system in series for 2 to **n** dampers are obtained. It is also obtained the current dividers in parallel for 2, 3, 4 resisters to **n** resistors. The analogous mechanical dynamic systems in parallels for 2, 3, 4 dampers to **n** dampers equations are derived.

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