Robert Hooke (1635-1703)

http://www-history.mcs.st-andrews.ac.uk/history/PictDisplay/Hooke.html

•Very early in his life he showed great interest in making mechanical toys and in drawing.

•As a chorister at Oxford, he came into contact with many scientists, including Robert Boyle, with whom he perfected an air pump.

•He began working on springs in order to develop a solution to the Longitude problem; his goal was to use springs, instead of gravity, for making a body vibrate. He published the first paper that discussed the elastic properties of solids, "De Potentiâ Restitutiva (Of the Spring)".

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ut tensio sic vis (As the extension, so is the force)

•Became interested in microscopy, and published "Micrographia".

•Was very active in London's reconstruction after the Great Fire of London In 1666; he was made a surveyor by the city magistrates, and designed (as did Christopher Wren) numerous buildings.

- **Had a clear picture of universal gravitation.**

At a meeting of the Royal Society of London in 1666, he explained

"I. That all heavenly bodies have not only a gravitation of their parts to their own proper centre, but that they also mutually attract each other within their spheres of action."

"II. That all bodies having a simple motion, will continue to move in a straight line, unless continually deflected from it by some extraneous force, causing them to describe a circle, an ellipse, or some other curve."

"III. That this attraction is so much the greater as the bodies are nearer. As to the proportion in which those forces diminish by an increase in distance, I own [says he] I have not discovered it although I have made some experiments to this purpose. I leave this to others, who have time and knowledge sufficient for the task."

not appear so rounded, and lying above the Paper, as it were, as it ought to do) that is, it was for the most part pretty oval end-ways, somewhat like an Egg, but the other way it was a little flatted on two opposite sides. Divers of these Eggs, as is common to most others, I found to be barren, or addle, for they never afforded any young ones. And those I usually found much whiter then the other that were prolifick. The Eggs of other kinds of Oviparous Insects I have found to be perfectly round every way, like so many Globules, of this sort I have observ'd some sorts of Spiders Eggs; and chancing the last Summer to inclose a very large and curiously painted Butterfly in a Box, intending to examine its gaudery with my *Microscope*, I found within a day or two after I inclos'd her, almost all the inner surface of the Box cover'd over with an infinite of exactly round Eggs, which were stuck very fast to the sides of it, and in so exactly regular and close an order, that made me call to mind my *Hypothesis*, which I had formerly thought on for the making out of all the regular Figures of Salt, which I have elsewhere hinted; for here I found all of them rang'd into a most exact *trigonal* order, much after the manner as the *Hemispheres* are place on the eye of a Fly; all which Eggs I found after a little time to be hatch'd, and out of them to come a multitude of small Worms, very much resembling young Silk-worms, leaving all their thin hollow shells behind them, sticking on the Box in their *trigonal* posture; these I found with the *Microscope* to have much such a substance as the Silk-worms Eggs, but could not perceive them pitted. And indeed, there is as great a variety in the shape of the Eggs of Oviparous Insects as among those of Birds.

Of these Eggs, a large and lusty Fly will at one time lay neer four or five hundred, so that the increase of these kind of Insects must needs be very prodigious, were they not prey'd on by multitudes of Birds, and destroy'd by Frosts and Rains; and hence 'tis those hotter Climates between the *Tropicks* are infested with such multitudes of Locusts, and such other Vermine.

Observ. XLII. *Of a blue Fly.*

THis kind of Fly, whereof a *Microscopical* Picture is delineated in the first *Figure* of the 26. *Scheme*, is a very beautifull creature, and has many things about it very notable; divers of which I have already partly describ'd, namely, the feet, wings, eyes, and head, in the preceding Observations.

And though the head before describ'd be that of a grey *Drone-Fly*, yet for the main it is very agreeable to this. The things wherein they differ most, will be easily enough found by the following particulars:

First, the clusters of eyes of this Fly, are very much smaller then those of the *Drone-Fly*, in proportion to the head.

And

Observ. XLII. *Of a blue Fly.*

ſeminal principle from which this minute Plant on Roſe leaves did ſpring, were, before the corruption caus'd by the Mill-dew, a component part of the leaf on which it grew, and did ſerve as a *concoct* in the production and conſtitution of it, yet might it be ſo conſummate, as to produce a ſeed which might have a power of propagating the ſame ſpecies: the works of the Creator ſeeming of ſuch an excellency, that though they are unable to help to the perfecting of the moſt compounded exiſtence of the greater Plant or Animal, they may have notwithſtanding an ability of acting ſingly upon their own internal principle, ſo as to produce a Vegetable body, though of a leſs compounded nature, and to proceed ſo farr in the method of other Vegetables, as to bear flowers and ſeeds, which may be capable of propagating the like. So that the little caſes which appear to grow on the top of the ſlender ſtalks, may, for ought I know, though I ſhould ſuppoſe them to ſpring from the perverting of the uſual courſe of the parent Vegetable, contain a ſeed, which, being ſcatter'd on other leaves of the ſame Plant, may produce a Plant of much the ſame kind.

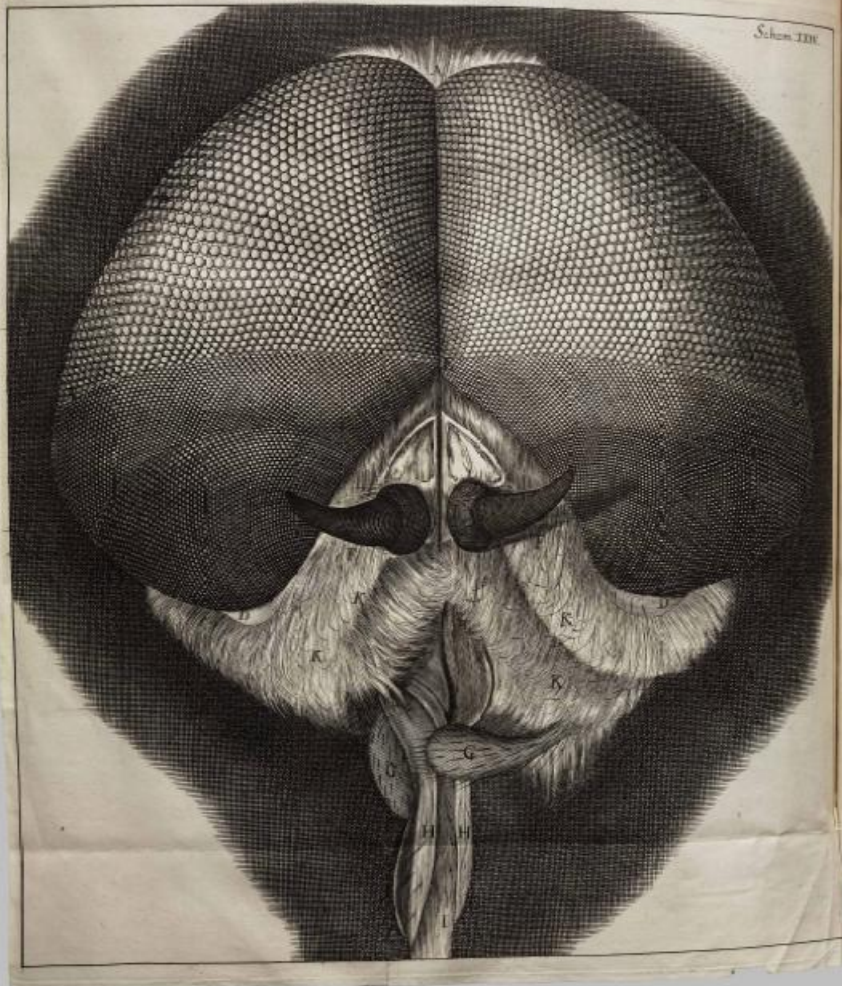
Nor are Damaſk-Roſe leaves the onely leaves that produce theſe kinds of Vegetable ſproutings; for I have obſerv'd them alſo in ſeveral other kinds of Roſe leaves, and on the leaves of ſeveral ſorts of Briers, and on Bramble leaves they are oftentimes to be found in very great cluſters; ſo that I have found in one cluſter, three, four, or five hundred of them, making a very conſpicuous black ſpot or ſcab on the back ſide of the leaf.

Obſerv. XX. *Of* blue Mould, *and of the firſt Principles of Vegetation ariſing from* Putrefaction.

THe Blue and White and ſeveral kinds of hairy mouldy ſpots, which are obſervable upon divers kinds of *putrify'd* bodies, whether *Animal* ſubſtances, or Vegetable, ſuch as the ſkin, raw or dreſs'd, fleſh, bloud, humours, milk, green Cheeſe, *&c.* or rotten ſappy Wood, or Herbs, Leaves, Barks, Roots, *&c.* of Plants, are all of them nothing elſe but ſeveral kinds of ſmall and variouſly figur'd Muſhroms, which, from convenient materials in thoſe *putrifying* bodies, are, by the concurrent heat of the Air, excited to a certain kind of vegetation, which will not be unworthy our more ſerious ſpeculation and examination, as I ſhall by and by ſhew. But, firſt, I muſt premiſe a ſhort deſcription of this *ſpecimen*, which I have added of this Tribe, in the firſt Figure of the XII. *Scheme*, which is nothing elſe but the appearance of a ſmall white ſpot of hairy mould, multitudes of which I found to beſpeck & whiten over the red covers of a ſmall book, which, it ſeems, were of Sheep-ſkin, that being more apt to gather mould, even in a dry and clean room, then other leathers. Theſe ſpots appear'd, through a good *Microſcope*, to be a very pretty ſhap'd Vegetative body, which, from almoſt the ſame part of the Leather, ſhot

out

Obſerv. X X. *Of* blue Mould, *and of the firſt Principles of Vegetation ariſing from* Putrefaction.



Obferv. XXXIX. *Of the Eyes and Head of a Grey drone-Fly, and of feveral other creatures.*

I took a large grey *Drone-Fly*, that had a large head, but a fmall and flender body in proportion to it, and cutting off its head, I fix'd it with the forepart or face upwards upon my Object Plate (this I made choice of rather then the head of a great blue Fly, becaufe my enquiry being now about the eyes, I found this Fly to have, firft the biggeft clufters of eyes in proportion to his head, of any fmall kind of Fly that I have yet feen, it being fomewhat inclining towards the make of the large *Dragon-Flies*. Next, becaufe there is a greater variety in the knobs or balls of each clufter, then is of any fmall Fly.) Then examining it according to my ufual manner, by varying the degrees of light, and altering its pofition to each kinde of light, I drew that reprefentation of it which is delineated in the 24. *Scheme*, and found thefe things to be as plain and evident, as notable and pleafant.

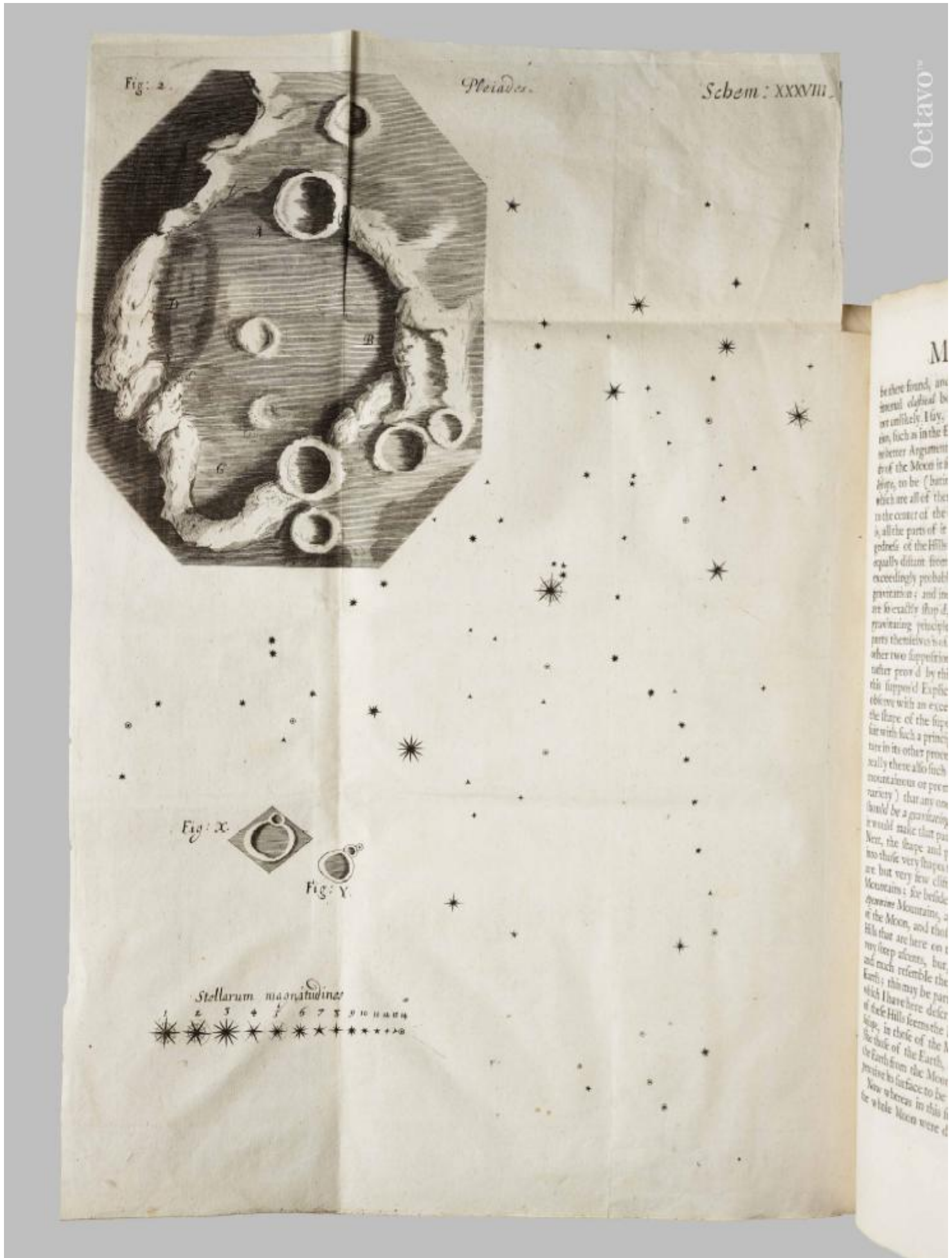
Firft, that the greateft part of the face, nay, of the head, was nothing elfe but two large and *protuberant* bunches, or *prominent* parts, A B C D E A, the furface of each of which was all cover'd over, or fhap'd into a multitude of fmall *Hemifpheres*, plac'd in a *trigonal* order, that being the clofeft and moft compacted, and in that order, rang'd over the whole furface of the eye in very lovely rows, between each of which, as is neceffary, were left long and regular trenches, the bottoms of every of which, were perfectly intire and not at all perforated or drill'd through, which I moft certainly was affured of, by the regularly reflected Image of certain Objects which I mov'd to and fro between the head and the light. And by examining the *Cornea* or outward fkin, after I had ftript it off from the feveral fubftances that lay within it, and by looking both upon the infide and againft the light.

Next, that of thofe multitudes of *Hemifpheres*, there were obfervable two degrees of bignefs, the half of them that were lowermoft, and look'd toward the ground or their own leggs, namely, CDE, CDE being a pretty deal fmaller then the other, namely, ABCE, ABCE, that look'd upward, and fide-ways, or foreright, and backward, which variety I have not found in any other fmall Fly.

Thirdly, that every one of thefe *Hemifpheres*, as they feem'd to be pretty neer the true fhape of a *Hemifphere*, fo was the furface exceeding fmooth and regular, reflecting as exact, regular, and perfect an Image of any Object from the furface of them, as a fmall Ball of Quick-filver of that bignefs would do, but nothing neer fo vivid, the reflection from thefe being very languid, much like the reflection from the outfide of Water, Glafs, Cryftal, *&c.* In fo much that in each of thefe *Hemifpheres*, I have been able to difcover a Land-fcape of thofe things which lay before my window,

Robert Hooke. *Micrographia.* London, 1665. THE WARNOCK LIBRARY

Obferv. XXXIX. *Of the Eyes and Head of a Grey drone-Fly, and of feveral other creatures.*



Obſerv. LX. *Of the Moon.*

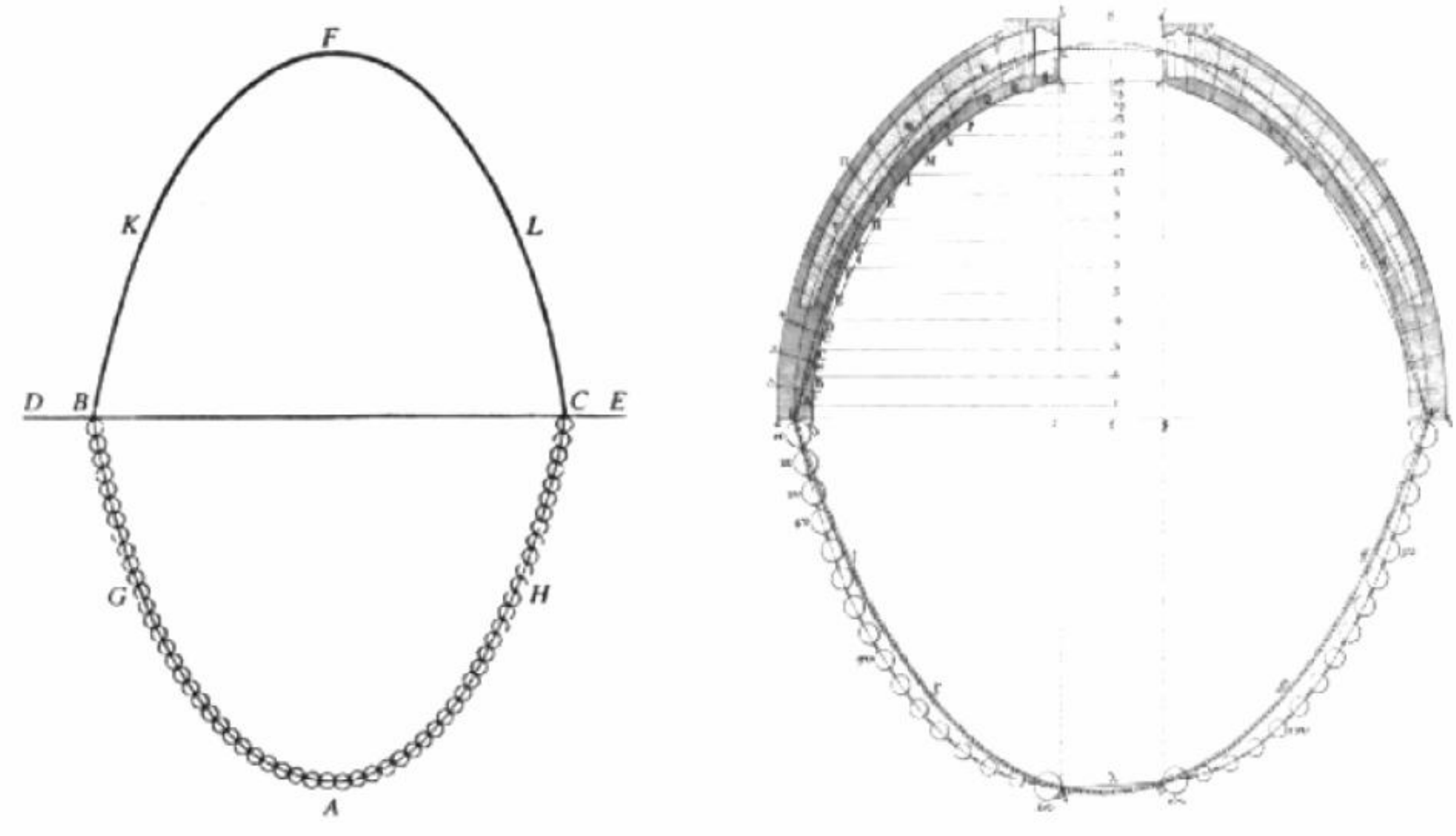


Fig. 1. (a) Poleni's drawing of Hooke's analogy between an arch and a hanging chain, and (b) his analysis of the Dome of St.-Peter's in Rome [1748]

EXAMPLE 2(B): METHOD: MAXWELL DIAGRAM WITH BOW'S NOTATION

GIVEN: The same symmetrical truss, drawn to scale, with asymmetrical loads, used in the preceding method of joints example, *Figure 8-79A*. Label the triangular spaces within the truss with numbers. Draw a light line envelope surrounding the truss and passing through each applied force and reaction. Label these spaces with letters.

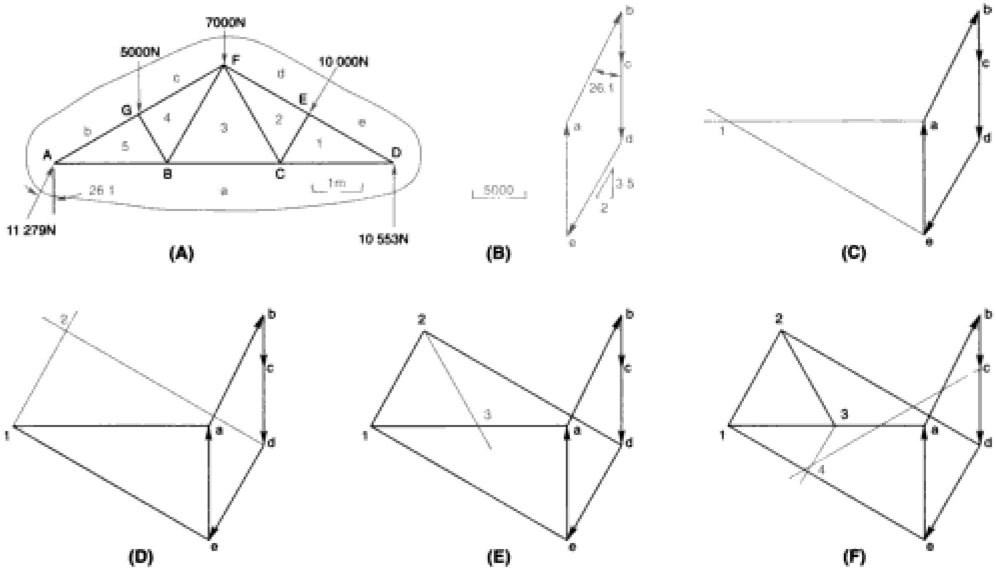
STEP 1 Start a force diagram (to a scale to keep the diagram on the drawing sheet) by reading the external spaces in a clockwise direction, a to b, b to c, c to d, d to e, and e to a. Plot each applied force and reaction, *Figure 8-79B*.

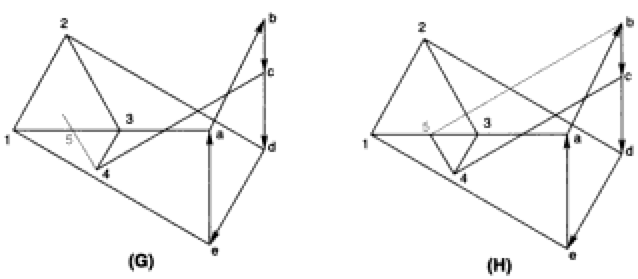
Either clockwise or counterclockwise will work, but once a pattern is started it must be used throughout the complete problem both for the Maxwell diagram and for determining whether a member is in tension or compression.

STEP 2 Start at a joint with only two unknowns, A or D. At joint D, go clockwise a to 1, 1 to e, and e to a to locate point 1, *Figure 8-79C*.

STEP 3 Now joint E has only two unknowns, so continue d to e, e to 1, 1 to 2, and 2 to d to locate point 2, *Figure 8-79D*.

Graphical methods of structural analysis started with (Flemish Engineer) Simon Stevin's (1548-1620) parallelogram rule and closed force diagrams (1586).





MEMBER	FORCE N	T OR C
AB	12,900	T
BC	8,400	T
CD	18,500	T
DE	21,400	C
EF	21,400	C
FG	17,900	C
GA	20,700	C
BG	4,300	C
BF	4,400	T
CF	10,200	T
CE	10,000	C

(I)

FIGURE 8-79 (A) Example 2 (b) Maxwell diagram with Bow's notation; (B) Step 1; (C) Step 2; (D) Step 3; (E) Step 4; (F) Step 5; (G) Step 6; (H) Step 7; (I) Step 8

From
Technical Drawing
D.L. Goetsch, W. Chaulk, J. Nelson

EXAMPLE 2(B): METHOD: MAXWELL DIAGRAM WITH BOW'S NOTATION

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STEP 3 Now joint E has only two unknowns, so continue d to e, e to 1, 1 to 2, and 2 to d to locate point 2, *Figure 8-79D.*

STEP 4 For joint C go a-3-2-1-a to locate point 3, *Figure 8-79E.*

STEP 5 Joint F has only two unknowns, so go d-2-3-4-c-d to locate point 4, *Figure 8-79F.*

STEP 6 Around point B go a-5-4-3-a to locate point 5, *Figure 8-79G.*

STEP 7 For the last joint, A, go a-b-5-a, *Figure 8-79H.* The closing line in direction 5-b should intersect point b on the Maxwell diagram for a correct solution.

STEP 8 Prepare a table of the forces in each member; scale the diagram for magnitudes and use the clockwise pattern to determine whether the force goes into the joint (compression) or goes away (tension), *Figure 8-79I.* For example, around joint C for member CF, 3-2 goes away from the joint; thus, CF is in tension. Scale the magnitude to be 10,000 N. Around joint F, 2–3 goes away from the joint F as expected because CF is a tension member.

Assignment

Use the Maxwell diagram method to determine the reaction forces and the forces in all members.