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been designed by Garand.† Jackson uses hydraulic pressure to force the clamps into contact;† Dolmen-Leblanc uses springs to
throw the toggles out of action;‡ Schurmann uses, instead of
the separate clamps, a ring, which is compressed externally;§
Napier also uses a ring, expanded from within.‖ Becker ar
ranges the clamp blocks to be operated by centrifugal force.¶
These are only a few of various modifications of the cylinder
coupling.

A form of axial friction coupling which acts with very slight
pressure is the Weston clutch, made by Tangye,‖‖ This acts
upon the principle of multiple plate friction (see § 107), as is
shown in Fig. 452.

The wooden discs are engaged with the case, and the iron ones
with the shaft. In the form shown the plates are pressed to
gether by the springs, and released by drawing back the collar
B and releasing the spring pressure. A larger example of
Weston's clutch is shown in Fig. 452. A is a winding drum, B
the shaft driven by the engine. The outer disc C and the inner
discs of the coupling are held apart by spiral springs, as shown
at a. A light pull on the cord c holds the drum stationary; a
stronger pull engages the clutch for winding; if the cord is left
slack the lead on the drum runs backward.

§ 158. AUTOMATIC COUPLINGS.

When power is transmitted to a shaft from two different
sources, as from two independent drives, it is desirable to have
one or both of them connected by a coupling which will auto
matically release or engage with the shaft, according to the dis-
tribution of work. If one motor tends to overrun it will then
be given more of the work, and as the resistance will be equal-
ized. Such a device is the coupling of Pouyer-Quintier, gen-

† Dingler's Polyg. Journal, Vol. 149, p. 27.
§ German Patent, 1879.
¶ Engineer, 1880, July, p. 64.
‖‖ German Patent, 1879.
* In the U. S. by the Yale & Towne Mfg. Co.

teeth when A drives B, but if B gains upon A, or A stops while
B continues to move, the paws are thrown out of action. The
direction of motion is shown by the arrow. The paws are re
leased by the action of the friction bands b and d, which are
made by uprising upon B, whenever B gains upon A, the
or the lever is most important. The pin
should not be driven in up to the shoulder on the taper, but
sufficient space left to ensure that the fit is tight in the taper.
This clearance is shown plainly in the figure. The same result.

† In Germany Uhlfon's Coupling is used for similar service, as
shown in Fig. 454. Here A is the part connected to the motor
and B is fast to the driven shaft. A is an internal ratchet wheel
into which the paws c enter. The springs a serve to insure the
entrance of the paws into the teeth, which engagement continues
so long as A drives B. If the speed of A is retarded, the paws are
retracted as shown in the lower part of the figure. In this
case the springs act to keep them out of gear, being the reverse
action to that of an ordinary ratchet gear.

The paws are fitted with half-journals (see § 96), and are held
in place by a plate ring, as shown. Uhlfon originally used
only two ratchet teeth in A, but increased the number afterwards
to four, so that the parts would engage in a movement of one-fourth
a revolution. It is better to use an odd number, as three,
and by proper spacing of the paws, the greatest play will be one-
half a space or one-sixth a revolution, with three teeth, as in
the case of Pouyer's Couplings. B may be the driving part in
stead of the driven, but in that case the direction of the arrow
must be reversed.

CHAPTER XI.

SIMPLE LEVERS.

JOURNALS FOR LEVERS.

In machine design a simple lever, or rocker arm, is a lever
arm which is mounted upon an axle or shaft, at the end, about
which it moves, and carries a journal upon the other end. For
the proportion of the journal see Chapter V. The forms which

FIG. 455.

This is shown in Fig. 453. In this case the parts are so dis
posed that the part A, which is driven by one source of motive
power, is loose on the shaft B. This part A may have gear

† In the U. S. by the Yale & Towne Mfg. Co.

may be given to such journals are shown in Fig. 455, and are
single overhanging, double, or forked. The manner of securing
the pin in the hub or the lever is most important. The pin
should not be driven in up to the shoulder on the taper, but
sufficient space left to ensure that the fit is tight in the taper.
This clearance is shown plainly in the figure. The same result.
may be attained by counter-sinking the collar into the hub on the lever. In the case of double overhanging pins, care should be taken that the load is equally divided between the two sides, so that the pressure upon each pin shall be equal to \( \frac{1}{2} P \). In the fork ended lever the fit on both ends of the pin should be portions of the same cone.

**Example 1.** For \( P = 400 \) lbs., we have from the tables in \( \text{Jo} \) for alternating pressure and wrought iron journals, the diameter \( d = 0.927 \sqrt{\frac{400}{1.89}} \), and the length the same. For steel, we have \( d = 0.955 \sqrt{\frac{400}{1.15}} \), and the length \( l = 1.30 \times 1.60 = 2.08 \). For a forked lever, a wrought iron pin with the same load the diameter, according to (91) would be \( d = 0.927 \sqrt{\frac{400}{1.44}} \), and the length \( l = 0.955 \times 1.60 = 3.13 \).

All levers are not subjected to alternating pressure, but have the pressure constantly in one direction, as for example, the beams of single-acting pumping engines, etc. In such cases larger journals are needed.

**Example 2.** A wrought iron journal for a forked lever, under constant pressure of \( 900 \) lbs., according to formula (97), should have a diameter \( d = \frac{1.44 \times \sqrt{900}}{2.08} \), and length \( l = 2.08 \times 5.00 = 10.40 \). If the material had been cast iron we should have \( d = 0.96 \sqrt{900} = 9.40 \), say \( 9.5 \), and \( l = 4.00 \). For steel we have \( d = 0.985 \sqrt{900} = 12.5 \), and \( l = 4.00 \).

![Fig. 457.](image)

For wrought iron shafts wrought iron levers should be used, and for cast iron shafts cast iron levers.

Let:
- \( w \) = thickness of metal of hub,
- \( \beta \) = length of hub,
- \( D \) = the shaft diameter for the statical moment \( J \times R \) of a lever of the same resistance, see (120) and (134).

\[
\begin{align*}
\frac{w}{\lambda} & = 2.0, \quad L = 25, \quad I = 3, \\
R & = 0.45, \quad 0.40, \quad 0.40
\end{align*}
\]

If a lever is to be fitted to a shaft of greater diameter than \( D \), we first determine the imaginary value of \( D \) and insert it in (152). The same method is adopted if a cast iron lever is to be used with a wrought iron shaft, and vice versa. The shape for cast iron levers is given above, in Fig. 456.

**Example 3.** If the lever of Example 2, Fig. 457, is made of wrought iron, and is 24 inches long, its statical moment \( J \times R = 24 \times 400 = 9600 \) inch pounds. This gives, from (134) \( D = 0.955 \sqrt{9600} = 9.5 \), and if we take \( \frac{w}{\lambda} = \frac{2}{2} \) we have from (42), \( w = 0.05 \times 9.5 = 1.35 \), \( \beta = 9.5 \times 2 = 19 \), say \( 18 \).

The hub may also be calculated of such dimensions as to be strong enough to be forced on cold, and thus obtain sufficient friction to hold without the use of a key (see (65), formula (66)).

The friction \( Q \) of the hub upon the shaft must then be 
\[
Q = \frac{20 \times J}{D^2}
\]

in which \( D' \) is the diameter of the shaft at the point where the hub is fitted.

**Example 4.** In the case of the same lever as the preceding example \( J = 25 \) and \( J' = 19 \), we have \( D = 9.5 \) and \( D' = 5.3 \) inch. We may then take \( \xi = \frac{9600}{400} = 24 \times 19 \) and substituting in formula (66), we get:

\[
\begin{align*}
D & = \frac{D'}{D} = \frac{D'}{D} \\
& = 19 \cdot 9.5 = 24 \times 19
\end{align*}
\]

The key is used as an extra precaution for security.

![Fig. 458.](image)

A special method of keying, especially adapted for the hubs of levers and wheels, has been designed by Engineer Peters. It consists of two parallel systems of keys, as shown in Fig. 458.
THE CONSTRUCTOR.

The taper of the keys is \( \frac{1}{4} \). The arrangement shown at (a) is preferable, as it weakens the hub less than (b). The angle \( \alpha \) may be taken as \( 135^\circ \), the thickness of keys \( b = \frac{7}{8} D' \), and mean width \( h = 2b \).

The form (a) is especially suited for hubs which are made in two parts. Those hubs which are upon shafts subjected to bending, are considered under the heading of Combined Levers, in Chapter XIII.

§ 162.

LEVER ARMS OF RECTANGULAR SECTION.

The calculations of the dimensions of simple lever arms of rectangular section are made upon the assumption that the force

\[ P \]

acts in a plane, passing through the middle of the arm, Fig. 459, and in a direction normal to the arm.

If we let

\[ h = \text{width of the arm at the axis,} \]
\[ b = \text{thickness of the arm at the axis,} \]
\[ S = \text{the maximum permissible stress,} \]
\[ \frac{h}{b} = \frac{P}{S} \]

Taking \( S \) for wrought iron = 5800, and for cast iron = 4250, we have

\[ b = \frac{0.00073 P R}{S^2} \]

\[ \text{for wrought iron.} \]
\[ b = \frac{0.00043 P R}{S^2} \]

\[ \text{for cast iron.} \]

These formulae are adapted for the determination of \( b \), when \( h \) has been selected, the latter being most conveniently chosen with regard to the other condition.

Example 1. Let \( P = 1400 \text{ lb.}, R = 32^\circ \) for a lever arm of wrought iron, and \( N = 150^\circ \) we have from (153):

\[ b = \frac{0.00073 \times 1400 \times 2}{(5800)^2} = 135^\circ \]

If \( b \) is kept constant for the whole length of the arm, the width at the small end may be \( 0.5b \), while if a constant ratio of \( b : h \) is kept, the small end is \( 0.5h \) (see \( \frac{2}{3} \), Case III and VII). If the force \( P \) does not act in the middle plane, an often occurs, then there must exist a combined bending and twisting stress on the arm. We may then derive a combined stress whose bending moment will give an ideal arm \( R' \).

If the plane in which the force \( P \) acts is distant from the middle of the arm by an amount \( e \), we may make approximately, (see § 150):

\[ R' = \frac{R}{1 + e^2} \]

or

\[ R' = \frac{0.927 R}{1.25 e} \]

and

\[ R' = \frac{0.625 R}{e} \]

is

\[ R > e. \]

\( R' \) may be determined readily by the graphical method, Fig. 460. The third case shows the method for inclined arms.

Example 2. In the case of the lever of the preceding example, let \( c = 135^\circ \). This gives \( R > c \), and we have from (154):

\[ R = \frac{1400 \times 2}{135} = 24 \]

\[ c = 98^\circ \]

\[ \frac{135}{98} = 1.38 \]

\[ \frac{135}{33} = 4.1 \]

\[ \frac{135}{45} = 3 \]

\[ \frac{135}{60} = 2.5 \]

\[ \frac{135}{75} = 1.8 \]

\[ \frac{135}{100} = 1.35 \]

\[ \frac{135}{140} = 0.96 \]

\[ \frac{135}{200} = 0.67 \]

\[ \frac{135}{400} = 0.34 \]

\[ \frac{135}{800} = 0.17 \]

\[ \frac{135}{1600} = 0.09 \]

Cast iron arms are sometimes made of cruciform section, see Fig. 456, in which case the ribs may be neglected.

§ 163.

LEVER ARMS OF COMBINED SECTION.

The sections shown in Fig. 461 are designed to secure an economy of material. Their dimensions are readily determined by first calculating a corresponding arm of rectangular section, and then transforming it into an I section, or double H shape. If \( A_0 \) be the depth and \( A_1 \) the breadth of the equivalent rectangular arm, and \( b \) and \( h \) the corresponding terms to be found, as in Fig. 461, we have

\[ \frac{b}{h} = \frac{1}{1 + a} \]

in which

\[ a = \left( \frac{b}{h} - 1 \right) \left[ \frac{6 (e/2) - 12 (-e/2)}{b^2} \right] \]

These formulas permit a choice of the ratios \( b : h \) and \( f : c \), which may be left to the judgment of the designer. In (155) the angle iron of the third example in Fig. 461 have been neglected, and may be considered as making up for the weakening of the rivet holes. The following table gives a series of values for (155) which will simplify the calculation materially. The table will also be found useful for other purposes, as all sorts of beams, crane booms, etc.

<table>
<thead>
<tr>
<th>( \frac{1}{1 + a} )</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
<th>7</th>
<th>8</th>
<th>9</th>
<th>10</th>
</tr>
</thead>
<tbody>
<tr>
<td>( k )</td>
<td>0.63</td>
<td>0.66</td>
<td>0.66</td>
<td>0.69</td>
<td>0.70</td>
<td>0.71</td>
<td>0.72</td>
<td>0.73</td>
</tr>
<tr>
<td>( l )</td>
<td>0.65</td>
<td>0.65</td>
<td>0.63</td>
<td>0.62</td>
<td>0.61</td>
<td>0.60</td>
<td>0.59</td>
<td>0.58</td>
</tr>
<tr>
<td>( m )</td>
<td>0.66</td>
<td>0.65</td>
<td>0.64</td>
<td>0.63</td>
<td>0.62</td>
<td>0.61</td>
<td>0.60</td>
<td>0.59</td>
</tr>
<tr>
<td>( n )</td>
<td>0.67</td>
<td>0.65</td>
<td>0.64</td>
<td>0.63</td>
<td>0.62</td>
<td>0.61</td>
<td>0.60</td>
<td>0.59</td>
</tr>
<tr>
<td>( o )</td>
<td>0.68</td>
<td>0.65</td>
<td>0.64</td>
<td>0.63</td>
<td>0.62</td>
<td>0.61</td>
<td>0.60</td>
<td>0.59</td>
</tr>
<tr>
<td>( p )</td>
<td>0.69</td>
<td>0.66</td>
<td>0.65</td>
<td>0.64</td>
<td>0.63</td>
<td>0.62</td>
<td>0.61</td>
<td>0.60</td>
</tr>
<tr>
<td>( q )</td>
<td>0.70</td>
<td>0.67</td>
<td>0.66</td>
<td>0.65</td>
<td>0.64</td>
<td>0.63</td>
<td>0.62</td>
<td>0.61</td>
</tr>
<tr>
<td>( r )</td>
<td>0.71</td>
<td>0.68</td>
<td>0.66</td>
<td>0.65</td>
<td>0.64</td>
<td>0.63</td>
<td>0.62</td>
<td>0.61</td>
</tr>
<tr>
<td>( s )</td>
<td>0.72</td>
<td>0.69</td>
<td>0.68</td>
<td>0.67</td>
<td>0.66</td>
<td>0.65</td>
<td>0.64</td>
<td>0.63</td>
</tr>
<tr>
<td>( t )</td>
<td>0.73</td>
<td>0.70</td>
<td>0.69</td>
<td>0.68</td>
<td>0.67</td>
<td>0.66</td>
<td>0.65</td>
<td>0.64</td>
</tr>
<tr>
<td>( u )</td>
<td>0.74</td>
<td>0.71</td>
<td>0.70</td>
<td>0.69</td>
<td>0.68</td>
<td>0.67</td>
<td>0.66</td>
<td>0.65</td>
</tr>
</tbody>
</table>

Example 1. A lever arm has a length \( L = 57.5^\circ \) and the journal pressure of the roll = \( P = 300 \text{ lb.} \). It is to be of cast iron of double I section with a height \( h_0 = 10^\circ \). According to (155) we have for a rectangular section

\[ A_0 = \frac{300}{10^\circ} \times 25.75 = 3500 \]

This is also too thick to be practicable, and hence the double I section may be compared. Here we may take \( e = 11^\circ, \frac{b}{h} = 4, \) and we get from the table \( \frac{1}{1 + 4} = 0.24 \) and \( \frac{0.24}{1.1} = 0.21^\circ \), and the flange