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III. *Several Experiments on the Attrition of Bodies in Vacuo. Made before the Royal Society at Gresham College, by Mr Fr. Hauksbee, F. R. S.*

*A Description of the Machine for Giving a Swift Motion to Bodies in Vacuo, without Admitting the External Air, represented in Tab. II. Fig. 1.*

**A.** A. Is a Ladder, such as is generally us'd in Houses.  
**B. B.** Is a Bar of Iron which passes through the Middle of the upper Step, and is fasten'd to the Back-board of the Ladder by 2 Nutts and Screws thro both the Board and Iron.

**C. C.** The Jaws of the Iron Frame which holds the great Wheel. **D. D.** 23 inches Diameter within its Groove.

**E. E.** The Brass Plate of the Air Pump on which the Recipient **f. f.** is placed.

**g. g.** The Spindle to which Bodies of different Magnitudes may be fasten'd, by a hole passing thro the Middle of them, sufficient to receive the Spindle; and by means of the 2 Nutts **h. h.** a larger or a smaller Body may be screw'd fast between 'em.

**i. i.** Is a Brass Plate turn'd true to the Ground Edge of the Recipient on which it is plac'd, having a Brass Box in the middle of it, which is full of Collars of Leather well oyl'd, thro which the Spindle passes: The hole of the Brass being likewise just fit to receive it.

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k. k. Two Pillars with Nutts to scrow down a piece of Board, which has an Iron fasten'd to it to receive the upper point of the Spindle, the lower one falling into a Brass Socket, scrow'd to the middle of the Plate of the Air Pump.

l. l. The Supporters reaching from the upper Board of the Ladder to the Pillars, to prevent the Recipients being drawn from its place by the motion and tug of the Wheel-band.

m. m. The small Wheel which the Band surrounds from the great one, and is 1 Inch and a half diameter.

n. n. The Winch which gives motion to the whole. The small Wheel m. m. making about 15 Revolutions to one of the large Wheel D. D. so that a Body fastned to the Spindle g. g. of the small Wheel m. m. must be turn'd 15 times round to once of the great Wheel; and according as it shall exceed in Diameter the small Wheel, so will the Velocity of the Motion of the Extreme parts be proportionably encreas'd.

o. o. Are two Screws which fasten the Ladder to the Floor.

### Experiment I.

*An Account of an Experiment made Novemb. 21. 1705. at a Meeting of the Royal Society at Gresham College, shewing that Light is Producibile upon a swift Attrition of Amber on Woollen in Vacuo.*

Being prepar'd with the Machine before describ'd, for giving a swift motion to Bodies *in Vacuo*, the Amber made use of in this Experiment was Beads, about the bigness of small Nutmegs, and Threaded; by which means a piece of Wood was surrounded with them, which I had purposely caus'd to be Turn'd, with a Groove on the edge of it, to keep the Beads from being displac'd upon a smart  
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**Attrition.** Likewise between every Bead was ty'd over a String from Pin to Pin, which were so many pieces of small Wire, drove thro the Wood for their better security and fastness, the Beads appearing about half their Diameter beyond the Wood to which they were fixt. (as in *Fig. 2.*) In this manner it was put on the Spindle, and fasten'd there by the two Nutts, as before describ'd. (See *Fig. 3.*) Then the Brass Plate on which the Woollen was wrapt, being screw'd to its place, (by means of the Socket, which receives the lower point of the Spindle) would then spring back, and embrace the Amber with a moderate force. (as in *Fig. 3.*) Thus prepar'd, and the Receiver plac'd over, with its upper Plate and Box for the Spindle to pass through, the Pump was set on work, and in a very little time the Mercury in the Gage was elevated to about 29 inches and a half, which shew'd the Recipient to be well exhausted of its Air. The Great Wheel being then turn'd, gave a very swift Attrition of the Amber on the Woollen, but no Light at first appear'd: Yet in a second or two of time it became visible enough; which shews it requires some degrees of Heat to produce the *Phenomenon*. I could not observe that the Continuance or Encrease of the Motion, did contribute any thing to the Enhancement of the Light, after the first production of it: Nor would the Light thus produc'd, live on the Amber to continue a Circle, notwithstanding the velocity of the Motion given; but dy'd so soon as it had deserted the Affricated Woollen. However, on the Woollen, (during the Motion,) where the Attrition of the Amber was made, the Light continu'd without Intermission, and was discernible at three or four foot distance. What farther to be taken notice of in this Experiment was, That it highly Corroborates and Confirms those made on the Production of Heat *in Vacuo* by Attrition: For the Amber was not only moderately heated, but appear'd to be burnt and crackt by the Intensity of it. And the Woollen

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against which it rubb'd, appear'd likewise not only discolour'd, but perfectly scorcht and burnt through : That altho the same Motion and the same Attrition was given the Amber in the Open Air, yet very little Light did ensue, in Comparison to the Appearance of it *in Vacuo* : That the Travel or Velocity of the extreme parts of the Amber, was equal to something more than one third of a mile in a minute : Supposing the large Wheel to make two Revolutions in a second of time, whose Diameter is 23 Inches ; the Diameter of the small one mov'd by it, one Inch and a half ; and the Diameter of the Wood and Amber on the same Spindle with the small Wheel, four Inches and a half.

#### Experiment II.

*Shewing the Necessity of the Air's Presence ( at least some degree of it ) in the Production of Fire, upon the Attrition of Flint and Steel.*

**H**AVING provided a Steel Ring about 4 Inches Diameter, its Thickness about one eighth of an Inch, which between two pieces of Wood of a less Diameter, I fixt on the Spindle with the Nutts, as mentioned in the foregoing Experiment ; its edge verging beyond the extreme of the Wood that held it about half an Inch. The Brass Plate, which I made use of for fastning the Woollen for the Attrition of Amber, serv'd likewise to fix a piece of Flint : An edge or corner of which stood expos'd to the Steel, which Brass Plate by its Spring would hold the Flint pretty strongly to it, notwithstanding some might be worn or chipt off by the Rapidity of the Motion given. In this manner it was Cover'd with a Receiver, and Brass Plate and Box, as the former. But before any Air was exhausted, the Great Wheel was mov'd, which gave motion to the small one, and consequently to the Included Steel, which

which exhibited sparks of Fire in a very plentiful manner. After some Air had been withdrawn, the Great Wheel was turned, as before, but the number of Sparks then produc'd did not only seem to be lessen'd, but a sensible decay of their Lustre and Vigour was manifest. And so at every stop that was made, to repeat the Experiment at greater Rarefactions, did the Sparks produc'd still diminish in their Quantity and Light; till at last, when the Receiver was well exhausted of Air, then altho a more violent Motion was given the Steel than before, yet not the least Spark appear'd to be struck from it: But a small Continued Light was visible on the edge of the Flint, that was rubb'd by the Steel. Upon the letting in a little Air, some Sparks upon the motion given, were discovered of a dull gloomy hue; but upon letting in a little more Air, I know not by what Accident, the whole quantity Insinuated, and then upon the repetition of the Wheels motion, the Sparks appeared as numerous and as vivid as at first.

### Experiment III.

*Touching the Production of a Purple Light, upon the Attrition of Glass on Woollen in Vacuum. Together with the Various Phænomena of the same Experiment at several Tryals. As likewise some other Experiments on the same subject.*

The manner of making the Attrition, and the uses of the several *Apparatus*, being already at large describ'd, I shall not need now to take farther notice of them. The Glass us'd in this Experiment was Globular, about 4 Inches Diameter, having a Passage thro the Middle of it to receive the Spindle, to which it was fasten'd with Corks and Screw. The Woollen against which it was to rub, was such as is now commonly sold for Gartering, the courser sort of which I purposely chose for its harshness,  
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thinking it likely to improve the *Phænomenon*, beyond the List of Cloath formerly us'd for the same purpose. This Woollen was wrapt about the Arms of the Brass Spring, (describ'd in former Experiments,) and being screw'd down-to its place, gently embrac'd the Glass Globe. Thus prepared, and the large Receiver put over all, the Pump was wrought, and in a little time had exhausted the Air from the Receiver: Then the large Wheel being turn'd, gave 15 Revolutions to the Included Globe, to one of its own; in which swift motion, rubbing on the premention'd Woollen, a fine Purple Light ensu'd, the included *Apparatus* being distinguishable by it, and continu'd so during the Attrition. Upon letting in a little Air, both the Light and its Colour did diminish: And as the Air at several times was suffer'd to re-enter the Receiver, so the Light became manifestly more Pale, and less Vivid. And even when the Receiver was repleat with Air, a small faint Light did discover itself upon the same Attrition given, as at first. What is farther observable in this Experiment was, That the Purple Light which appear'd, seem'd to be about the breadth of half an Inch, and about one in height, being visible no where but on each Arm of the Brass Spring, where the Glass in its motion rubb'd on the Woollen. That the Light remain'd steady without the least Undulation, notwithstanding the Motion of the Glass was considerably swift. This being all that occur'd at that time, I now beg leave to give some Account of the Various *Phænomena* that has happen'd at divers Repetitions of the same Experiment.

The first time I made it, its success was much the same as I have just now related: But when I came to repeat it twice or thrice, with the same Glass, no Purple Light appear'd, a pale one then succeeded in its room, nor all the means I us'd could recover it, till I took a new Glass, which after I had us'd for the same purpose two or three times,

times, serv'd me as the former; nor could it be Reviv'd again without a new one. In this Experiment it was sometimes observable, that the Glass, when taken out after a violent Attrition, would be so hot as not to be held in the naked hand without a sensible Offence. That the Woollen on which it rubb'd would not only appear discolour'd, but sometimes perfectly burnt through. Sometimes upon making this Experiment, it has happen'd that a Light would be carried quite round the Glass Globe, thereby making a continued Circle of it, during its Motion; notwithstanding it toucht the Woollen in no more parts than in the former Experiments. At other times, a perfect *Halo* would discover itself around the Stagnant Light; which seems to me to proceed from some few drops of Water, that will sometimes Insinuate by the Spindle through the Box on the upper Brass Plate, where is always kept Water, to prevent the entrance of Air there. This Water descending the Spindle till it reacht some more extensive part, would there, by the violence of the Motion given, be thrown all about the Receiver in small drops, some of which were likely to fall on the Woollen, where being heated by the Motion of the premention'd Glass, evaporated, appearing as a *Halo* around the Light; for since I made a Contrivance, to prevent the Waters scattering, no such Appearance has happen'd.

Sometimes I have observed the Light to break from the Agitated Glass, in as odd a form as Lightning: Particularly at a time when I us'd some Lint of Cloath, that had been drencht in Spirit of Wine, which was fasten'd to one Arm of the Brass Spring, on the other of which was ty'd some of the same Lint, that had been steep in Water impregnated with Salt-petre; but both the pieces of Lint were very well dry'd before I made use of them.

At another time I made use of two flat Shells of Oysters well dry'd ; instead of the Woollen for the Attrition of the Glass, each Arm of the Brass Spring had one fixt to it. Upon the usual Motion given the Glass *in Vacuo*, a Light appear'd, resembling a fierce flaming Spark, just upon the spot where the Glass and Shells toucht one upon another. The Light seem'd not to extend itself, but was comprehended in a small Compass.

I try'd next what would ensue upon the Attrition of Woollen on the premention'd Shells *in Vacuo*. The success was, that there was a Light produc'd, but appear'd very dim and gloomy, at best like a faint *Halo*.

After all these, I thought it not amiss, to try in what degree the Woollen might contribute to the *Phanomena* of the foregoing Experiments. I took some of the Lint formerly mentioned, and bound it about the edge of a Wooden Wheel I had caus'd to be Turn'd for that purpose ; the Wheel, with its Woollen edge, I fasten'd on the Spindle, as usual, and upon the Brass Spring was used the same Gartering, as in the first Experiment. These being put together, as in all the others, and the Receiver exhausted, the large Wheel was turn'd, and upon the Attrition of the Woollens, a small glimmering Light did succeed ; but the Continuance of the Motion, gave no encouragement to hope for any increase of it. I expected to have found the Woollens at least discolour'd, upon the Friction of them, which was sometimes made more than moderate. On the contrary, not the least Sign of any such thing appear'd. The Light totally disappear'd, upon the readmission of less than a quarter of the Recipients natural Content of Air, altho the Attrition then made was as great as it had been at any time before. I cannot discover that the various Colours of Woollen (as yet that I have try'd) does any thing contribute to the Different Colours of Light, exhibited in any of these Experiments:

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## Experiment IV.

*Touching the Production of a Considerable Light, upon the Attrition of Glass on Glass in Vacuo, and in Common Air.*

For this Experiment I made use of a Globular Glass, about three Inches Diameter, fixt on the Spindle, ( as in the last, ) and to the two Arms of the Brass Spring ( taken notice of in the same ) were ty'd two slips of thin Board ; to each of which were first fasten'd two pieces of Glass Tube, by putting some small Neal'd Wires through their Cavities, which Wires likewise passing through some holes of the Board made for that purpose, kept them tight in their places, ( in form of *Fig. 5.* ) In this Mode, being cover'd with a large Receiver, and fitted in all respects as usual, the Pump was wrought ; which in a little time had exhausted the Air from it. Then upon turning the large Wheel, a swift Motion was given to the included Glass Globe, in which Motion, rubbing on the premention'd Tubes, a considerable Light was exhibited : The whole Included *Apparatus* became perfectly distinguishable by it, and would have been much more so, had not the Day-light prevented : It then being but very little after 5. P. M. a clear Horizon, and in an open Room, when the Experiment was made. The Colour of the Light produc'd resembled Melted Glass, not only just on the parts where the friction was made, but seemingly likewise at the Extrems of the Tubes A. B. where the Globe in its motion toucht them not.

What farther Observable in this Experiment was, That upon suffering the Air to re-enter the Recipient at several times, at every of which, the Motion being given, as at first, no sensible Decay of Light, or Colour of it appear'd, excepting at last, when the Tubes by much rubbing became

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worn, and consequently lessen'd in their Spring; so the Light (in proportion to the abatement of their force on the Moving Body,) would be diminish'd; as I have often observ'd, when the Motion has been made for some small time, only in *Vacuo*, or in Common Air. And had the Experiment been begun where it finish'd, the lesser quantity of Light (from the premention'd Cause) would then have been exhibited in *Vacuo*. Hence it follows, That the Different Mediums did no ways contribute to the Augmentation or Diminution of the Light produc'd, but seems wholly to proceed from the weakening of the Spring, by the wear of the Bodies; which is begot by the violent Attrition of one upon the other in either medium. I do not find that the pollish, or glaze, on the outside of a Glas. adds any thing to the Light, having produc'd the same by a Glas much worn by often using.

I have repeated the same Experiment about noon in a clear day; the success was, that the Light produc'd in *Vacuo* was then as sensible to sight, as a piece of red hot Glas of the same bigness at the same time would have appear'd in the open Air. But notwithstanding the Appearance is such, it is no longer so than the Motion is continu'd. Hence it is to be observ'd, That altho it seems to be of the Colour of Red hot, or Melted, yet it is not; for were it really so, it must of Necessity some small time outlive the Motion; which in the darkest Night I could (as yet) never discover.

## Experiment V.

*Touching the Production of Light upon the Attrition of Glass on Glass under Water.*

This Experiment was nothing more than a Repetition of the last, saving only the Included *Apparatus* was entirely cover'd with Water : From the surface of which when the Air came to be withdrawn, and the great Wheel turn'd as usual, 'twas easie to discover a pretty smart Light, upon the first motion of the Included Glass Globe on the Tubes, illuminating the whole body of the Liquid. The parts of the Tubes where the friction was made by the Globe were distinguishably Red ; but soon lessen'd in their Appearance, and in no long time extinguish'd. The Water (by the Continuance of the Motion) approaching nearer and nearer to the Colour of Whey ; and at last became so thick, by the Grit or Powder produc'd by the Attrition of the Glasses, that the Light could then be but just discover'd thro the Body of it, and that not constantly, but like faint flashes at distances. This Experiment I have made, when it has succeeded to appear more Luminous than at this tryal. I have observ'd the Dust (produc'd from the Glasses upon their Attrition) thro a good Microscope, but could not learn by my greatest attention that the parts were any ways melted ; they appear'd of a long and slender figure.

Tab: 2

Philos: Trans act: N: 304:

