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Engineering Science

Strength & Test of Strength of Materials

"Strength of Materials" A. Morley, Longmans & Green

Stress = load / unit area.

Strain = extension / unit length.

For economical design of structures etc, the quality & strength of the material to be used must be known. For example, wrought iron is very ductile compared with other materials, mild steel has qualities in most of ating, both ductility, tensile strength, stresses applied to it in modern practice, cast iron has a high compression value, but is of little use for tensile work, high carbon steel may be used when greater tensile strength & compression strength are required.

In other fields there are forgings made of steel or wrought iron (drop forgings etc) cast steel for use when high shear from turning is found, & malleable castings, eg cast iron casting which have been heat treated.

All material used in construction in England must satisfy the specifications as laid down by the B.S.I. eg, tensile tests, compression & compression in bending tests, ductility tests (hot & cold).

Generally speaking the "safe working stresses" as used in practice today, are:-

MILD STEEL. Tension & compression in bending 18 000 lbs / □". in shear 13,500 lbs / □"

HIGH CARBON STEEL. Tension & compression in bending, & shear increase up to 50% of figures for mild steel.

CAST IRON. Tension 4000 lbs / □" compression 20 000 lbs / □". shear 4000 lbs / □" ?

WIRE DRAWN STEEL. Steel which has had a further rolling after cooling, so raising its yield point but reducing its ductility. Safe working stress in tensile & compression has been increased to 27,000 lbs / □".

TIMBER. Varies according to type of timber & how the load is to be applied in respect to the grain.

BRICKWORK. 8 tons / □ ft according to the type of brick used

CONCRETE. In a 1:2:4 mix compression in bending 750 lbs / □". tension neglected, pure compression 35 tons / □ ft

Soil. Used for carrying loads, soil having a carrying angle of repose. Average English soil having angle of 35°. Average soil pressure (permissible) 2 - 4 tons / □ ft.

V E R T A A L O E F E N I N G :

In de eerste zin t e v e r , vertaalt door ..... ?
In zin twee, zegt ge in het Engels niet: h i j e e t a l t i j d , maar hij ..... ?
In zin vier: z i j m o e t t h u i s b l i j v e n - a t h o m e .
En in de volgende zin i n d e k a z e r n e - a t .....
In zin zeven kunt ge het woordje d a t beide keren onvertaald laten.
In zin acht zegt ge in het Engels: 'n k w a r t i e r .
In zin negen vindt ge de ontkennende vorm.
In zin tien: o o k n o o i t , tussen w e r k en s t a a t .
In zin elf: Z e g , vertalen door I s a y .
In zin dertien: g e l o o f , vertalen door d e n k .
In de laatste zin komt weer een ontkenning voor.

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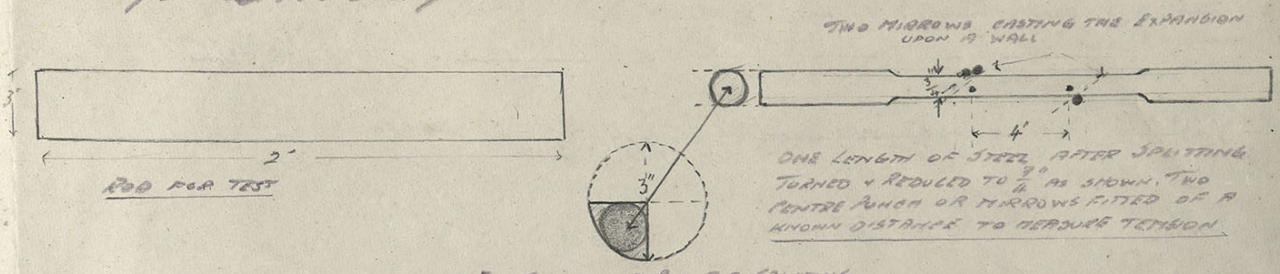
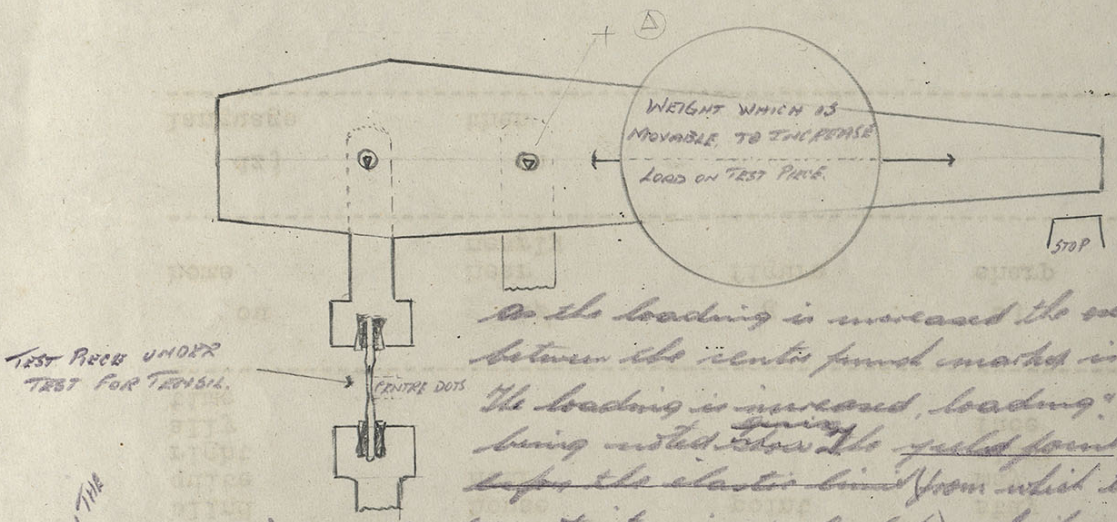
Test for tensile strength

Sample to be tested - a piece of 3" dia round steel 2' long cut from a 100' length.





As the loading is increased the extension between the centre punch marks is measured. The loading is increased, loading & extension being noted, ~~then~~ the yield point, ~~& up to the elastic limit~~ (from which the material will return to its original size) which is just before the elastic limit when extension goes on without the load being increased, maximum strength, & ultimate strength when breaking takes place. Ultimate strength in mild steel being usually less than the maximum strength. The graph is drawn as a straight line up to the yield point.

DATA TAKEN FROM THE GRAPH

Mild steel bar ½" ϕ 4" between centre pops.

Safe working stress 18,000 lbs/□"

Ultimate strain 60000 lbs/□"

YIELD POINT AT 30,000 LBS

$\frac{\text{Stress}}{\text{Strain}}$ = Young's Modulus (E) $E = 30 \times 10^6$ lbs/□"

Strain on bar = $\frac{\text{stress}}{E} = \frac{18000}{30 \times 10^6} = .006$"/unit length

Unit area of ½" ϕ = $\frac{\pi d^2}{4} = .198$ □"

Load = .198 □" × 18000 = 3550 lbs.

U I T S P R A A K O E F E N I N G :

Spreek uit met:

a:	i:	u:	o:
far	eat	move	or
past	need	too	for
sharp		noon	quarter
half			

---

e:	ae	e	i
heard	at	deaf	still
turn	stand	very	early
early	language	well	dinner
working	ally	bread	money
	hand	rest	minute
			figure

---

u	ü	ø	ö
look	study	from	stop
	tongue	figure	on
	butter		clock
	money		

---

ai	au	oi	ei
blind	house	point	stay
quite	hour		may
right			slave
ally			face
time			

---

ou	iø	g	sj
home	hear	figure	sharp
	nearly		

---

dzj	dh
language	then

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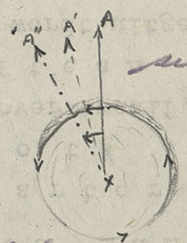
and with 7000 lb load, is .0052" per inch of material, compression with 7000 lb load is .0052" per inch of material.

Torsion tests are made on materials which may be used to transmit energy of rotation such as shafting, i.e. shafting & compression springs etc.

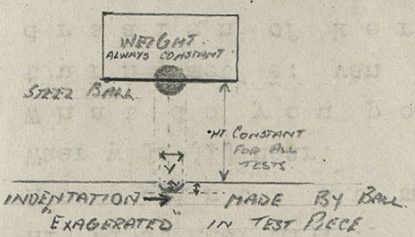
One end of the test piece is fixed & the other end subjected to a twist. Twisting is continued until fracture in the form of shear takes place. The length & diameter of the test piece is measured & the loading & the angular distance turned through are noted at intervals, from which the safe working stress can be ascertained.

Brinells test piece (A x A' angular and "x" lbs load is increased

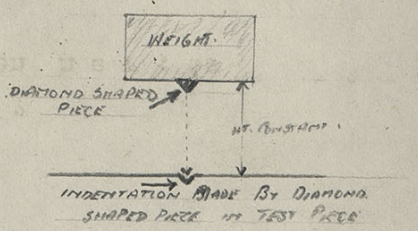


subjected to twist the distance twisted through Twisting increases as until fracture occurs.

Hardness Brinell or Vickers hardness testing machines. A hardness number is estimated from the indentation made by dropping a small hard steel ball in the case of the Brinell, & a diamond shaped piece in the Vickers from a certain height onto the test piece.



BRINELL HARDNESS TEST.



VICKERS HARDNESS TEST.

Fatigue test. A circular test piece is stated with a load attached to one end. In rotating the stress is continually changing from compression to tension & vice versa. After a certain no of thousands of revolutions have taken place & no deformation or fracture has taken place the material is found OK.

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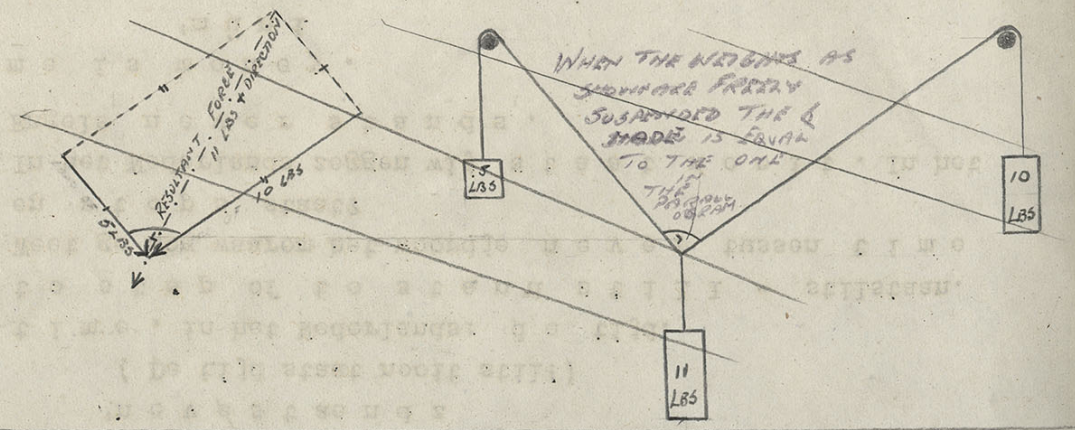
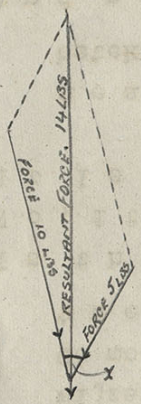
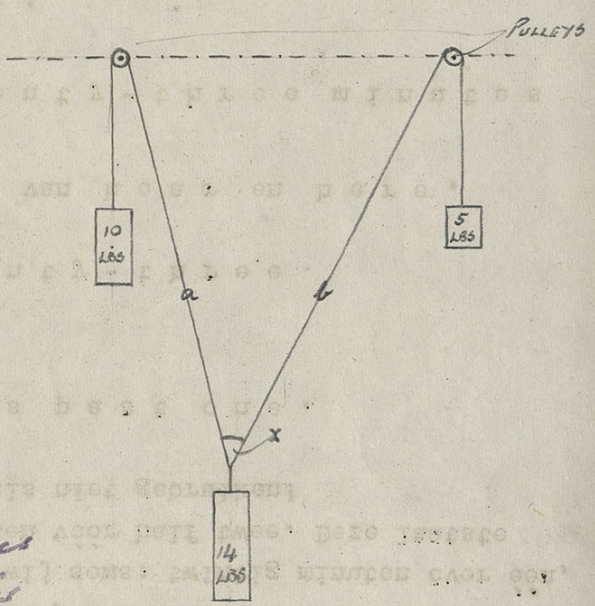
To find the resultant of two forces not parallel.



To find the resultant of two forces not parallel to one another

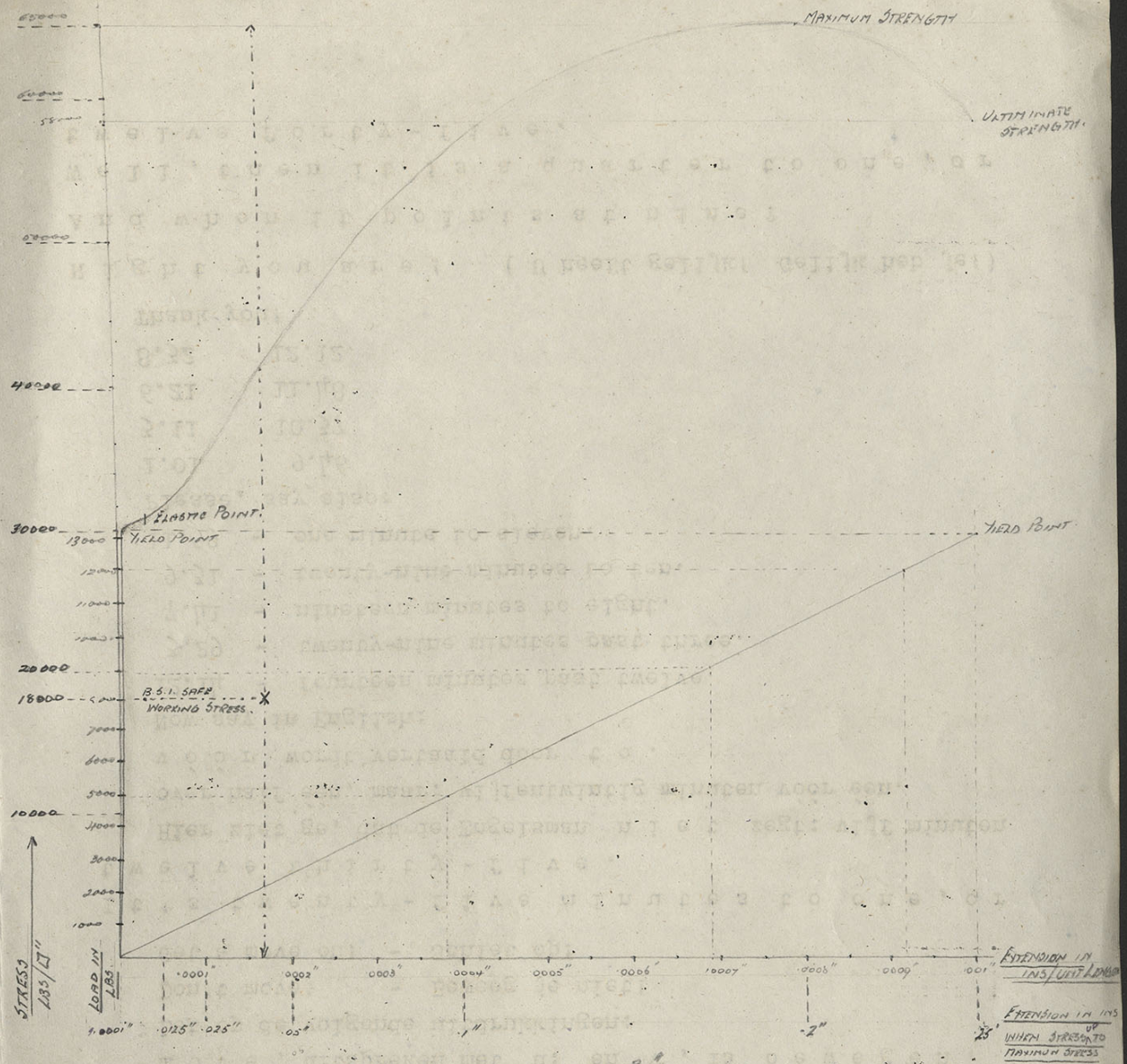




The resultant of two forces not parallel to one another may be found by the parallelogram of forces as shown.

If weights were arranged as shown over pulleys when they became in a state of equilibrium the line a & b would take up the same angle as the angle X in the parallelogram of forces

For a force to remain at rest it must have an equal & opposite force.



GRAPH SHOWING TENSILE STRENGTH OF $\frac{3}{4}$" MILD STEEL BAR UNDER TEST.

B.S.I. safe working stress of 18000 lbs/□" seem to be a safety factor of 3½ - 4

When test bar was ($\frac{3}{4}$" dia) was loaded to 5000 lbs. extension was ·0003½" per unit of length.

When loaded to 18,800 lbs (30,000 lbs/□" yield point) extension was ·001" per unit of length.

The graph shows a straight line up to the yield point.

OTHER TESTS FOR MATERIALS

Compression tests are made by concentrically loading the test pieces as the loading is increased the contraction of the material is noted. The compression per load is equal to the extension per load of similar materials i.e. extension of $\frac{3}{4}$" mild steel bar

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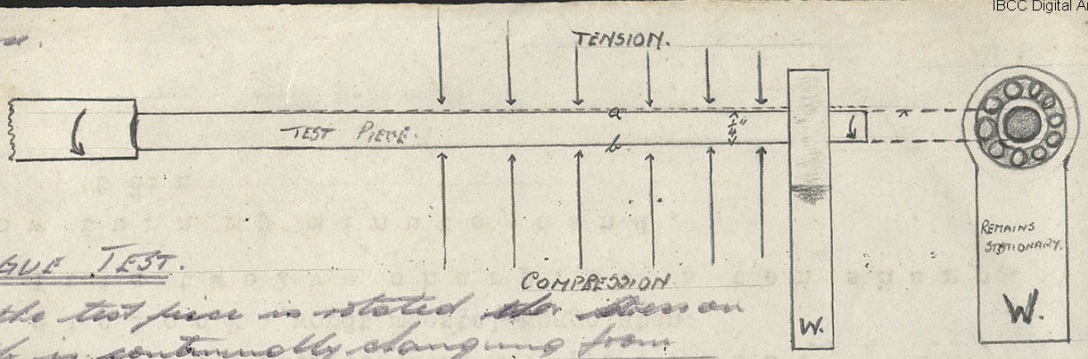
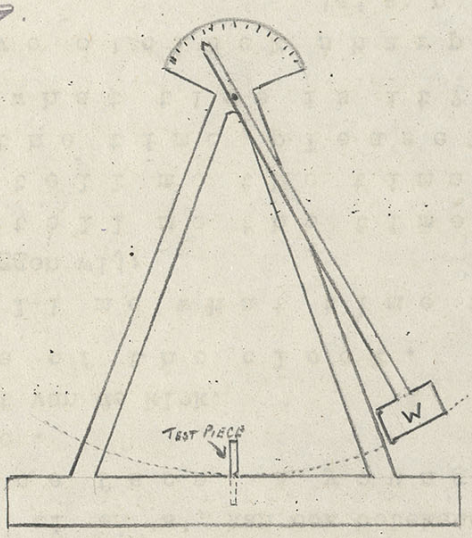
for use.

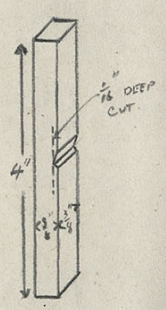


FATIGUE TEST.

As the test piece is rotated the stress on a & b is continually changing from tension & compression.

Impact Test. Test for materials which may be subjected to shock loading.





TEST PIECE

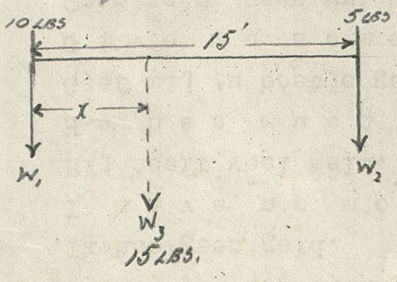
IZOD IMPACT TESTING MACHINE

The test for tensile & compression & torsion are the test most important, the hardness, fatigue & impact test are used more for materials used for specialised job.

Composition & Resolution of Forces.

Moment = force x distance.

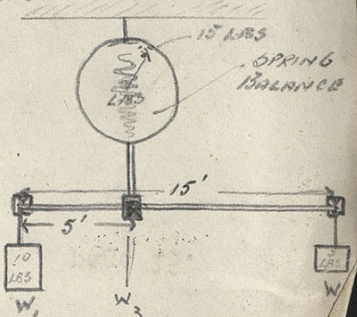
To find the resultant of two parallel forces. Two forces, W_1 & W_2 of 10 lbs & 5 lbs each respectively acting on a 15 ft beam, find W_3 resultant.

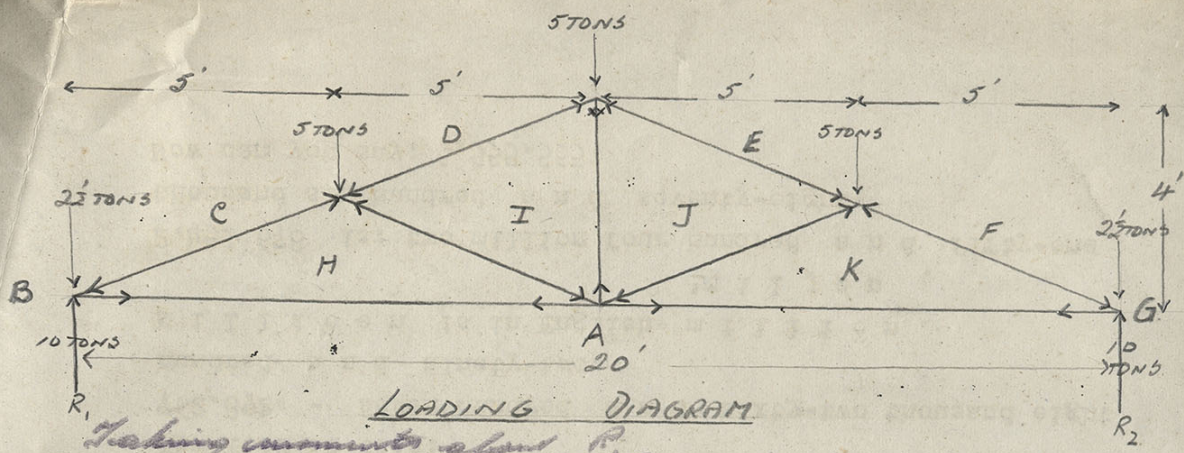


Moment = force x distance

$$X \times 10 = (15 - X)5$$
$$10X = 75 - 5X$$
$$15X = 75$$
$$X = 5'$$

A practical way of showing W_3. A beam 15' long loaded 10 lbs & 5 lbs. Point of balance W_1 W_3 equals 15. Total load 15 lbs as shown on spring balance.





LOADING DIAGRAM

Taking moments about R_1

$$0 = (20 \times R_2) - [(2\tfrac{1}{2} \times 20') + (5 \times 15) + (5 \times 10) + (5 \times 5)$$

$$= 20R_2 - 200$$

$$20R_2 = 200$$

$$R_2 = 10 \text{ TONS}$$

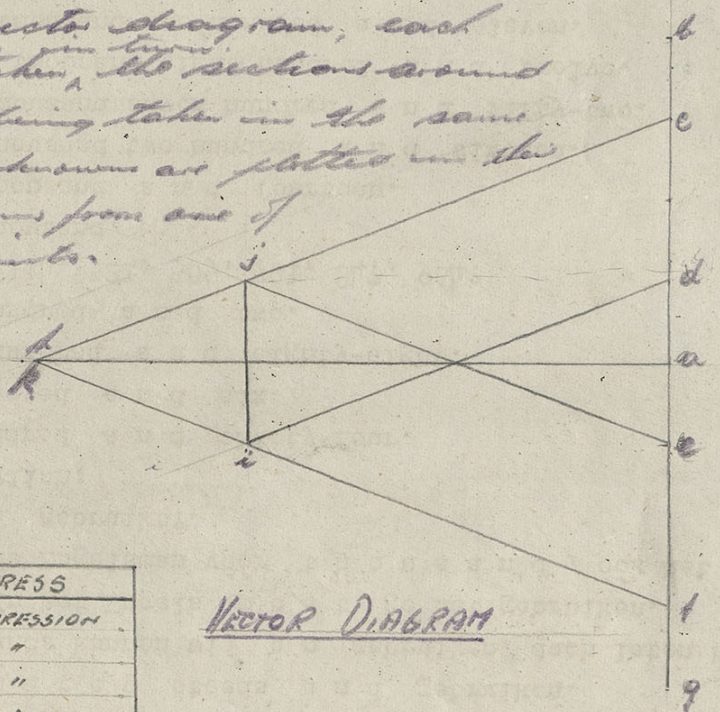
$$\therefore R_1 = 20 - R_2$$

$$= 20 - 10$$

$$R_1 = 10 \text{ TONS}$$

SCALE 1 TON = 5 MM

To draw the vector diagram, each section is taken in the sections around each joint being taken in the same rotation. The unknown are plotted in the same directions from one of the known joints.



VECTOR DIAGRAM

MEMBER	LOAD	STRESS
CH	21 TONS	COMPRESSION
DI	14 "	"
EJ	14 "	"
FK	21 "	"
KA	19½ "	TENSION
HA	19½ "	"
HI	7 "	COMPRESSION
IJ	5 "	"
JK	7 "	"

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