

John Wybard

Tactometria. Seu, Tetagmenometria. Or, The geometry of regulars practically proposed: after a new, most artificial, exact and expeditious manner (together with the natural or vulgar, by way of mensurall comparison) ... A work very usefull and delightfull for all such as are either ingenuously studious of, or necessarily exercised and employed in the practice of the art metricall.

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Preface

Wybard's book contributes to the study of English measures because:

- ☛ It vouches for the acceptance of the 231-cubic inch wine gallon in the mid-seventeenth century.
- ☛ It confirms the existence in the 1640's at the Guildhall in London of two capacity standards:
 - one of 224-cubic-inches. This standard was remeasured in 1688 by Halley and Flamsteed and again in 1819 by a parliamentary committee, with results similar to Wybard's. The 224-cubic-inch wine gallon probably represented the volume of eight avoirdupois pounds of wine. It had no descendents. The 231-cubic-inch gallon was defined differently; some say eight Troy pounds of wheat, others 8 *libra mercatoria* of wine.
 - one of "well nigh" 266 cubic inches. This standard probably represents the corn gallon of Henry VI, one-eighth of 9 stricken gallons, each gallon being the volume of 8 Troy pounds of wheat. For a full discussion, see Connor, chapter 9.
- ☛ It illustrates the state of metrology at the time.

In transcribing this material for the web, every long "s" has been changed to a regular "s". Otherwise we have tried to imitate the original printing as closely as possible. Numerous copyediting and proofreading errors have been preserved: for example, words occur with several different spellings (powred, poured; neer, near), and italicization is inconsistent. The type itself was worn, and the uppercase sort contaminated with italic letters. This book was not a production to which great care was given.

The only abbreviations which might puzzle a modern reader are *li.* for pound (*libra*), and p.w. for pennyweight. The term *ferè*, which is also found in French books of arithmetic, apparently means the number it follows has been rounded up.

[page 264]

Part III, Section II.

Setting forth the Quantities of the Wine and Ale-gallons,
in reference to the gauging of Vessels.

It is generally holden by Artists about the City of *London*, that a *Wine-Gallon* containeth in its concave Capacity, 231 cubicall or solid inches, or is insensibly different therefrom: But for the *Ale* or *Beer-Gallon*, I finde the same to be as generally controverted among them. Mr. *William Oughtred*, a reverend Divine, and most eminent Mathematician, before-named, after some experiments made by him to find out the solid content of this *Gallon* in inches, besides the experiments of some others which came to his sight, finding some difficulty therein, in regard both of the irregularity which he observed to be usually in the several *Standard-Gallons* which he met with, and also their disagreement one from another in their Contents, as himself confesseth and declareth in his foresaid book of the *Circles of Proportion*, *Part I, chap. 9.* looketh back there to the first ground and principle of our English Measuring from *Barley-corns*: and so at length he commeth to a rationally conjecture of the *Ale-gallon* (and that very neatly, and pretty nearly also, as I shall straightway shew) in cubique inches, according to the number of the square-parts or Feet in the common *Statute-Pertch* or *Pole*, viz. $272\frac{1}{4}$, as you may see in the place fore-cited.

But Mr. *John Reynolds* aforementioned also, (who seemeth to have been as industrious in this, as in many other mathematicall experiments) wil have this *Gallon* to contain $288\frac{3}{4}$ cubique inches; holding that the *Wine-gallon* (which he strongly affirmeth to be 231 inches) is to the *Ale-gallon* in such proportion precisely, as 4 to 5; or rather for the reduction of *Wine-measure* to *Ale-measure*, as 5 to 4; which is according to Mr. *John Goodwyn* long agoe, in his little Tract
This Mr. *Goodwyn* was Master in the Mathematicks to Mr. *Reynolds*, as himself hath told me. entitled, *A Table of gauging*, published above 50 years since, and dedicated to the then Lord Major and Aldermen of the *City of London*: wherein he shewing how to reduce *Wine-measure* into *Ale-measure*, & *contra*; saith, that 5 gallons of wine-measure make but 4 gallons of *Ale-measure*: with which very nearly agrees the opinion (not certain experiment perhaps) of some others, who wil make this *Gallon* to contain just 288 inches upon this ground, that a cube-Foot should hold in its concave capacity just 6 *Ale-gallons*, and so consequently one *ale-gallon* must contain just 288 inches, which that learned gentleman Mr. *Edm. Wingate*, a *Barrester* of *Grayes-Inne* (a man eminent for his mathematicall abilities) first declared to me by word of mouth, and soon after I found the same noted in his book of the use of his *Rule of Proportion*, *chap. 10.* And these two jump

so nearly together, as if one were borrowed from the other : but I declaring this to Mr. *Reynolds* at my first seeing of him, he said that he had not observed this thing.

Now as for Mr. *Oughtred's* Ale-gallon of $272\frac{1}{4}$ inches, the said Mr. *Reynolds* indeed alloweth of such a Gallon-measure, but not for any liquid thing, but for drie things, as Corne, Coals, Salt, and other dry things measurable by this kind of Measure; and so calleth it the drie Gallon-measure : And thereupon he will have to be 3 severall Gallons (or other like Measures) one for *Wines*, (which also serveth for oiles, strong-waters and the like) Another for *Ale* and *Beer*, and a third for Corne, Coales, and the like; and this he maketh lesser than the Ale-measure, whereas surely it should rather be greater, if there be any difference at all between them : And these three severall Gallon-measures, he compareth together, or differenceth by these three numbers, viz. 28, 33, 35. as to show their proportions one to another : viz. the *Wine-Gallon* (231) to the dry Gallon-measure (272.25) as 28 to 33, which is so in the least terms, rationally or absolute ; but otherwise in the least proportionall termes, irrationall or unabsolute, and finite or limited, I find them to be as 7 to 8.25. And the said *Wine-Gallon* to his *Ale-Gallon* (288.75) as 28 to 35, which in the least rationally termes, is indeed as 4 to 5; but otherwise in the least termes irrationall (but finite or limited) I find them to be as 1 to 1.25. and the which again is integrally rationally, 100 to 125: And the dry-Measure to the Ale-measure, as 33 to 35, which cannot be abbreviated in terms rational.

And surely, evil Custome seemeth to have brought up three such distinct measures (and which the foresaid Mr. Wingate hath also expressed to me) For at the *Guild-Hall* in *London*, where is generally holden to be the true Standard for these Measures, and so from which all others of the like kind throughout the Kingdome, are usually derived, there are but two such distinct Measures only (as we have been there informed for a certain truth) viz, one for *Wines* (and so for strong-waters, oiles, and the like) and the other for *Ale*, *Beer*, and drie things, as Corn, Coales, Salt and the like; which latter is commonly called the *Winchester Measure*, and from this are taken the bigger drie Measures, as the *half-Peck* and *Peck*, and so on to the *Bushell*, which is the greatest of our drie Measures: Which said Standard-Measures at the *Guild-Hall*, the foresaid Mr. *Reynolds* confessed to me (going to him on purpose to receive some satisfaction from him about the Wine and Ale or Beer-measures (which was in *June* 1646, and then he gave me in writing under his hand, the solid content of the Ale-gallon to be $288\frac{3}{4}$ inches, and so its proportion to the Wine-gallon to be exactly as 5 to 4 (or for the reduction of Ale-measure to wine-measure, as 4 to 5) that he had never made any triall of them, (neither could I find that any other had, or if they had, it was surely to small purpose) but only of those Measures in the Tower of *London* (which he pleads for to be the most ancient and true standard Measures) and at *Cowpers-Hall*, and some other such places, which seem to be but some particular Customary measures, differing from the generally received Standard-measures at the *Guild-hall*.

And therefore to be fully satisfied in this point, concerning the true *Wine*,

and Ale or Beer Measures, according to the common Standards, (and more especially about the Ale or Beer-measure, finding such a diversity of opinions concerning the same, and in so vast a difference, as that between *Mr. Oughtred's* and *Mr. Reynold's* Ale-gallon, being $16\frac{1}{2}$ cube-inches My self and one *Mr. Baptist Sutton*, (a man well known in the City among artists) did agree to go together to the *Guild-hall*, where he was well acquainted with the keeper of the Standard-measures and Weights, who otherwise I found to be very nice and scrupulous in shewing of them ; and for our further satisfaction herein, we made known our intention to the foresaid *Mr. Wingate*, who much approved of the same, expressing his desire also of it: And so August 9th. 1645 ; we repaired together to the *Guild-hall*, carrying along with us two large square glasse-vials, which we first weighed in a Gold-smiths Ballance by Troy-weights, (as being the best) which were supposed to be exact enough; and afterwards filling the two brasse-standard-Gallons for *Wine*, and *Ale* or *Beer*, with fair water from the Cisterne, and that with all possible preciseness, we poured forth the same with the like accuratenesse, into the said two glasse vials, and then weighed the Glasses with the water in them by the same weights : and so comparing the weight of each Glasse alone, with the weight of the glasse and water together, we found the Wine-Gallon of water to weigh $117\frac{3}{4}$ ounces-Troy, and the Ale-gallon of water $140\frac{9}{16}$ ounces, (which last, according to the common division of the Ounce-troy by penny-weights, is 140 ounces, 11 penny-weights, and a quarter) which do hold in proportion (from the lesser to the greater) as 10000 11937, which comes very near, as 5 to 6. Then seeing that Weight and solid measure do hold in proportion to one another, so as that one may be deduced from the other, as I have shewed before; if we compare these two Gallon-weights of water, with several experiments made by my self, and *Mr. Reynolds*, severally (and conferred together) for the finding out of the true weight of water in relation to its solid measure in inches, (or for the comparing of its gravity and magnitude together, which thing is most admirable and excellent use, as I shall shew more afterwards) we shall thereby discover the solid capacity of the said two Gallon-vessels in inch-measure; which is the very ground-work of Gauging.

Now as to the aforesaid experiments; the said *Mr. Reynolds* did first (amongst other things to this purpose) cause a Vessel to be made of Wood, by an exact*

**Mr. John Thompson* in *Hosiar Lane* Workman in the form of an oblong rectangle *Parallelepipedum*, (or long Cube as some term it, though improperly, as they call an oblong rectangle *Parallelogram* a long Square) whose Base was $4\frac{1}{2}$ inches square, and the heighth, depth, or length, (which you will) 14 inches, and so the solid capacity thereof, $283\frac{1}{2}$ inches; and which was closed up at both ends or bases, saving that in the middle of one end, was made an hole for the pouring in of water, and which was no bigger, then that he might guess in the filling thereof to a drop or two of water, more or lesse : which Vessel therefore being precisely filled with fair settled Rain-water (as being the fittest, as I shall shew afterwards) and then as

precisely weighed by Troy-weights, he found the water thereof alone to weigh 12*li.* and 5¼ oun. or 149¼ ounces troy. And he not being contented with this own experiment, he caused such another Vessel to be made, every way like and equal in its dimensions with the former, and that by the same Workman; which he filling with the like water, found it to agree in weight exactly with the former. But yet he not resting fully satisfied with these two experiments, he procured such another Vessel to be made, by another Workman, of the very same dimensions with the former ; which he filling with the like water as aforesaid, found the weight of the said water alone to be 12*li.* and very near 6 oun. Troy (or 12½ pounds-Troy *ferè*) exceeding the former weight about ¾ of an ounce, and which he conceived to be the truer, (notwithstanding the exact agreement between the two former experiments) by comparing these experiments with some others of the like kind, which had been made before by himself, or some other body ; And this difference of weight seemeth to proceed chiefly from some difference of measure in the Inch, by which the first two Vessels, and the last were made, being done by two several Workmen. And therefore (considering the difficulty in a work of this nature, in respect of the nicety and curiosity of the experiment) he comparing these with some observations which I had then made by the bye, to this purpose ; we concluded together at length, that the nearest and indifferent weight of the water exactly filling up the foresaid Vessel of 283½ cubick or solid inches, would be 12*li.* and 5½ oun. Troy (or 149½ ounces) and this to stand good.

And then after this, I got an exact cubical Vessel to be made of thoroughly seasoned wood, with all the accuratnesse & precisenesse that could be, being 6 inches the in-side, (or the base thereof exactly 6 inches square) and so the whole Cube in its concave capacity, exactly 216 inches; and which then, to keep it from sucking in water in any part, or any water to soak into it, was well primed all within, with a thin oile-colour (yet of a sufficient body) having afterwards a Cover put on it, with a little hole in the middle thereof, about ¾ of an inch wide, as the foresaid Vessels of Mr. *Reynolds* had : And which cubical Vessel I then filling with all the exactnesse and precisenesse that might be, with fair setled Rain-water, at *Gold-smiths-Hall*; and so having the same as exactly weighed by the Standard Troy-weights ; I found the weight of the water alone (deducting the weight of the empty Vessel it selfe first of all had, from the weight of the vessel and water together) to be upon the very point of 114 ounces, or 9*li.* & ½. without any considerable difference therefrom : and thus I found it to be, at two several trials. Now according to the two first observations of Mr. *Reynolds*, aforesaid ; 216 inches of the forenamed water, should weigh 113.7 oun. Troy, *viz.* 113 oun. and 14 p.w. which comes short of our observation, by about a quarter of an ounce; and according to his last observation the same should weigh 114.3 oun. *ferè*, *viz.* 114 ounces and near upon 6 p.w. which exceeds the weight found by us, just so much as the other wants of the same; So that the weight of this cubical body of water produced by our experiment, falleth directly in the middle between the several

weights of the same deduced from his foresaid experiments, upon one and the same kind of vessel. And according to this our most exact observation; the weight of 283.5 cubick or solid inches of the foresaid water, (being the content of each of *Mr. Reynolds* his three foresaid vessels) will be 149.625 ounces troy exactly, which is 149 oun. 12 p.w. and an half. And this is the very arithmetical Mean be[t]ween his two first observations, agreeing one with another, being 149.25 oun. and his last, being 150 oun.

And so now according to this experimental Conclusion of mine own; I shall proceed exactly in the subsequent operations upon the Wine and Ale-Gallons : For so the weights of the two severall Gallons of water aforesaid, being compared severally with this experiment, the solid capacity of the Wine-gallon, will be found 223.105 inches, and of the Ale or Beer-gallon, 266.329 inches.

But I not resting fully satisfied with this one experiment in the said standard-Gallons (though we conceived the same to be performed with as much care and diligence as might be) and so desirous to trie the same thing over again, to see how nearly two severall trials would agree to confirm the matter; knowing that two testimonies upon any thing are much better then one ; I again moved the said *M. Wingate* and *Mr. Sutton* (whom I still desired as witnesses to what was done) for another triall of this thing, and that divers times ; but could not accomplish my desires herein, til about two yeares after : And so in *July* 1647, I and *Mr. Sutton* went together

2^d. experiment upon the wine and ale-gallons. again to *Guild-hall* (*Mr. Wingate* having promised to go along with us, but was hindered by other occasions) carrying along with us two other great glasse-Vials like the former, into which first powring the foresaid Standard-gallon of water exactly filled, and then weighing the said Glasses with the water in them severally, by the great standard-Ballance there, with Avoirdupois-weights, and afterwards the empty Glasses severally (being wel dried first) by the same weights, and so comparing them together as before; we found the weight of the Wine-gallon of water alone, to be 8*li.* 1 oun. 3 dr. avoirdupois (or $129\frac{3}{16}$ ounces avoirdupois) and of the Ale-gallon of water, to be 9*li.* 9 oun. 12 dr. (or $153\frac{3}{4}$ ounces avoirdupois) which are in Troy-weight (according to the most exact Proportions of the Avoirdupois weight to the Troy-weight before noted, *viz.* 14 to 17 and 56 to 51) 9*li.* 9 oun. and 5.223 dr. or 13 p.w. (which is 117.65 oun. troy) the Wine-gallon ; wanting of the first observation or experiment (*viz.* 9*li.* and 9.75 oun. or 117.75 oun.) only 0.1 oun. troy, which is 2 p.w. or $\frac{4}{5}$ of a dram-troy, which difference is of no moment. And for the Ale-gallon, 11*li.* 8 oun. and $\frac{5}{28}$ of a dram-troy or $\frac{25}{56}$ of a p.w., *viz.* $10\frac{5}{7}$ gr. (which is $140\frac{5}{224}$ oun. or 140.0223 oun. troy) wanting also of the first experiment (*viz.* 11*li.* 8 oun. and $11\frac{1}{4}$ p.w. or $4\frac{1}{2}$ dr. or $140\frac{9}{16}$ oun. or 140.5625 oun. troy, (about half an ounce-troy, and which difference is of small moment in the matter of gauging; but yet this latter experiment is the truer, as more nearly agreeing with the other experiments and observations following.

Now these two Gallons of water in this second experiment, are in proportion

(from the lesser to the greater) as 100000 to 119013, which comes near the former proportion : And being compared with the foresaid experimentall Conclusion made by me, (for the weight of water in reference to solid inch-measure) will give the solid content of the Wine-gallon, 222.9 inches, and of the Ale-gallon, 265.3 inches ; which wanteth of the former solid measure in the Wine-gallon, not fully $\frac{1}{5}$ of an inch, and in the Ale-gallon, about 1 inch. Which difference between these two experiments, especially in the Ale-gallon, though in the matter of Gauging, the same can breed no sensible error or difference, as wil afterwards plainly appear, when we come to shew our gauging-Lines : yet for my further and fuller satisfaction in this nice and curious piece of art, so much handled and controverted by Artists, as I said before ; and that I might come as near the matter as possibly might be; I urged again for another triall:

And therefore in *November* next following, I again repaired to the *Guildhall*, carrying with me two other large glasse-vials, (differing much in form from the other before used, though indeed this be nothing materiall to the purpose) which I first caused to be weighed severally by the standard-*avoirdupois* weights there ; and then (with the help of the keeper of the Standards) filled both the standard-Gallons with fair water from the Cistern, with all the accuratenesse that might be, as before ; and which with the like accuratenesse being poured out into the said two Glasses : I caused the Glasses with the water in them, to be weighed severally by the same weights and Ballance, and that as exactly as might be, and thereupon found (by the Comparison aforesaid) the Wine-Gallon of water to weigh alone, 8*li.* 1 *oun.* 11 *dr.* *avoirdupois* (or 129 $\frac{11}{16}$ *oun.* *avoirdup.*) and the Ale-gallon of water, to weigh 9*li.* 9 *oun.* 15 *dr.* *avoirdupois*, (or 153 $\frac{15}{16}$ ounces) which do exceed the second observation, in the weight of the wine-Gallon, 8 *dr.* or half an ounce *avoirdupois*, and in the weight of the Ale-gallon, only 3 *dr.* or $\frac{3}{16}$ of an ounce *avoirdup.* And these two last Gallon-weights of water, do hold in proportion (from the lesse to the greater) as 100000 to 118699*ferè*, which is very little lesse then the former proportions. And these also being collated with our foresaid experiment of 216 cube-inches of water, to weigh 114 *oun.* *troy* (or 9*li.* and an half) which is in *Avoirdupois*-weight according to the nearest proportions of the *Troy*-weight to the *Avoirdupois*, before declared and demonstrated, 129 $\frac{9}{52}$ *oun.* (or 7 $\frac{14}{17}$ *li.*) do give the solid capacity of the Wine-Gallon, 223.784 inches, and of the Ale-gallon 265.629 inches ; which do exceed the first experimental observation, in the Wine-gallon, by 0.679 inch only; & the second, by 0.86 inch, and doth want of the first observation in the Ale-gallon, only 0.7 inch, and exceeds the second, by 0.3 inch only ; which last is very little.

But I being desirous to be further satisfied in the weight of these two last Gallons of water : So soon as I had performed the same at the *Guild-hall* by the *Avoirdupoiz* weights there ; I caused the said Glasse-Vials with the Gallons of water in them, to be straightway carried unto *Gold-smiths-Hall*, to be tried by the great

Standard-Balance of Troy-weight there (as being the most exact kind of weight) which first weighing each glasse together with its water, and afterward each Glasse alone (being thoroughly drie) I found (by comparing the one with the other as before) the weight of the Wine-gallon of water alone to be $118 \frac{2}{16}$ oun. troy, viz. 118 oun. and $\frac{1}{2}$ dr. or $1\frac{1}{4}$ p.w. (which make 9li. 10 oun. 0.5 dr. or 1.25 p.w.) and the weight of the Ale-gallon of water alone, to be 140 oun. and $4\frac{1}{4}$ p.w. or 1.7 dr. (which is 11li. 8 oun. and 4.25 p.w. or 1.7dr. Troy) And these two Gallon-weights do hold in proportion (from the lesse to the greater) as 100000 to 118761, which exceeds that which was produced by the avoirdupois-weight, (viz 118699ferè) by 62 parts of 100000. And being conferred with our foresaid experiment for finding the proportion between the ponderall and dimensionall quantity of water, or its gravity and magnitude; will give the solid content of the Wine-Gallon, 223.697 inches, and of the Ale or Beer-gallon, 265.666 inches : which exceeds the first experiment, in the wine-gallon, by 0.59 inch ; and the second by 0.776 inch; and wants of the third experiment in the same, from the avoirdupois-weight by the ballance, only 0.087 inch. And it wants of the first observation in the Ale-gallon, 0.66 inch ; and exceeds the second by 0.36 inch only; and this third by avoirdupois-weight from the ballance, only by 0.04 inch ferè, which is as much as nothing.

And here having a fit occasion and opportunity, I shal (by way of Digression)

The foresaid severall Proportions between the Troy and Avoirdupois Weights, cõpared again together, & examined by the Ballance upon another Experiment.

speak somewhat more concerning the Proportions between the Troy and Avoirdupois weights, for a further confirmation & verification of what was said formerly, and also demonstrated upon a Cannon-bullet concerning the same : And therefore the weight of these two last Gallons of water, taken first by Avoirdupois-weight at the Guild-hall, (viz., 8li. 1 oun. 11 dr. or $129 \frac{11}{16}$ oun. the Wine-gallon, and 9li. 9 oun. 15 dr. or $153 \frac{15}{16}$ oun. the Ale-gallon) being converted into Troy-weight, and that first, by the more common termes of proportion, viz. 60 to 73 for pound-weight, or 80 to 73 for ounce-weight, wil give the Wine-gallon, 9li. 10 oun. 6 p.w. and 19.125 grains exactly, or 118 oun. 6 p.w. and 19.125 gr. or 118 oun. 2 dr. and 43.125 gr. troy; & the Ale-gallon, 11li. 8 oun. 9 p.w. 8.62 gr. or 140 ounces, 9 p.w. 8.62 gr. or 140 oun. 3 dr. & 44.62 gr. troy, which do exceed the true weight taken from the Ballance at Goldsmiths-hall, by 5 p.w. and 13.125 gr. or 2 dr. and 13.125 gr. in the Wine-gallon, and by 5 p.w., and 2.62 gr. or 2 dr. and 2.62 gr. in the Ale-gallon. And then by the other terms of proportion, viz., 14 to 17 for librall weight, or 56 to 51 for uncial-weight, the Wine-gallon wil be 9li. 10 oun. 2 p.w. and 3.96 gr. or 118 oun. 2 p.w. and 3.96 gr. or 118 oun. 0.5 dr. and 21.96 gr. troy : and the Ale-gallon, 11li. 8 oun. 3 p.w. and 20.7 gr. or 140 oun. 3 p.w. and 20.7 gr. or 140 oun. 1 dr. and 32.7 gr. troy; which differ from the true weight of the Ballance, (by way of excesse) in the Wine-gallon, but 21.96 gr. or 22 gr. ferè; and (by way of defect) in the Ale-gallon, only about 9 gr. which

differences are very inconsiderable, the greatest of them not amounting to a penny-weight, whereas the least of the differences produced by the vulgar proportions, is above a quarter of an ounce-troy. And hereby it is again most manifest, that these latter Proportions between these two kinds of weight, are much the truer, and surely the nearest and truest that may be found, and are therefore generally to be received.

And these our experiments beforegoing for the discovering of the solid

4th. experiment
upon the Wine
and Ale-gallon.

Contents of the foresaid Wine and Ale-gallons at the *Guild-hall*, may be confirmed by some other experiments which I afterwards made upon the same. For before my second observation of this thing, by the weight of the Gallons of water, I caused a concave *Cube* to be made of Brasse, of 4 inches the side exactly, and so the whole *Cube*, 64 inches; into which (being set level) my selfe, and Mr. *Sutton* aforesaid, together pouring out the two Gallons of water in the Glasses which we had from the Standard-Vessels at the *Guild-hall*, as aforesaid, with all the accuratenesse and precisenesse that might be (at severall times) we found first the Wine-gallon to fill the *Cube* three times, and then halfe the *Cube* (as nearly as we could possibly measure it) which being computed, doe make 224 cube-inches exactly, for the solid content of the Wine-gallon ; And then we found the Ale-gallon to fill the *Cube* 4 times, and moreover to arise to such an height of the said *Cube*, (*viz.* 0.7 inch) as being computed, did make 11.2 cube-inches; all which together do give 267.2 cube-inches for the solid capacity of the Ale-gallon. Both which do so neerly agree with the former experiments (especially in the Wine-gallon) as that this experiment may sufficiently confirme the former; this being as plaine and demonstrative an experiment as may be. And if it had been performed by a cubicall Vessel so large, as might have received into its concave capacity each of the Gallons of water wholly at once (which indeed I afterwards wished had been done, but my forementioned Cubicall Vessell of wood was made long after the triall of the Experiment) then the same might probably have yet come nearer the truth; for that the often filling of this small *Cube*, might cause some small errour, which by a more large or capacious Vessel, might have been avoided, wherein the solid content of each *Gallon* might have been had at once, by the heighth (or depth) of its water; though indeed the difference between this which we tried, and some of our former experiments (in the Wine-gallon) is in a manner insensible, and between all of them, in respect of both Gallons, is altogether inconsiderable. And this experiment by the brass *Cube*, I afterwards tried again by my self, and found it to differ as much as nothing from the former. But indeed to have the solid Contents of the Wine and Ale-gallons so very exactly and precisely by their liquid Contents, as can be imagined according to the strictnesse of Art, is (I may say) impossible, unlesse the Standard-Vessels were so narrow-mouthed, as that in the filling thereof, one might be able to guess at a few drops of water, which in the Standard Vessels at the *Guild-hall* (and I thinke in all others) cannot be done, they being so wide at the mouthes or tops, as

that a spoonfull of water more or lesse, in the filling thereof is hardly discernable, or so much more, as might breed the difference of halfe an ounce, more or lesse, in the weight of the water, and so consequently of one inch more or lesse, in the solid content; seeing that one inch cubick or solid of water weighth (as wee shall shew anon) halfe an ounce-troy, at least: And yet in all these severall experiments and observations compared together, the greatest difference of solid measure is but about one inch and a halfe, and that in the Ale-gallon : but yet setting aside the experiment made by the brass *Cube*, (which is too large;) the greatest difference in the same wil be but one inch solid, which wil breed no sensible error in the matter of gauging, as I said before. And which may shew how very near the matter we have come, for the discovering of the true Contents of the common standard-Gallons for *Wine* and *Ale* or *Beer*, and surely as near the truth as can wel be gone.

But yet that there might no likely way be left unattempted, for the discovery

5th. experiment of this thing, I wil add to the former, one experiment more, in the Ale.gallon being very demonstrative, which I made last of all in the alone, by taking it's foresaid brasse standard-Ale-gallon at the *Guild-hall*, by taking Dimensions. the proper linear Dimensions thereof, it being indeed an exact segment of a Cone (or Calathoidall) the internall or concave superficies from the top to the bottome, being very straight and smooth, as well as the externall or convexe Superficies, and also exactly circular throughout ; only a little shelving or arching at its meeting or connexion with the bottome, and this not precisely plain , but rather a little hollowish, yet not so much as to make any sensible error in giving the solid in giving the solid capacity of the Vessel, as wil straightway appear, by comparing the same with the observations before-going, and also one other observation following after. Which standard-gallon Vessel, as it is somewhat like in form to one of those Circles of Pro- which Mr. *Oughtred* speaketh of in the forecited place of his *Circles* portion.*Part 1 of Proportion*, concerning Gauging (as being shewed unto him, and chap.9.Sect.4. also the measures thereof first given him, by that great Antiquary Mr. *William Twine* of *Oxford*, whom he saith to have undergone great pains and charge in finding out the true Contents of our English Measures (and whom I wel knew at *Oxford*, being of the same House with him) So also it comes very near it in all its dimensions : For by the Diameters of the top and bottome, and the height of that Vessell which they together measured, (and which you may see in the fore-mentioned book) they found, that the same would contain in its concave capacity, 268.85 cubick inches, which exceedeth the measure of our Gallon-Vessel, produced by the experiment of the brasse *Cube* aforesaid, but little more then one inch and a half ; and the measure deduced from the first experiment by weight, about two inches and an half ; and that which was deduced from the second experiment, by weight, (being the least of all) by about three inches and an half : But indeed, beside that the sides of that standard Ale-gallon were a little arching (as

Mr. *Oughtred* saith) he observed divers other irregularities in the said Vessell, which might wel hinder the discovering of the true Content thereof, by some few inches.

Now the linear dimensions of the Standard *Ale-Gallon* at the *Guild-hall* (which I took as exactly as I could, and I believe insensibly differing from the truth) I found to exceed those of Mr. *Twine's* Vessell (taken both by him and Mr. *Oughtred* together, as I noted before) in the Diameter of the top, but 0.33 inch; and in the Diameter of the bottome, but 0.1 inch; and to want of that in the perpendicular height (or the depth) 0.8 inch ; by which I find the solid dimension of this Conicall Vessel (or of this decurtate or detruncate Cone) to be 265.5 inches, according to a multiple or conjunct composition of the aggregate of the two Bases, amd their meane Proportionall (produced most exactly by Logarithmicall supputation) with a trient of the Altitude, thus,

greater Base,	36.63790	}	A	Square inches
lesser Base	22.902210			
meane Proport.	<u>28.967055</u>			
Aggreg.	88.507225			
$\frac{1}{3}$ altitude	<u> 3</u>		M	
Solidity	265.521675			cube-inches

Which comes very neer the solid Content of this Vessel produced by all out former experiments ; especially the second and third, from which it differs as much as nothing; the one of them, giving 265.3 inches, and the other 265.6 inches.

And all these our experiments in the *Ale-gallon*, may yet be further confirmed by another observation or experiment, being taken from the *half-Peck*, w^{ch} they hold at the *Guild-hall*, to be equall in Content to the *Ale-gallon*, as being taken therefrom (and so I find it to be) and which I shall deduce from the *Bushell*, according to the Dimensions thereof, established by an Act of the *common. Councill* of the City of *London*, and yearly published by authority of the *Lord Major*, which ordains the breadth or wideness of a *Bushell* to be 19 inches, and the depth $7\frac{1}{2}$ inches; which being cast up according to a *Cylindrical* dimension, will be found to contain in its concave capacity, 2126.5 cubick or solid inches, whose $\frac{1}{8}$ for the *half-Peck*, is 265.8 inches, from which the solid Measure of the *Ale-gallon*, found by most of our former experiments, doth insensibly differ in a manner, especially that of the third experiment (by weight both *avoirdupoiz* and *Troy*, from the ballance) which gave the same, 265.6 inches ; or somewhat nearlier, that from *Troy-weight*, 265.7 *ferè*. And if we shall mediate between that of the first observation, being the greatest (except that of the *brasse Cube*, which is too large) *viz.* 266.3 inches, and that of the second, being the least, *viz.* 265.3 inches, (as is usually done in such like cases, where several observations or experiments made upon on and the

same thing, do a little differ, and as they for the most part will, let all the art and industry be used that may be) the Mean between them, wil be just 265.8 inches, for the solid capacity of the Ale-gallon, exactly agreeing with that of the half-Peck.

And nearly agreeing with the foresaid Bushell, I found the Content of a standard-Bushell of *Queen Elizabeth*, which I was informed to be in the hands of the City-Founder, which was made out of Brasse, in the last year but one of her reign, viz. Anno 1601 having her Inscription or Title about it ; and somewhat resembling a segment of a Cone, it being wider at the top then at the bottome, whose dimensions there fore I took with all the accuratnesse that might be, and found the Diameter of the top (or upper base) to be one foot, and 7.5 inches, or 19.5 inches : the Diameter of the bottom (or lower base) one Foot and 5 inches, or 17 inches : and the depth (or height) 8 inches (or more accurately, 8.1 inches) which being cast up, according as the *Ale-gallon* beforegoing ; the solid capacity thereof wil be found, 2122.165 inches ; thus,

<i>greater Base,</i>	298.6476
<i>lesser Base.</i>	226.9801
<i>mean Proport.</i>	<u>260.3595</u>
<i>Sum.</i>	785.9872
$\frac{1}{3}$ <i>altit.</i>	<u>2.7</u>
	55019104

15719744

Solidity, 2122.16544 Cube-inches

Which wanteth of the London-Bushell, (being 2126.465 inches) 4.3 inches : But indeed this Bushel was made a little turning or winding outwards near the edg or top therof, (w^{ch} was made very sharp or thin) which might give so much more in the solid content thereof, as to make it equall with the City-bushell; and so I suppose this London-bushell was first intended to be made equall with that of *Queen Elizabeth*, as nearly as might be ; And indeed the true Diameter of the top (from edge to edge) I found to be 19.6 inches, according to which if the solid capacity of the Bushell should be computed, the same would be found, 2134 inches, but that is too large : and the other comes nearer the truth : And the 8th part of this last, for the half-peck, and so for the Ale-gallon, will be but 266 $\frac{3}{4}$ inches.

Another measure of an Ale-gallon, Mr. *Oughtred* makes mention of in the place fore-cited, as being presented to him also by the foresaid Mr. *Twine*, it being (as he calleth it) a Standard-Gallon of *Queen Elizabeth*, which the said Mr. *Twine* had tried by another Vessell made of brasse, in manner of a *Parallelepipedum*, whose base was exactly six inches square, and the Sides divided into inches, and twentieth parts : into which he pouring out the said standard-Gallon filled with water, found it to arise unto such an height therein (viz. 7.6 inches) as being computed, would give 273.6 cubique inches for the solid content of the said Ale-gallon. And hereabout Mr. *Oughtred* conceives might be the true Content of the other Ale-

There came into the hands of the City-Founder, together with the foresaid standard-Bushell of Queen *Elizabeth*, a standard Ale-gallon of the same Queen, made of Brasse in the very same year of her Raigne, having also her epigraph about it; & which, I went with an intent chiefly to have measured; but indeed before my comming thither, it was sold away to a Town in Yorkshire called *Whitby*: But the same having been compared with the standard Ale-gallon at the *Guild-hall*, by the measure of water; was found to agree therewith, without any considerable difference, both as one of the Foundersmen, and also the under-keeper of the Standards for the City, told me, who were present at the triall thereof: which may be a means to confirm that at the *Guild-hall*: And these two standard Gallons, as they were both of a like capacity, so also of a like form.

But having by our two last experiments (especially the 5th.) most plainly and manifestly discovered in a geometricall manner, the dimensionall quantity of the *Ale-gallon* in inch-measure, as neerly as may be (which two most plain and demonstrative experiments do not considerably differ, the difference between them being but .3 of an inch-cubique) and then by the 2d. and 3d. experiments, the ponderall quantity thereof, in respect of the weight of water exactly filling the same (which two experiments also do not considerably differ; the difference being but 3 dr. avoirdupois, as we there shewed, or about 1½ dr. troy, being neer 1/6 of an ounce-troy) especially the 3d. experiment (which I take to be the most exact for this *Gallon*, in this respect) we may thereby (collating them together) be able to discover that which was experimented by me, from my large cubicall Vessell of 216 inches: and also confirme the same; and so consequently likewise confirme the solid Contents of the *Wine* and *Ale-gallon*, first of all discovered or produced thereby: For the solid measure of this *Ale-gallon*, being found most plainly and demonstratively by our two last observations or experiments, to be very nigh 266 inches; and the weight of the water exactly contained in it, found most neerly (by the 3d. experiment) to be (in Troy-weight) 11li. 8 oun. and neer about 4 p.w. or 140.2 ounces: the weight of the water exactly contained by our foresaid Cubicall Vessell, will be found thereby (according to geometricall proportionality) 113.86 oun. which wants of that found by us, only 0.14 oun. which is but 3 p.w. And so likewise may the same be very neerly confirmed

gallon measured by him and Mr. *Twine*.

All which experiments and observations aforegoing, (with some others made by Mr. *Oughtred*) may sufficiently demonstrate, the true Ale-gallon not to be of so large a capacity, as to contain 288 cubick inches, and upwards, as Mr. *Reynolds*, (and some others) will have it.

As for the discovering of the standard *Wine-Gallon* at the *Guild hall*, in a geometricall manner, by the Linear dimensions thereof, as before of the *Ale-gallon*; the truth is, I attempted not the same, in regard of the irregularity which I found in that Vessel, by the much arching or curvity of its Sides (whereby it is much like to that Ale-gallon which Mr. *Oughtred* and Mr. *Twine* thus measured; only this is wider at the bottome then at the top, whereas that was wider at the top then at the bottome, as the *Ale-gallon* at the *Guild-hall*) which makes it to differ from a segment of an exact Cone and so may rather be taken for a segment of a Conoid.

by the *Wine-Gallon*, according to our 4th. and most plain demonstrative experiment for the same (by the brasse concave Cube) by which the solid measure thereof being found 224 inches; and by the three former experiments (conferred together) the weight of the water contained exactly in the said Gallon-vessel, very neer about 9*li*. and 10 oun. Troy, or 118 oun. the weight of the water exactly contained in the foresaid large cubical Vessel of 216 inches, will be found thereby (according to the foresaid proportionality) very nearly as before, *viz.* 113.78 oun. which wants of the true weight found by us, but 0.22 oun. and which is only about 4 p.w. or $\frac{1}{5}$ of an ounce-troy.

Moreover for a further confirmation of this thing, and that very nearly, I shal produce another experiment, which I made upon the foresaid brasse-Cubical Vessel of 64 inches : For so soon as I and Mr. *Sutton* aforesaid, had measured out the Standard *Wine* and *Ale-Gallons* thereby, as aforesaid ; we first weighed the said concave *Cube* by a small Ballance of his, with Troy-weights, and than again filled the same with fair water, as precisely as possibly we could ; which we also weighing together, found the additional or differential weight (take it which way you will) to be (as nearly as we could possibly guesse) 33.5 ounces, for the water alone ; And afterwards I being desirous to make a further and exacter triall of this experiment, I carried this *Cube* unto *Goldsmiths-hall*, where I procured the same to be weighed first alone, by the exact Standard Troy-weights, with all the accuratnesse that might be ; and then filling the *Cube* with fair setled water, as precisely as possibly I could, had the same weighed together, with the like accuratnesse ; and so by collating these two several weights together, found the weight of the 64 inches of water alone, to be exactly in a manner as before, *viz.* 33.5 oun. (or but some few grains over) and this the *Assay-master* judged to be the nearest weight thereof that could be given, considering the widenesse of the Vessel to be such, (and that fully open on one side) as that some few drops of water more or lesse in the filling thereof, were not very discernable. Now according to our former experiments, the weight of this cubical body of water, wil be found, 33.7 oun. troy ; (or rather 33.8 *ferè*) which comes pretty near the other : but indeed this last being deduced from our experiments made by Vessels of a much greater capacity (or by a greater quantity of water) must needs be the truest ; so that the other is somewhat wanting of the true weight. And these our experimentall Conclusions upon the weight of water in reference to its solid measure ; or the comparing of its quantity ponderall with its quantity dimensionall, I shall also afterwards as nearly confirm by a manifest experiment made last of all by me, upon a solid body of a known magnitude in inch-measure, in respect of its gravity taken both in the aire and in the water, and the same compared together.