A new digester or engine for softening bones, containing the description of its make and use in these particulars: viz, cookery, voyages at sea, confectionary, making of drinks, chymistry, and dying. With an account of the price a good big engine will cost, and of the profit it will afford / [Denis Papin].

PAPIN

1681

wants the first leaf
with Order of Royal Society
for printing the book. Signed
by Christopher Wren Dec 8.
1680.

A New Digester OR ENGINE FOR SOFTNING BONES,

CONTAINING THE

DESCRIPTION

Of its *Make* and *Use* in these Particulars :

VIZ.

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WITH AN

Account of the Price a good big Engine will cost, and of the Profit it will afford.

By *DENYS PAPIN* M. D. Fellow of the ROYAL SOCIETY.

LONDON,
Printed by *J. M.* for *Henry Bonwicke* at the *Red Lyon* in S. *Paul's* Church-yard. 1681.

DESCRIPTION

OF THE

ENGINE

OF THE

NEW DISCOVERY

TO THE MOST ILLUSTRIOUS THE ROYAL SOCIETY.

Most Honoured Sirs,

THE favourable Acceptance you give to all those who, according to your Institution, are studious to increase both Natural Knowledge, and the Commodities of Humane Life, hath encouraged me to present you with these Experiments as my best Endeavours to follow your Example: I confess they are nothing near deserving to be offered to such sagacious Wits; but I have seen how quickly and easily you distinguish between good and bad in all manner of Writings, and how kindly you bear with the defects of those whose designs are good; I hope therefore you will be pleased to honour this small Treatise with your Protection, and give me leave to profess my self with all imaginable Respect,

Most Honoured SIRS,

Your most humble and
most obedient Servant,

D. PAPIN.

PREFACE.

SOme *Experiments of the ſcrewed* Balneum Mariæ *have already been printed in the ſecond continuation of the Phyſico-mechanical Experiments of the Honourable* R. Boyle *put forth this year* 1680. *but that Book being writ in Latine, and not giving the Deſcription of the Engine, nor the ways how to uſe it ſafely for want of ſufficient Tryals, I thought it would not be improper now to make upon that Subject a ſeparate Treatiſe in the vulgar Tongue for the uſe of ſuch Houſekeepers and Tradeſmen as may have occaſion for it.*

Having therefore reaſon to believe that this Piece may fall into the hands of divers perſons that would never read the Hiſtory of the Royal Society, nor Mr. Boyle's *Book about the Uſefulneſs of Experimental Philoſophy, I thought this to be a very fit place to undeceive thoſe that imagine it to be a folly to look for new Diſcoveries, and that all things are already found out. For the confuting this errour I will take nothing but from my ſubject, and even amongſt ſeveral inſtances it affords I will uſe but one. Therefore I ſhall only ſay, that Cookery is ſuch an ancient Art, the uſe whereof is ſo general and ſo frequent, and people have been ſo earneſt upon the improving of it, that it ſeems if any could be brought to perfection, this ſhould be it: nevertheleſs no body can deny but it will be now conſiderably improved, ſeeing by the help of the Engine here treated of, the oldeſt and hardeſt Cow-Beef may be made as tender and as*

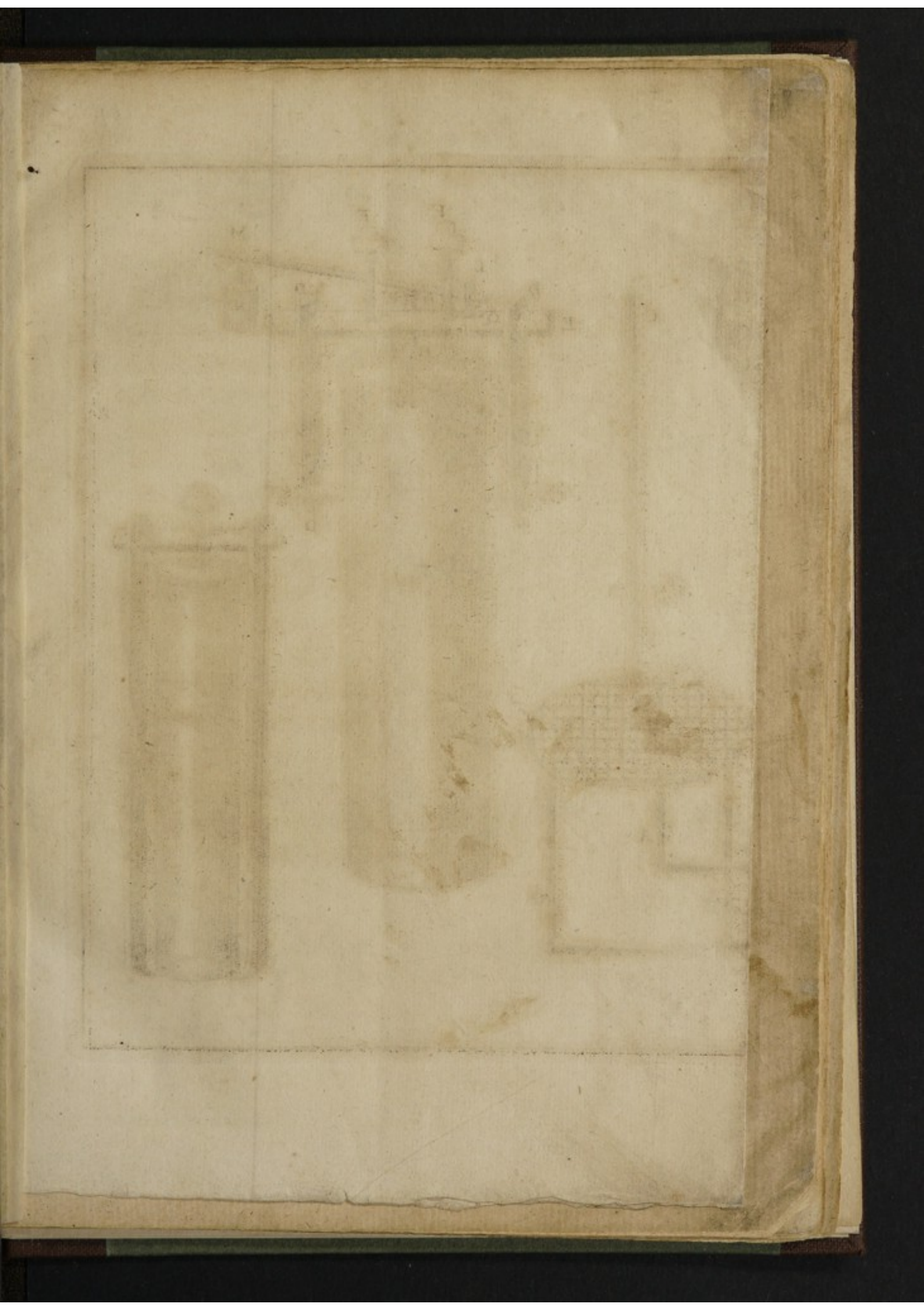
ſavoury

savoury as young and choice meat. I may besides say, that this was no hard matter; for every one knows that compact Bodies, if hot, will burn more powerfully than those of a more rare contexture: That red-hot Iron, for example, will do more than Coals: so there was no question but that Water being heated enough for boiling, and shut up so as not to be able to expand it self, as by ebullition it doth, such Water, I say, would effect much more than if permitted to its ordinary boiling expansion. For my part, assoon as this came into my mind by making some Experiments about Compression for Mr. Boyle, *I thought it so certain, that I made no question to undertake that Tryal: yet though the thing was so easie, no body, that I know of, had any thoughts of it: many Learned men have done and do still things of much more difficulty, but no body can see all things: Therefore we must confess, that there may still remain Discoveries to be made by small as well as great Capacities. And no man that industriously prosecutes a Subject, though seemingly never so trivial, need despair of obtaining that great felicity of having made some Discovery, the usefulness whereof may recommend it to Posterity.*

INDEX.

ERRATA.

Page 1. line 19. for GG read GG Fig. 2. p. 3. l. 2. for LG r. LQ. p. 16. l. 32. for Exper. 3. r. Exper. 2. p. 20. l. 13. for Chap. 2. r. Chap. 1. p. 45. l. 3. for other glass r. Weather-glass. p. 48. l. 35. the paragraph to begin at *Because* and a *comma* after *taste*



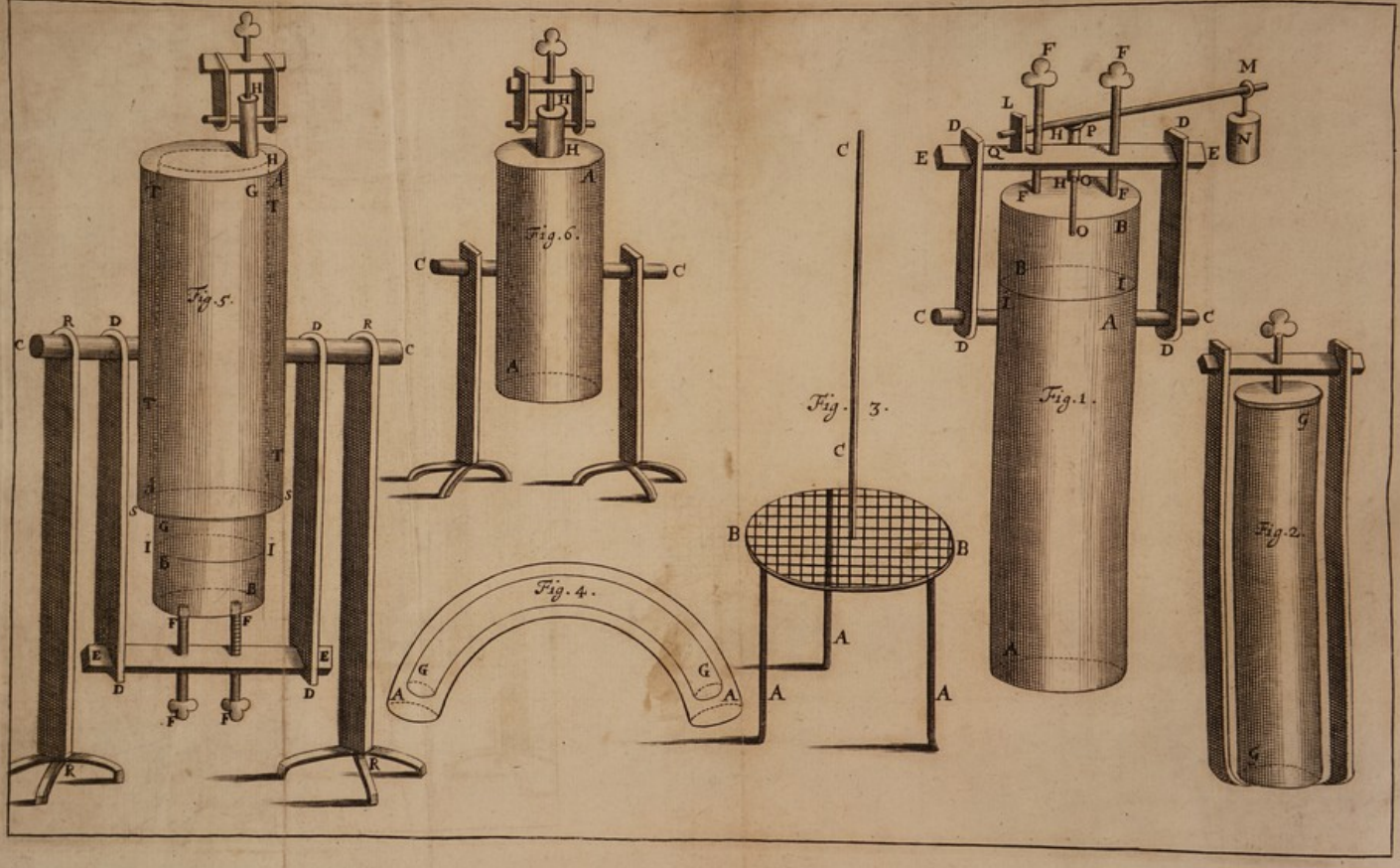


Fig. 5.
Fig. 6.
Fig. 4.
Fig. 3.
Fig. 1.
Fig. 2.

CHAP. I.

The Description of the Engine, and how to use it safely.

AA. *Is a Brass Cylinder hollow within, shut up at the bottom, and open at the top.*

BB. *Is another hollow Cylinder of the same bigness as the other, but much shorter, being to cover and shut the same by applying both their apertures to one another, as you may see in the Scheme.*

CC. *Are two Appendices or Ears cast to the Cylinder,* AA. *as the Tronions of a piece of Ordnance.*

DDDD. *Are two pieces of Iron put upon the Appendices* CC. *at one end, and the Iron bar* EE. *at the other.*

EE. *Is an Iron bar put through the ends of the Iron pieces* DD. *and so may easily be taken off or put on, when we have a mind either to open or to shut up the Engine.*

FF. *Are two Screws, which being fitted to the holes in the bar* EE. *serve to press both the Cylinders* AA. BB. *against one another.*

GG. *Is another hollow Cylinder made of Glass, Pewter, or some other Material, fit to receive those things that are to be boiled: this being filled and stopt with a cover exactly ground to it, and pressed upon it with a Screw, as you see in the Figure, is to be included in the Cylinders* AA. BB. *with water all round about it.*

TO use this Engine with conveniency and ease, it ought to be fitted in a Furnace built on purpose for it, and should go in as far as the Appendices CC: so the fire being underneath, and the

Screws FF well faſtned, you may boil your meat as long as you pleaſe, without danger of waſting it by the exhalation of the volatile parts.

It is to be noted, that ſuch a long and ſlender ſhape is better than any other for ſuch an Engine, becauſe it may be kept ſhut with leſs ſtrength: for it is well known, that the wider an aperture is, the more ſtrength is required to keep the cover from being lifted up by the inward preſſure.

It is to be noted alſo, that the cover BB muſt have ſome depth, that being filled with water, it may always keep ſome moiſture in a circular piece of paper, which is to be put in the joynt II: for the two Cylinders can never be ground to one another ſo exactly as to keep in Liquors when highly compreſt, unleſs there be ſome paper put between them, and that paper cannot ſtop it exactly neither, unleſs it be wet: yet the depth of the ſaid cover BB ought to be but little, that the Engine being almoſt all cloſed in the Furnace, it may the better receive and keep the heat.

This Engine is, without doubt, ſimple enough, and eaſie enough to be kept in order; but the miſchief is, that it is much more troubleſom to look into it than into ordinary pots: and becauſe it doth more or leſs effect, according as the included water is more or leſs compreſt, and according as the heat alſo is greater or leſs; it may ſometimes happen, that you will draw your meat before it is ready enough; and ſometimes too you may burn it: It was therefore neceſſary to find out ſome way how to know both the quantity of the inward preſſure, and the degree of heat.

To know the Quantity of the inward Preſſure.

You muſt have a little pipe open at both ends, as HH: this being ſoddered to a hole in the cover BB, is to be ſtopt at the top with a little valve P exactly ground to it, and fitted alſo with a paper between. This muſt be

be kept down with an Iron rod LM, one end of which must be put into an Iron staple LG fastned to the bars EE, and the other end kept down by a weight N to be hung upon it nearer or further from the valve, according as you would have it keep it less or more strongly down upon the end of the pipe to resist the less or greater pressure from within, much after the manner as a weight is hung upon an ordinary Roman balance or Stilyard.

To prevent the drying of the paper of this valve, I take a little pipe OO tyed about with hemp, and thrust it down into the pipe HH, so that one end reacheth pretty far into the water in the Engine: whence it comes to pass, that if some of the said water be lost, the inward pressure will nevertheless drive up water through the said pipe OO against the valve P, which makes the said valve more exact, and more fit to shew whether any thing gets out that way.

The pipe HH must be but slender, that it may be kept shut by a little weight: in the Engines I have hitherto imployed, this pipe is about $\frac{1}{5}$ of an inch over, so that its aperture to an aperture 1 inch over is as 4 to 25: therefore being more than six times less, it may be kept shut with a weight more than six times lighter too. Now according to the Experiments of Mr. *Boyle* in his continuation of Physico-mechanical Experiments, the ordinary pressure of the Air against a hole 1 inch over is about 12 pounds, and therefore *it is about 2 pounds against the aperture of the said pipe HH.* The rod LM is 12 inches long, and the distance from L to P is 1 inch: so that 1 pound weight hanging at M, presseth as much upon the valve P as 12 pounds could do, if directly laid upon the said valve; and so it cannot be lifted up, unless the inward pressure be six times stronger than the ordinary pressure of the Air. Therefore when there is one pound weight hanging in M, and yet the water gets out under the valve, one may conclude that the *inward pressure is about eight times stronger than the ordi-*

nary preſſure of the Air, becauſe it lifts up not only the weight N, which is equal to 6, but alſo the rod LM, which I have found by tryal equal to 4 pounds or two preſſures againſt the valve: and ſo by increaſing or leſſening the weight, or by removing it from one place to another, one may always know near enough how ſtrong the inward preſſure is.

The ſame Pipe HH is alſo very commodious to fill up the Engine with water after it is ſhut by the Screws: and the pipe OO is not to be put in till the Engine be perfectly filled with water by the pipe HH.

To know the Degree of Heat.

I wiſh I had been able to make a Thermometer divided as it ſhould be, to ſhew preciſely by how much the heat is increaſed or diminiſhed: and I believe by that means, comparing the ſeveral degrees of heat with the quantity of the effect thereby produced, one might diſcover ſeveral things about the Nature both of heat and of the Materials wrought upon: but for want of time and other neceſſaries for that deſign, I have inſtead of it uſed another way very eaſie, and yet exact enough for all the uſes here ſpoken of. I hang a weight to a thread about three foot long, ſo that every ſwing makes about a ſecond, and I let fall a drop of water into a little cavity made for that purpoſe at the top of it, and I tell how many times the hanging weight will move to and fro before the drop of water is quite evaporated: and I take care that the place where I put the drop may be clean, becauſe a little greaſe will conſiderably hinder its evaporating.

So being able to know the degrees both of heat and preſſure in the Engine, one may eaſily order it ſo as to do the effect juſt as deſired, if it hath but once been tryed how powerfully it works? For you need but take the quantity of coals found out by Experience to be the moſt convenient: ſet it in the Furnace under the Engine,

gine, leave the doors and the registers of your Furnace open till the heat is come to your intended degree: then you are to shut both the doors and the registers, that the fire may be choaked, and so let your Vessels cool; but you must also have laid upon the rod LM as much weight as is necessary to make the intended inward pressure: and you may be sure that by always keeping the same rule, the effect will be found always very near the same: at least I can assure you, that I have missed very often when I went to work at a venture; but since I have found out ways thus to rule me, I have always succeeded very well, unless by some mischance.

Yet it is to be noted, that if we would put into the pot much less meat than it can hold, the pressure in this could not be made so great as in the Engine: and indeed I had sometimes pots broken by the ambient water pressing upon them harder than they could bear: the weight hanging from the rod LM could not give me any notice of the pressure in the pot; therefore it will be better to put in too much than too little meat: or if you please to do all exactly, and lose nothing, you may follow the directions given *Chap.* 2. *Exper.* 12.

Because it would be a hard matter at Sea to make use of the contrivance described afore to know the quantity of pressure, for that the motions of the Ship would shake the weights and open the valve P: you must instead of that leave your *Balneum Mariæ* empty enough, that the intended heat may just make the intended inward pressure: For Example, if you will make ten pressures in your Engine with a degree of heat that may dry up the drop of water in 5 seconds, you are to put in your Engine but $\frac{1}{10}$ of the water it can hold, and give but the said degree of heat, and you may be sure that the inward pressure will be about ten times as great as the ordinary pressure of the Air, as you may see *Chap.* 2. *Exper.* 16. By that means you may (instead of the Iron rod and of the weight) fasten the little valve P with a Screw; and that will be very easie, if the little pipe HH be

be cast with small Appendices as the Cylinder AA, only things need not be strong here, because the aperture is but little.

It will not be requisite to know all the several quantities of Water necessary to make all the several degrees of pressure, with all the several degrees of heat; but, for ordinary use, it will be enough to keep always the same quantity of water in the Engine, and find by experience what degree of heat will be necessary for every operation with such a quantity of water.

I wish I had been able to do things as well as I have described them here, then I could precisely say what quantity of coals or wood is necessary for every operation; but my affairs being always uncertain, I have built no Furnaces, but have always set my Engine in a Chimney-corner, and put the fire in the said corner between the Chimney and the Engine. So it is very likely I have not kept the fire so well as might be done in a good Furnace: nevertheless I will venture to give an account of several things I have already done with this Engine, because that will be a good help still to find more easily the quantity of fire fit for other Engines to be made hereafter. I believe also that the proportion between two several operations will be the same in all Engines. I have found, for Example, that the quantity of coals necessary to boil Mutton is by $\frac{1}{3}$ lesser than the quantity necessary to boil Beef: So when you have found by experience what quantity is necessary to boil Beef in any Engine, you must take less by $\frac{1}{3}$ when you will boil Mutton in the same Engine, and so proportionably for other Operations.

But before I come to give an account of the Experiments, I think it will not be improper to say, that after I had made the first *Balneum Mariæ* shut by Screws, I had a mind to make another shut without any Screws by the help of a great oval Valve applied inwardly, but that may be taken quite out because of its oval shape, which hath been described for the Wind-gun in the

Honoura-

Honourable Mr. *Boyle*'s Book about Physico-mechanical Experiments printed this year 1680. That *Balneum Mariæ* is 6 inches over, and 18 inches deep, so that I can put in a pot that will hold 9 or 10 pounds of meat together: but because the great Valve was not made strong enough to keep its figure exactly, paper cannot make it tite; I did always make use of leather for that purpose; and because leather melts in such hot water, it cannot hold long, and the inward pressure drives it away, and the water gets loose. Nevertheless when I have met with good strong leather of an equal thickness, I have been able sometimes to soften the biggest bone of a Leg of Beef without spoiling the meat; but sometimes also, when the leather was not good, the meat was spoiled, and the bones could not be softned; therefore I use that Engine but seldom: however if such could be made that would hold with paper alone without leather, this latter way might be better than the first, because the springs of the Iron hold not long, so that we must look to fasten the Screws from time to time; but in this latter Engine you might be sure that the greater the inward pressure is, the harder would the valve be shut: nevertheless I would advise you rather to shut the *Balneum Mariæ* with Screws, till the Work-men be more skilful in the making such valves,

Thus much for the Description of the Engine, and the ways how to use it safely: I shall now come to the Experiments from whence you may know some of its Proprieties and Uses; but because some of the Experiments gave occasion to some Physical Observations, I thought it would not be amiss to relate them, though they had no connexion with the subject in hand; I have therefore distinguished them by the Character, that they may be left by those who care not for such things.

CHAP.

CHAP. II.

Experiments for Cooks.

EXPERIMENT I.

June 2. having filled my Pot with a piece of a Breast of Mutton, and weighed seven ounces of Coals, I lighted the fire; the heat came to such a degree as to dry up a drop of water in 3 seconds time, and the inward pressure was about nine times stronger than the ordinary pressure of the Air: I let the fire go out of it self, and the Vessels being cooled, I found the remaining coal to weigh about half an ounce: so that there had been but 6½ ounces consumed; nevertheless the meat being taken out, was found to have contracted an empyreumatical taste, and the juyce of it did not turn to a Gelly so strong as when the meat is not over-done.

EXPERIM. II.

June 4. I repeated the same Experiment, and I took but 6½ ounces of coals; but by blowing I made such a heat, that a drop of water would evaporate in less than 2 seconds, the remaining coals did not weigh full half an ounce, and the inward pressure was a little greater than in the former Experiment. Now although the quantity of coals had been lesser at this time, the meat was nevertheless much more burnt than the other, because, I believe, I had blown the fire more briskly.

EXPERIM. III.

June 6. I repeated the same Experiment, and took but five ounces of coals, and gave just heat enough to dry up the drop of water in 4 seconds, the inward pressure

ſure as before, then the Mutton was very well done, the bones ſoft, and the juyce a ſtrong Gelly: ſo that having had occaſion to boil Mutton ſeveral times ſince, I have always obſerved the ſame rule, and never miſſed to have it in the ſame condition, which I take to be the beſt of all; becauſe, if the coction was leſſer, the bones could not be ſoft; and if it was ſtronger, the Gelly being ſofter, could not be ſo nouriſhing. Yet I do not think that the perfection in this caſe is limited to a little more or leſs: but I believe rather that Mutton may be conſiderably more boiled, and be very good ſtill; yet I had always rather to under-do it a little than over-do it, becauſe when it is over-done, there is no remedy; and if ſome pieces of bone be not ſoft enough, it is very eaſie to put them again with new meat.

EXPERIM. IV.

June 9. I made the Experiment with a Breaſt of Beef, and took ſeven ounces of coals: I urged the fire till one drop of water would dry up in 3 ſeconds, and the inward preſſure about nine times as ſtrong as the ordinary preſſure of the Air: the coals that were not conſumed did weigh about three quarters of an ounce, and the Beef was very well boiled, although there were ſome parts of the bones not quite ſoftned: yet I would not adviſe people to beſtow any more fire to boil Beef, becauſe it is always very eaſie to boil the bones again: and I had rather ſeveral times boil the meat but as much as may be neceſſary to take it off from the bones, becauſe afterwards the bones may without any danger be boiled aſunder, as you may ſee by the following Experiments.

EXPERIM. V.

June 12. I did put Mutton and Beef together into my pot, and made the fire but with three ounces of coals; and though I preſt the fire pretty briskly, I could not

make the inward preſſure above three times ſtronger than the ordinary preſſure of the Air, and the heat but ſuch as to make a drop of water to evaporate in 90 ſeconds: The Veſſels being cooled, I found the Mutton ready enough to pleaſe moſt people; but the Beef was undoubtedly too raw for any body: the Juyce did not turn to a Gelly, though I had put no water to it.

I believe that the preſſure and the heat in this caſe were ſo little, rather for want of having well fitted the Engine, than for want of coals; for I have obſerved ſince that time, *That the better the Engine is cloſed, the more heat it acquireth with the ſame quantity of coals.*

June 13. I repeated the ſame Experiment, and filled the Pot partly with raw fleſh, and partly with ſome of the fleſh boiled the day before. I took but four ounces of coals, and having increaſed the fire as briskly as I could, I made the inward preſſure but five times ſtronger than the ordinary preſſure of the Air, and the heat but ſuch as to make a drop of water to evaporate in 40 ſeconds: the coals that remained not conſumed, did not weigh above two drams: the meat was very well done and tender; but the bones did not at all ſeem ſofter than before, although thoſe of the day before had already endured the fire of ſeven ounces of coals, three the firſt day and four the ſecond.

June 15. I repeated the ſame Experiment, and did put into the Pot the meat that had already been boiled twice, and alſo raw fleſh: at which time I imployed five ounces of coals; but I preſt the fire ſo gently, that the heat could never make a drop of water to evaporate in leſs than two minutes or 120 ſeconds. The fire being gone out of it ſelf, I found the meat done enough, and that which had endured the fire of twelve ounces of coals was very good ſtill, without Empyreume, and the bones not at all ſoftned: So I found that it was very eaſie to dreſs fleſh without bones, ſince it may be left upon the fire three times as long as is neceſſary, and yet it will not at all be ſpoiled.

EXPE-

EXPERIM. VI.

June 16. I made the same tryal with bones, and took those very bones that had been thrice boiled with the meat of the last Experiment: these being put into a glass-pot with fat of Mutton alone that had been already boiled, I shut them into the Engine, then having made such a heat as to dry a drop of water in 4 seconds, and the inward pressure nine times stronger than the ordinary pressure of the Air; I did quickly put out all the fire, and the bones were found very well softned. I did again inclose the same bones in the same pot with the same fat of Mutton, and added to them a new piece of bone that had never been boiled, and having given the fire, as before, I found the new piece of bone well softned, and all the rest still very good.

June 17. I did for the third time inclose the same bones in the same pot, and again a new piece of bone quite raw: and having given again the same heat, I found the new piece of bone well softned, and all the rest not at all impaired.

I repeated again the same Experiment with the same bones and the same fat of Mutton; but at this time I made a stronger and longer fire: and it fell out, that the first bones were almost brought quite to a powder, and smelt of burning, yet the taste did not seem so unpleasing as when flesh is so burnt. As for the fat, it had no ill taste at all, only it seemed to be a little softer than some of the same fat that had been boiled but once: so I cannot tell whether by much boiling one may not make it change its nature, but I am sure it would require more time than I can bestow.

The three first Coctions mentioned in this Experiment are sufficient to shew that bones, as well as flesh, may be boiled at least three times as long as there is need, and yet they will be in no danger of burning: so it is plain, that the most careless and unexact persons will be able enough to boil them asunder.

Proprieties.

Before I proceed I must take notice, that in the fifth Experiment some bones that had endured the fire of twelve ounces of coals, were not at all softned to sense, although five ounces of coals may be enough to produce that effect: from whence it appears, that the weighing of coals would signifie but little, unless we did at the same time observe how briskly we augment the fire; for there would be always danger of doing the meat more or less than we intend: and we may reckon this as a Propriety of this Engine, *That the more briskly we press the fire, the more effect it produceth with the same quantity of coals.*

This Experiment put me in mind to make another that might manifestly shew, that the inward pressure is a great help to advance coction: therefore I took two little Vessels very like one another, and well fastned by Screws, one of them was well soddered every where, but the other had a little hole left in its cover for the vapors to get out. These Vessels being filled with water and meat after the same manner, and put together in the same Bath of Sand, and left there in an equal heat for three quarters of an hour, I took them off both together, and found that the meat that had been exactly shut up, was rather over than under done; but the other was a great deal too raw: therefore we may reckon this also amongst the Proprieties of this Engine, *That the greater the inward pressure is, the greater effect is produced by the same heat and in the same time.*

EXPERIM. VII.

Having found some difference between Beef and Mutton, the one being harder to be boiled than the other, I had a mind to see whether there would not be some difference also between flesh of the same kind, but of different ages: therefore *June* 4. I took Lamb and filled two Glasses with it, and put some water into one of them. Now since five ounces of coals have been enough

to boil Mutton, I took but four ounces and half for the Lamb, thinking it would be more easie to be boiled. I prest the fire as briskly as I could, but a drop of water would not dry away in less than 11 or 12 seconds: the inward pressure was eight times stronger than the ordinary pressure of the Air: (the heat was but so little, which may be because the greater share of the coals had been once already kindled) the fire being gone out by little and little, I found but one dram of coals that had not been consumed. In the Glass without water the bones were softned at some of the ends only; but in the Glass with water the bones were all very soft: yet the meat was much less savoury than in the other Vessel.

This Experiment caused me to think; 1. That the bones of young beasts require almost as much fire as those of old ones to be boiled. 2. That water is a dissolver fit to soften bones, but that it impairs the taste.

EXPERIM. VIII. Propriety.

That I might know pretty near what difference may be found as to the perfection of the Operation when the fire goes out of it self, or when it is all taken off and quenched as soon as the heat is come to the intended degree, *July* 5. I filled again two glass-pots with Lamb, as before, and having kindled a great deal of coals, I prest the fire till a drop of water would dry away in 3 seconds, and presently I took off all the fire: I found the bones in the Pot without water a little softer than in the former Experiment, and in the Pot with water I found them all very soft, but the meat was not at all spoiled: So I think *it is near the same to press the fire with* 4½ *ounces of coals so as to dry away a drop of water in* 10 *seconds, and then let the fire go out of it self, or to press the fire with six or seven ounces of coals, and then take it all off as soon as a drop of water drys away in* 3 *seconds:* therefore the same proportion may be observed in other Operations. For Example: If I were to make an Operation that might be performed with a quantity

of

of coals that could make the Engine hot enough to dry a drop of water in 20 *seconds*, leaving afterwards the fire to go out of it self: and if I would save time, I should make a good fire that the heat might quickly come to dry a drop of water in 6 *seconds*, and presently take away all the fire: and so in all other Operations, keeping still the proportion as 10 *to* 3; yet I confess this Rule is not demonstrated, neither doth the matter in hand require such a Mathematical exactness.

When I say nothing of the inward pressure, as in this Rule, it is to be understood that it ought to be always equal.

EXPERIM. IX.

July 11. I took a Rabbet, and having filled with it two Glass-pots, and put some water in one, and none in the other, I kindled five ounces of coals, and having prest the fire till a drop of water would dry away in 4 seconds, I let the fire go out of it self. The Vessels being cooled, I found the Rabbets bones well softned in the Pot with water; but in the other they were all very hard: yet the flesh having been well seasoned, it was as tender and savoury as any Pasty can be; but in the Pot with water it relished not so well by a great deal.

By this Experiment I saw that Rabbets bones are harder than those of Mutton: and I was more fully satisfied that water helps much the softning of bones.

EXPERIM. X. Propriety.

I took another Rabbet, and having shut it up, as in the former Experiment, I kindled five ounces and half of coals; but the paper in the joynt of it having been spoiled, the inward pressure was not as strong again as the ordinary pressure of the Air, because the water could get out; and for that reason also the heat could not well be kept: for, notwithstanding the quantity of coals in this Experiment was greater, the drop of water was twenty

times

times longer evaporating than in the former Experiment: So that we may reckon this for a Propriety of this Engine, *That the greater the inward preſſure is, the leſs quantity of coals is required to give a certain degree of heat.* The Rabbet was very tender, but the bones were not at all ſoftned, no not in the Glaſs where I had put water; but ſome that had been boiled the day before, and put again to be made more ready, were found very well ſoftned.

By this Experiment I ſaw, that although ſome boiled bones do not ſeem to be ſoftned at all: yet they have got a great preparation towards that, though it doth not appear to ſenſe.

EXPERIM. XI.

July 13. I took an old male and tame Rabbet, which is ordinarily but a pitiful ſort of meat: I ſeaſoned it, and put it into two Glaſs-pots: I kindled ſix ounces of coals, and preſt the fire till the drop of water would evaporate in leſs than 4 ſeconds: the inward preſſure was about ſix times ſtronger than the ordinary preſſure of the Air. The fire being gone out of it ſelf, I found the Rabbet very ready, and the bones ſoftned, and it was as ſavoury as young Rabbets uſe to be: the Juyce of it turned to a good Gelly: ſo that I think this to be the quantity of fire moſt fit to boil Rabbets.

EXPERIM. XII. Proprieties.

Auguſt 12. I put Pigeons into two little Glaſs-pots, weighing them one after another, before I incloſed them in their frame: I preſt the fire till the drop of water would dry away in 5 ſeconds, and the inward preſſure was ten times as ſtrong as the ordinary preſſure of the Air. The Veſſels being cooled, I found both the covers ſticking pretty faſt to their Pots: ſo that it was apparent that the Air within the ſaid Pots was rarified, and that ſomething had got out of them. I weighed them one after the other being well dried, as I had done before the boiling, and I found that one of them (wherein I had put, by weight,

weight, an eighth part leſs of meat than the Veſſel could contain of water) was exactly the ſame weight as before, and the bones were very tender, and the Juyce a ſtrong Gelly without Empyreume. The other Pot (wherein I had put a greater weight of meat than it could hold of water) was grown heavier, and the Juyce in it was not ſo well congealed as in the other. It is very like that the great quantity of meat being too much rarified in this Pot had opened the cover, ſo as to admit ſome of the water from the *Balneum Mariæ* which had increaſed the weight and diluted the Gelly; but in the firſt Pot the rarefaction of the meat was able only to drive out a little Air without any ſenſible opening of the cover.

From this Experiment I think we may conclude, that one Propriety of this Engine is, *That if we boil Pigeons ſo as to make the drop of water dry away in* 5 *ſeconds with an inward preſſure ten times as ſtrong as the ordinary preſſure of the Air, the weight of the meat in the Pot muſt be but* ⅞ *of that which the Pot can hold (ſeven pounds of meat, for example, in a Pot that can hold eight pounds of water) for by that means the preſſure in the Pot is as ſtrong as in the Engine; and yet nothing is loſt.*

In the ſixteenth Experiment you may ſee that the water being taken in the ſame weight, would do the ſame effect: ſo that ſome people would think that all other bodies ſhould be alſo taken in the ſame weight, becauſe thoſe that would take up leſs room upon the ſcore of their ſpecifick gravity, will by the ſame reaſon expand themſelves ſo much the more; but this would be a great miſtake: for I have tryed *Chap. 6. Exper.* 3. that Spirit of Wine, though of a leſſer ſpecifick gravity than Vinegar, will nevertheleſs rarifie a great deal more by heat. Therefore (if we will be very exact not to loſe any thing, and to have the intended preſſure in the Pot) we muſt find by experience how far and how powerfully other bodies will rarifie, as in this Experiment I have found it

for

for Pigeons, to fill afterwards the Pot accordingly.

At the same time I had in another Engine some of the same Pigeons a boiling: the heat was such, that it dryed a drop of water in 3 seconds, but the inward pressure was but five times as strong as the ordinary pressure of the Air. The Vessels being cooled, I found the bones not quite so soft as in the other Engine, though they had been in a greater heat: yet they were almost all fit to be eaten.

This Experiment makes me believe, that we may reckon this amongst the Proprieties of this Engine, *That it is almost the same thing to have the drop of water dry away in 3 seconds and five pressures, as to have it dry away in 5 seconds, and ten pressures in the Engine.*

So people may find out by experience in any other case what quantity of pressure may do instead of a certain quantity of heat: and if one had an exact Thermometer as I have said in *Chap.* 2. one might perhaps draw from thence great lights for other things.

I say besides, that this Experiment shews that good *Balnea Mariæ* fitted to hold great pressures, would save a great deal of fire: for we have seen *Exper.* 10. that the greater the inward pressure is, the less coals will serve to bring the Engine to a certain heat: and now we see that such a degree of heat raised with less coals, may produce a greater effect, than if we had been forced to bestow more coals for it where this pressure is wanting.

FISH. *EXPERIM. XIII.*

June 15. I took a Macquerel and put it in a Glass-pot with green Gooseberries; I included the Pot in the Engine, and with four ounces and two drams of coals I brought the heat to dry away the drop of water in 10 seconds, and the inward pressure was seven times as strong as the ordinary pressure of the Air. The fire being gone out by little and little, I found that the remaining coals weighed about two drams: the fish was very ready and firm, though the bones were so soft, as not to be felt in

eating: the fish, before it was boiled, did weigh nine ounces, and after boiling not above seven: so that I had two ounces of good Juyce, which would have been thrown away, if the fish had been boiled after the ordinary way: and moreover the taste was a great deal better, the volatile Salts not having got away, or been dissolved in water: the Goose-berries had a very good taste, and nothing of burning.

EXPERIM. XIV.

June 19. I made the same tryal with a Pike, and I gave the fire, as in the former Experiment: the fish was found very ready, and its flesh firm, and the bones soft, though they seemed somewhat harder than those of the Macquerel. A Gentleman having tasted of this, inquired whether it was the dissolving of the bones that made the fish so savoury: this perswaded me, that my thinking such fish better than ordinary, was not out of preoccupation. The Juyce of the Pike came to a strong Gelly, which did not happen to that of the Macquerel. I cannot tell whether this difference proceeded from the nature of the fish, or from the temperature of the Air.

EXPERIM. XV.

June 20. I took a great Eel, and having shut it up, as I use, I kindled four ounces and half of coals, so that the drop of water did dry away in 6 seconds, and the inward pressure was seven times stronger than the ordinary pressure of the Air: the fire being gone out of it self, the Eel was found very ready, so was the skin and bones, and all without Empyreume; but its flesh was not so firm as that of other fishes: the juyce did not congeal, which I think did proceed from the excess of fire rather than from the nature of this fish, since its skin seems very fit to make Gelly. All these Experiments make me believe that all fishes may be made ready almost with the same degree of heat.

EXPE-

PULSES. *EXPERIM. XVI.*

July 2. I put Beans in a Glass-pot, some of which were raw, and the other had been boiled already with Hartshorn: I poured a little water into the pot to see the difference between those Beans that would lye in the water, and those that would be at the top of them above the water: I kindled the fire so as to dry away the drop of water in 5 seconds, and the inward pressure ten times stronger than the ordinary pressure of the Air; I took away the fire presently, and the Vessels being cooled, I found all the Beans very soft, and no difference between those that had been boiled twice, and those that had been but once; but those at the top were full of wrinkles and more savoury than those in the bottom which were swelled with water: the skin was very soft, except a very thin one which was somewhat harder: so that it would be needless to take off the skin of such Beans.

By this Experiment I was more confirmed, that Aliments in this Engine may, when they are ready, be kept upon the fire a great while without danger.

Propriety.

In the above-mentioned Experiment I was careful not to lay upon the rod LM more weight than was necessary to make the inward pressure ten times stronger than the ordinary pressure of the Air: so that the *Balneum Mariæ* being pretty hot, the great quantity of water was able to lift up the little valve at the top of the Pipe HH, and it ran slowly that way till I took off the fire; but when the fire was quite out, nothing more could get out, though the heat was still such as to dry away the drop of water in 5 seconds. So it is plain, that the remaining water had now room enough in the Engine to expand it self, and that such a degree of heat could not make it pres stronger than ten ordinary pressures of the Air. Therefore I was desirous to see how large that room ought to be: to that end I opened my Engine

with so much wariness, that I lost no water; and having weighed all that I found in it, I saw that there had been lost $\frac{1}{8}$ or little less; because out of eight ounces which I had first put into it, I found above seven remaining. Therefore we may reckon this amongst the Proprieties of this Engine, *That if we put into it $\frac{7}{8}$ of the water it can hold, and make such a heat as to dry away the drop of water in 5 seconds, the inward pressure shall be ten times stronger than the ordinary pressure of the Air.* After that same way one may find by experience how much room must be left empty for any other pressure and for any other degree of heat we have a mind to make, and that will be necessary to know at Sea, as I have said *Chap.2.*

EXPERIM. XVII.

July 15. I put some green Pease into two little Glass-pots, and poured water into one of them almost enough to cover the Pease, into the other I poured no water: I pressed the fire till the drop of water would dry away in 4 seconds, and the inward pressure was ten times as strong as the ordinary pressure of the Air. I took off the fire, and the Vessels being cooled, I found the Pease extremely well softned: those without water had given juyce almost enough to cover them; their colour was of a dark red, and their smell and taste had somewhat of burning; in the other pot the Pease were green still and had a very good taste, but not so high as those without water. Having melted some fresh Butter, the taste of the Pease without water did not seem to me too strong with such a Sauce, I liked them better than the other: Yet it will be better not to boil Pease so much, these having endured so much heat as would soften bones. The Pease which I had put in with the Cods were very soft and good, but the inner rinds of the Cods were not at all altered, though they had endured so much heat.

This Experiment seems to prove, that water is the best thing to hinder the burning of the Pease; but I believe that if many other things were added to fill up the

the spaces between the Pease, it would do as well for that purpose: for I have tryed another time, that having boiled Goose-berries at the same time in the same pots both without water, with this only difference, that in one pot the Goose-berries were entire, and in the other they were bruised; it came to pass, that the entire ones had contracted much Empyreume, though their glass was much emptier, and so the pressure in it could not be so great; but those that were bruised and did fill up the pot with their own juyce, had no taste of burning. Therefore I would advise you, for the better success of this Experiment, to fill up the spaces with the juyce of other Pease, because being already satiated with the taste of the Pease, it will not rob those new ones that are to be boiled in it.

This Experiment shews, that many digestions may be perfected a great deal better in this Engine, where we may fill up the Glass, than in the ordinary way where much room must be left empty. It might also suggest good thoughts about the nature of the Empyreume; but it is better to stay for further tryals.

CHAP. III.

Experiments for Voyages at Sea.

EXPERIM. I.

THE greatest inconveniency in long Voyages at Sea comes, according to the most common opinion, from the Victuals, which having been kept salted a great while, have lost their volatile and spirituous parts, so that the remaining gross and terrestrial ones are apt to make a gross and terrestrial blood which causeth the Scurvy: Therefore it is likely, that Gellies being made of volatile parts, and easie to be digested, would be apt to correct that defect of the salt meat; but they use to be so

so dear and so hard to be made, that it is rare to get any at Sea: this made me believe that it would be a good thing to find a way how to make them every where easie and cheap. Therefore

June 18. I took Beef-bones that had never been boiled, but kept dry a long time, and of the hardest part of the Leg: these being put into a little Glass-pot with water, I included in the Engine, together with another little Glass-pot full with bones and water too, but in this the bones were ribs, and had been boiled already. Having prest the fire till the drop of water would dry away in 3 seconds and ten pressures, I took off the fire, and the Vessels being cooled, I found very good Gelly in both my pots; but that which was made out of ribs, had a kind of a reddish colour, which, I believe, might proceed from the medullar part; the other Gelly was without taste or colour, like Harts-horn Gelly; therefore I do not see any reason why it should not have the same effect; and I may say, that having seasoned it with Sugar and Juyce of Lemmon, I did eat it with as much pleasure, and found it as stomachical as if it had been Gelly of Harts-horn.

Though this Experiment be most necessary at Sea, yet it will be very useful upon Land too: Gellies being every where good for several diseases, it will be very convenient to be able to make easily for one penny more than we could buy for a shilling.

EXPERIM. II.

I filled again a Glass-pot with water and some of the hardest bones of a Leg of Beef: in another Glass-pot I put the bones of a Breast of Mutton that had been boiled already, but not softned. Having shut them both in the same Frame, so that one was no more constrained than the other, and having inclosed them in *Balneo Mariæ*, I prest the fire till the drop of water would dry away in 9 seconds; but then it fell out, that the little Valve P not holding, because I had put leather

to

to it, all the water from the *Balneum Mariæ* got out with so much violence, that I was surprised at it: yet this lasted about a minute, because the aperture was but little. No question but at the same time the water in the Pots did expand it self too and run over; for I found them much emptied: yet they did differ from one another, because the liquor with Mutton-bones turned to a strong Gelly, though the bones were not softned but in some extreme parts, and that Gelly did weigh but $\frac{2}{3}$ less than the water I had put to it; in the other Pot the bones were not softned at all, the liquor would never congeal, only it was a little thicker, and there had been above $\frac{1}{3}$ of it spilt, though this Pot had its brims a great deal higher than the other.

This Experiment made me believe: 1. That it would be better still to provide Mutton-bones than Beef-bones. 2. That it would be to no purpose to undertake after the ordinary way to make Beef-bones gelly, because it requireth such a great heat, and so much water would be lost by evaporation. 3. *That Gelly is of a contexture much more difficult to be evaporated than ordinary water.*

EXPERIM. III.

June 23. I put the same Beef-bones into the same Pot with new water, and the weight of the water was as much again as that of the bones: in the other Pot I put Gristles with double their weight of water too. Having increased the fire till the drop of water would dry away in 3 seconds, and the inward pressure ten times stronger than the ordinary pressure of the Air, I kept the fire so for four or five minutes more, and then I took it off; and the Vessels being cooled, I found the bones pretty brittle, but the liquor was not thick enough to be called Gelly: yet I believe if that which had been spent in the former boiling had been there still, the Gelly had been strong enough. The Grisles in the other Pot were almost quite melted down, and were turned to a strong Gelly from the bottom of the Pot to the middle of it,

but

but above that the liquor was no thicker than in the other Pot.

This Experiment made me think: 1. That one pound of Beef-bones might afford about two pounds of Gelly. 2. That it would be better to provide Grisles, because they are wholly glutinous, and will dissolve in water; but because water is not so heavy, the Grisles will sink and stay in the bottom, and imbibe just as much water as is necessary to make a Gelly. 3. That it is the Cement that unites the parts of the bones which is dissolved in the water to make it a Gelly: since after that the bones remain brittle.

EXPERIM. IV.

June 29. I put more bones into two little Glass-pots than was necessary to congeal the water they were in: one was with Beef-bones, the other with Mutton-bones. I increased the fire till the drop of water did dry away in 3 seconds, with the inward pressure ten times stronger than the ordinary pressure of the Air. I kept the fire to that degree about a quarter of an hour, and then took off but part of it, leaving the rest to keep the heat yet longer. The Vessels being cooled, I found very good Broth without Empyreume in both the pots, but it did not turn to gelly, which, I think, could not proceed but from too much boiling: since in the former Experiments with less bones and less heat I had got a strong Gelly.

From this Experiment it appears, that the degree of heat is much to be observed to make a great quantity of Gelly, and that it is not enough to keep it from burning; for it might for all that be much over-done. Now that degree of heat which is best of all, cannot be found but by several Experiments.

EXPERIM. V.

June 29. I put Beef-bones into one of the little Glass-pots with an equal weight of water; into the other I put

put as much Ivory as I could, with water to fill up the chinks. I blew up the fire till the drop of water would dry away in 6 ſeconds with the inward preſſure twelve times as great as the ordinary preſſure of the Air: then I took off the fire as faſt as I could, and the Veſſels being cooled, I found that the Pot with Ivory had been broken, becauſe the Ivory that was crowded in it, ſwelling by humidity and heat, had been ſtronger than the Pot: the Ivory was grown brittle. In the other Pot the bones were not ſoftned yet but in ſome Apophyſes: the liquor was not congealed neither, except in the bottom; but the next day being a little cooler, I found it turned all to a Gelly, and I poured it upon ſeveral glaſs Plates that it might dry: the next day *July* 1. though it had been evaporating 24 hours, I found it melted again, becauſe, as I think, the weather was a little warmer. I uſed it to glue a broken glaſs which did, ſince that time, hold very well, and can be waſhed as well as if it had never been broken.

From this Experiment I judged; 1. That the heat had been too weak, as in the foregoing it had been too ſtrong: and ſo to bring the bones to a good gelly, the fire ſhould be augmented, as in *Exper.* 1. or thereabout. 2. *I was more fully perſwaded that it is the glue of the bones which is diſſolved to make gelly.* 3. *I found that very few glutinous parts are ſufficient to congeal much water; for though this had been congealed in Summer-time in a Garret, yet when it was dryed I had ſo ſmall a quantity of glue remaining, that I was ſurpriſed at it.* 4. *I found that a very little heat is enough to hinder theſe congelations, and therefore in all appearance the quantity of gelly would be much greater in Winter than in Summer-time from the ſame quantity of Materials.* 5. *That ſuch Congelations are very differing from thoſe that are made meerly by cold, ſince the Ice ſwims at the top, but Gelly ſinks to the bottom of the water.*

To uſe the glue here ſpoken of, it muſt be kept clean,

and when we have occasion to use it, we must dissolve some of it with three or four drops of clean water to wet the brims of the glass, and then joyn them, as before, as exactly as we can: the same may be applied to China-dishes, Ivory, Amber, and such other brittle bodies.

EXPERIM. VI.

July 1. I filled two glass-pots, the one with one ounce of shavings of Harts-horn and two ounces of water, the other with an ounce of Whitings bones and two ounces of water. Having continued the fire till the drop of water would dry away in 7 seconds with the inward pressure twelve times stronger than the ordinary pressure of the Air, I took off the fire presently, and the Vessels being cooled, I found a very strong gelly in the Pot with Harts-horn: I gave some of it to a person that makes such Gellies pretty often, and she said that there must be something more in this than in hers, because this had both smell and taste pretty strong; but in hers there was neither of them. I think this difference did proceed only from the Spirits and volatile Salts that are kept in by means of the Engine fastned with Screws, and that fly away in the ordinary boiling: and from thence it is very probable, that this new gelly hath much more virtue in it. The Harts-horn also was all very soft; but in the ordinary way it is brought but to a powder that feels hard between the fingers.

In the other Pot the fish-bones were quite soft, but the liquor would not congeal: yet being dryed, there was found some glue remaining, but in small quantity, and not so strong as that of Beef bones.

EXPERIM. VII.

July 2. I filled two glass-pots, the one with half an ounce of Harts-horn and two ounces and half of water, the other with bones and water in the same proportion as five to one, and the bones were shaved as well as the Harts-horn. Having augmented the fire till the drop of water

water would dry away in 5 seconds with ten pressures, I took it off quickly: the next day I opened the Vessels, and found that in the pot with bones the liquor was but little thicker than water; in the other there was a good gelly, but not so strong as that in the foregoing Experiment: I heated it again, and as soon as it was melted I filtrated it and squeezed it as well as I could, and I set the remainder a drying, (*that remainder being dryed after a weeks time was found to weigh* $2\frac{1}{4}$ *drams: so that all the congealing parts drawn from the Harts-horn did weigh but* $1\frac{1}{4}$ *dram, and that had been enough to congeal* $2\frac{1}{2}$ *ounces of liquor which is* 16 *times as much weight*) the liquor that had been filtrated did in a short time turn to a gelly much stronger than Harts-horn gelly uses to be: therefore I believe I may be confident that a certain quantity of Harts-horn will congeal five times its weight of water; and it may be by practising there will be found some degree of heat that will make more: but though we could do no more, yet this would be a considerable thing, since in the ordinary ways the quantity of gelly is less by half and not so good, and it requires much more fire, and time, and fresh water, which is of consequence at Sea: For although I must needs have water to make gelly after my way, that water is not lost, since it remains all in the gelly; but if you make it after the ordinary way, above three quarters of the water will evaporate away.

EXPERIM. VIII.

Having found by the last Experiment that Harts-horn doth yield so much gelly more than the bones do, I had a mind to try whether the reason of it was not because the degree of heat was fit for Harts-horn, but not strong enough for bones: Therefore I repeated the same Experiment with the same circumstances, but at this time I increased the fire till the drop of water would dry away in 4 seconds: and the Vessels being cooled, I found the gelly of Harts-horn pretty good still, but the liquor upon

the bones was not very thick: yet I found some gelly after I had poured out gently the over-swimming liquor, but that liquor weighed above an ounce: so I thought that truly the bones do not contain so much congealing parts as Harts-horn doth. Having filtrated and squeezed the matters of both my Pots, I kept the remainders of them asunder each in a glass well stopt, for fear they should dry, and about two weeks after I found them fermented, and of the same smell and taste as Parmezan Cheese, and very fit to be eaten with bread. When I had shewn such Harts-horn to the Royal Society, they judged that in all likelihood, being in that condition, it would yield more Spirits and more easily than usually it doth. The bones were in all things very like the Harts-horn, and some time after worms were generated in them, which did not happen to the Harts-horn: so that it being usual to see worms generated in good rather than in bad Cheese, it seems that in this the bones have some advantage above the Harts-horn, as well as the Harts-horn is to be preferred to them for the quantity of gelly it yields.

Having found some difference both for the quantity and for the readiness in drawing Gellies from several Bodies, as also for the strength of that kind of glue, I believe there might be found a difference in several other Proprieties of them; and seeing our bodies are but congealed liquors, it is likely, that if people would go on with this tryal and draw Gellies from several parts of the same Animal, and from several Animals of the same kind, but of different ages, and from several kinds of Animals that live a great deal longer one than the other, as from Hares and Rabbets; and then if they would compare all the several proprieties of these Gellies with one another, it is likely, I say, that it would be a great help towards making a better Theory than hitherto we have about the causes of the lastingness of our life: and such a Theory would, it may be, prove of more consequence than many people are apt to believe.

From

From all the Experiments contained in this Chapter, I think it very likely, that if people would be perſwaded to lay by Bones, Griſtles, Tendons, Feet, and other parts of Animals that are ſolid enough to be kept without Salt, whereof people throw away more than would be neceſſary to ſupply all the Ships that *England* hath at Sea; the Ships might always be furniſht with better and cheaper Victuals than they uſe to have. And I may ſay, that ſuch Victuals would take up leſs room too, becauſe they have a great deal more nouriſhment in them in proportion to their weight. This is plain in Harts-horn, which will make five times its weight of gelly, (which is accounted to be of a great nouriſhment) and yet afterwards it will turn to a ſubſtance very like Cheeſe which cannot be eaten in great quantity.

EXPERIM. IX.

June 20. I boiled two Macquerels in the ſame manner as hath been deſcribed *Chap.* 2. *Exper.* 13. ſo that their bones were ſoft: then I left one dry in the open Air, and having kept it for eight days, though in very hot weather, it was not corrupted at all; but another piece which I kept in the ſauce was corrupted before three days.

I had a mind to try afterwards, whether an ordinary boiling would have the ſame effect: and to that end *June* 26. I boiled a Macquerel after the ordinary way, and having ſet it to dry, as I had done with the other, I found that it would ſtink in leſs than four days. From this Experiment I believe it appears, that this Engine would be uſeful to dry Victuals ſo as to keep them without Salt, and without loſing their juyce, and it may be ſuch Victuals will prove much more wholeſom than ſalt Victuals that are ſo much uſed at Sea.

EXPERIM. X.

This Engine being ſo uſeful to hinder the waſting of freſh water by evaporation, I thought it might alſo in ſome

some cases make Sea-water serve instead of fresh water: Having therefore dissolved one dram of Salt in forty drams of water, (which I have heard from Mr. *Boyle* to be much the same proportion of Salt as is in Sea-water) I took an ounce of dry Pease, and having put them in a glass-pot with double their weight of the said salt water, I included them in the Engine. I blew up the fire till the drop of water would evaporate in 4 seconds, with an inward pressure ten times stronger than the ordinary pressure of the Air. The Vessels being cooled, I found that the Pease had imbibed all the water, and were very well softned; and Dr. *King* having tasted the same, found them very savoury and not too much salted: it is very likely that Beans and all other Pulse will do the same. I think therefore that in supplying a Ship with Victuals, we may reckon that the Pulse will change double their weight of Sea-water into fresh water, or at least make it serve for nourishment as well as if it had been fresh, and this may diminish very much the quantity of fresh water Ships must be incumbred with. If people should use Sea-water to boil Pease in after the ordinary way, it would come to pass, that the evaporation wasting but the watry parts, would make the Pease exceeding salt, and besides that, they could never be well softned.

I did also try whether Sea-water could be used to make Gellies, therefore I put some of the same salt water into a pot with an equal weight of Mutton-bones; and having increased the fire, as I use to make Mutton-bones gelly, I found a very strong gelly indeed, but it was too salt by a great deal, the quantity of congealing parts being so little, that it cannot much contemperate the saltness of the water: I think therefore that Sea-water should be mingled with double its weight of fresh water to make gelly withal.

CHAP.

CHAP. IV.

Experiments for Confectioners.

EXPERIM. I.

June 27. I put Cherries into two Pots, in one of them there was water enough to cover the Fruit; to the other I added nothing at all: having forced the fire till the drop of water would dry away in 40 seconds, with the inward pressure 3 times stronger than the ordinary pressure of the Air, I found the Cherries very well boiled, and those had much juyce where I had added no water; those with water had much more liquor, but their taste was more wateriſh.

The next day I put some of these Cherries to dry in the open Air, and I put some also to boil again with Goose-berries, to see whether a new boiling would spoil them: I blew up the fire till the drop of water would dry away in 10 seconds, with the inward pressure eight times stronger than the ordinary pressure of the Air, and after that I did not find the Cherries at all altered, but were still as big and as entire as before they had been boiled; I put some of these also to dry in the open Air. The next day I found that all these Cherries would dry very well and not corrupt; but those that had been boiled but once without water were bigger than all the rest, and those that had been boiled twice were very wrinkled and grown smaller than the others that had been as long again a drying.

This Experiment shews that some Fruit may without danger remain a great while upon the fire in this Engine after they have been boiled enough, and that makes them to be not so fit to corrupt as they were before: therefore I believe, if those who are skilful that way, would make a Syrup to keep such Fruit in without drying, they might have Sweet-meats, which not having been

been boiled in Sugar, would keep much better the taste of the Fruit; but I think the Syrup should be thicker than usual, because the moisture of the Fruit is apt in a little time to mingle with it, and make it more liquid.

Experience must teach us what degree of heat will be the best to preserve Fruit without much altering its taste.

EXPERIM. II.

July 6. I put into a pot five ounces of Goose-berries, and having continued the fire till the drop of water would dry away in 15 seconds, I presently put it out. The Vessels being cooled, I found that the Goose-berries had yielded an ounce and half of liquor pretty thick: I put some of these Goose-berries to dry in the open Air, and they did dry very well and not corrupt.

This Experiment made me the more apt to believe that Sweet-meats might be so ordered as to keep much of the taste of the Fruit; and I believe at the same time one might have a great conveniency to make clear Cakes, because the juyce fit for that purpose is all kept in this Engine, and may be drawn a great deal sooner than after the ordinary ways.

EXPERIM. III.

July 22. Three weeks ago I shut up ripe Goose-berries in a great glass, and put to them water satiated with Sugar to fill up the interstices: to day seeing these Goose-berries ferment apace and make abundance of bubbles, I put some of them in a glass-pot with some of their liquor, and having inclosed it in the Engine, I continued the fire till the drop of water did dry away in 6 seconds, with an inward pressure five times stronger than the ordinary pressure of the Air. I took off the fire, and the Vessels being cooled, I found the Goose-berries very well boiled, soft, and of a good taste: though the Fermentation had made them hard and unpleasant to the palate. I included at the same time another pot full with fresh Goose-berries, to which I added one part of Sugar to five parts of Fruit:

I found

I found them also very ready, and of a very pleasing taste, but much more sweet than those that had been fermented.

After I had left these two glass-pots for ten days together well covered, but not above ⅔ full, I saw no Fermentation in them; but the Fruit grew a little musty in the pot containing those Goose-berries that had never been fermented; but in the other pot there was no change at all: so that it seems the Fermentation before boiling is a remedy against corruption. I took the Fruit that grew musty, and having exactly filled a lesser glass with it, I fastned a good cover to it with a Screw, this prevented further corruption; and that same Fruit in five or six days began to ferment, and the juyce ran over, though the Screw prest the cover pretty hard.

August 30. I opened that same glass whose cover was fastned with a Screw, and having put some of the Fruit and Juyce into a little glass-pot, then having shut all in the Engine, I increased the fire till the drop of water dried away in 6 seconds, with an inward pressure twelve times stronger than the ordinary pressure of the Air. I took off the fire, and the Vessels being cooled, I found the Goose-berries had, by boiling again, lost much of their sweetness, but their taste was very pleasing, it may be many people would like it better than before: having put some of their Juyce into a glass, and some of the Juyce that had not been boiled again into another glass, I put them both together *in Vacuo*, and I saw that the Juyce twice boiled had given over fermenting, because it did not bubble, but the other did mightily.

From all I have said in this Experiment I believe I may conclude: 1. That if we keep Fruit, as I have said in the beginning, that is to say, if we let them ferment softly in Vessels well stopt, we may at any time make with them very good Sweet-meats at a cheap rate, by the help of the Engine that will soften the Fruit, and keep the Spirits from evaporating. 2. There will be less danger of growing musty when the Fruit hath been boil-

ed so during the Fermentation. 3. If any mustiness appears, we may hinder it by filling up the Vessels and fastning the cover with a Screw. 4. If the Fermentation begins again, we may stop it by a new boiling. Yet this Experiment ought to be continued some time longer before we can be assured how far it will go. I do not here describe the way how to fasten a cover to a glass with a Screw, since it is the same that hath been said in *Chap.* 1. for the Pot GG, and people that would make a great Trade of that kind, might instead of glasses make use of high earthen pots.

EXPERIM. IV.

August 17, & 18. I repeated the same Experiment; but instead of Gooseberries I made use of Plums, I boiled some of them three several times, but I learned nothing worth relating, only that Plums, after they are boiled, fermenting with $\frac{1}{3}$ or $\frac{1}{4}$ of Sugar, will taste like Wine, stronger and more pleasing than Gooseberries, and I do not question but many men will approve of this pleasant relish beyond that of most Sweet-meats. I did also observe, that when I distilled them in the manner described *Chap.* 6. *Exper.* 3. they yielded juyce in a greater quantity and thicker than when boiled, as the Gooseberries before-mentioned were.

CHAP. V.

Experiments to make Drinks.

EXPERIM. I.

July 22. I included, two or three weeks ago, some ripe Gooseberries in a great glass, and filled all the interstices with water and Sugar: to day seeing the Fruit did ferment apace, I took out some with the liquor, and filled therewith $\frac{1}{3}$ of a little glass-pot; then I made use of

of some of this liquor alone to fill another glass-pot, wherein I had put some fresh Gooseberries unfermented: having included these two pots in the same frame and in the same Engine, I advanced the fire till the drop of water would dry away in 2 seconds, and kept it so for a while; the inward pressure was ten times stronger than the ordinary pressure of the Air. The Vessels being cooled, I found the pot containing the fermented Gooseberries to be half empty and mightily burnt; but the Vessel containing the fresh Gooseberries was scarce at all the emptier, though there were in it a good deal of fermented liquor which had no taste of burning.

From this Experiment I concluded, that when Wine is made so by infusing fruit in water and Sugar, there is much more strength in the fruit than in the liquor: so that the fruit by fermenting comes to be near as apt to rarifie as Spirit of Wine it self (see *Chap. 6. Exper.* 2.) Therefore I thought if I did make Wine with fruit alone without water, it would be mighty strong; but because the juyce of Gooseberries and several other Fruits are too thick to make Wine withal, unless they be boiled, I think that this screwed Engine is very necessary to boil these Juyces, seeing we can perform it without water, and without evaporating the most subtile parts, therefore I made the following Experiment.

EXPERIM. II.

July 25. I put ripe Gooseberries into a Pewter-pot, and having inclosed it in the Engine, I continued the fire till a drop of water would dry away in 3 seconds, with an inward pressure ten times stronger than the ordinary pressure of the Air: I presently took off the fire, and the Vessels being cooled, I found that the Gooseberries had yielded a very red juyce, and that in the places where the Gooseberries had been burst next to the Pewter pot, they had acquired a very fine purple Violet colour.

I put this morning some of the same ripe Gooseber-

ries with water and Sugar into a glaſs Veſſel well ſtopt; and afterwards I put ſome of the Gooſe-berries, newly taken out of the Engine, into another glaſs with ſome of their Juyce and ¼ of Sugar, that I might ſee which of them would ferment ſooner and better.

Auguſt 2. Two or three days ago I ſaw the Gooſe-berries ferment in both glaſſes much alike, and to day having taken ſome of the Juyce out of the two glaſſes, I put them ſeverally into two Vials, and then I put them both together *in Vacuo*, where I obſerved, according to my expectation, that the Juyce of thoſe Gooſe-berries that had been boiled, was much more like the nature of Wine than the liquor of the other glaſs, for that bubbled more, and its taſte was more pungent and ſpirituous.

Auguſt 3. I ſeparated the boiled Gooſe-berries from their Juyce, and ſqueezed them that they might yield more: I put all that Juyce into a Bottle which I have kept ever ſince, that is, near ſix weeks. For two or three days in the beginning that liquor fermented mightily, threw out the Cork and ran over, though it was not ⅔ full; but ſince that time it hath been much abated, and now its taſte is very good and pungent, yet it doth ferment ſtill, ſeveral bubbles ariſing in it, and it is not clarified: this makes me believe that ſuch Wine may be kept for a great while, and that it is to be feared rather that it will be too long a making, than that it will grow ſour too ſoon.

I put the remainder of the ſqueezed Gooſe-berries into another Glaſs with water and a little Sugar: this in leſs than 24 hours began to ferment very violently, and in a fortnight the liquor was pretty well clarified and good to drink, but not ſo ſtrong as that without water, and I believe alſo it would have grown ſour in a ſhort time. This Experiment was made by gueſs and without Scales; but I gueſt the fruit to have been about ¼ of the weight of the water, and the Sugar ⅛.

From this Experiment we ſee that the ſame fruit, by means

means of this Engine, may afford two sorts of Wine; the one to keep long, and the other to drink quickly.

EXPERIM. III.

August 5. I took some of the Juyce of the Goose-berries above-mentioned, in the time it did ferment most briskly, and having put it into a little glass-pot, and then in the Engine, I continued the fire till the drop of water would dry away in 10 seconds, with an inward pressure three times stronger than the ordinary pressure of the Air. I found that the liquor had got a taste near to that they call in *France raisiné*, and it was pleasing to drink, and apt to quench thirst. Then that I might know whether the liquor had been much altered by boiling in the Engine, I put some of it into a little glass, and took some also out of the great Bottle that was a fermenting, and having put it into another glass, I included them both at the same time *in Vacuo*, and found that the liquor which I had set upon the fire during its fermentation, did not bubble so much as common water would do; but the other liquor did at the very first suction rise all into bubbles.

From this Experiment I gues: 1. That by boiling a Liquor, whilst it ferments, we may quickly take away the ill quality it hath to generate winds, and cause pains in the Belly. 2. That such a liquor would not hurt the Head neither, as Wine doth, because the Spirits are not yet quite so loose, as they are in Wine: and this appears, because the Wine boils in some measure *in Vacuo Boyliano*, but this liquor doth hardly yield any little bubbles. 3. That such a liquor would not easily dye, since the Spirits can so hardly extricate themselves: And lastly, I am very apt to believe that it would be a good nourishing and strengthning Drink, since Bread is reckoned to be the staff of life which is put into the Oven, even during its fermentation: yet we must expect further Experiments before we can have any certainty of it; in the mean time we may be sure that such drink may be got ready pretty soon.

EXPE-

EXPERIM. IV.

August 17. I took Juyce of Plums distilled after the manner to be described *Chap.* 6. *Exper.* 3. and because it was thicker than that which is drawn without distilling (for the Juyce which remains in the heat with the fruit, is thereby continually attenuated) I thought I should use more heat to attenuate the same: therefore having shut it after the ordinary way, I continued the fire till the drop of water would dry away in less than 2 seconds, with an inward pressure twelve times stronger than the ordinary pressure of the Air: I took away the fire, and the Vessels being cooled, I found (contrary to my expectation) that the Juyce was become almost all solid from the top to the bottom of the pot, and that it was turned into a black stuff much burnt which could easily be powdered between ones fingers; yet there were many cavities full with a very fluid liquor, which had such an acrimony, that the Tongue could hardly endure it: so that the heat did work upon that Juyce almost the same effect as the Runnet doth upon Milk.

I have kept for two months together some of the same distilled Juyce of Plums, and I found that it was not at all grown hard, as that which had been in such a great heat was; but it hath fermented very little in comparison with those that are more fluid.

This Experiment shews that the degree of heat is to be well observed in making Drink, not to give too much nor too little: and that distillations of Juyces may indeed prove very good to make clear Cakes, Gellies, Syrups, &c. but for Drinks, ordinary boiling, as I have said of Goose-berries, will do better: yet in time it may be, such thick Juyces will make stronger Wines than thinner ones; but I am afraid that will require many years.

EXPERIM. V.

August 17, 18, &c. I kept Juyces of Plums to make the

the same Experiments, as I have said of Goose berries; but I think it needless to give the particulars of them, because I learnt nothing new by them, but that Damsons, if they be not too ripe nor over-boiled, will make Wine much stronger than Goose-berries: and that having mingled a little Juyce that was a fermenting with a Bottle of Juyce newly drawn, this mixture did, like a Ferment, hasten the fermentation in the said Bottle.

CHAP. VI.

Experiments for Chymists.

EXPERIM. I.

July 13. Dr. *Slare*, Fellow of the Royal Society, had a mind to try whether the Engine could not be useful to draw quickly the most stubborn Tinctures in Chymistry; therefore we put into a little glass pot Salt of Tartar with rectified Spirit of Wine: into another pot we put Amber with some of the same Spirit of Wine. We continued the fire till the drop of water would dry away in 3 seconds, with an inward pressure twelve times stronger than the ordinary pressure of the Air, and then we did put it out presently. The Vessels being cooled, we found in the first pot that the tincture of Tartar was as strong as it could have been made in a months time after the ordinary way, and its taste was lixivious; in the other pot the tincture of Amber was a great deal stronger than usually it is.

EXPERIM. II.

July 15. Dr. *Slare* had also a mind to make a tryal of the tincture of Antimony: the fire was lighted by 10 of the clock in the morning, I continued it till the drop of water would dry away in 2 seconds, with an inward pressure twelve times stronger than the ordinary pressure

ſure of the Air: I took off ſome part of the fire, ſo that the heat being diminiſhed, the drop of water did evaporate but in 3 ſeconds, and nothing could get out of the Engine; I kept the fire much about that ſame ſtrength till 1' in the afternoon, then I left it till about three of the clock, at which time I found the Veſſels much cooled, and the fire almoſt out. I lighted it again, ſo that the drop of water would evaporate in 1' ſecond, and then I ſaw again ſomething get out through the little Valve P, and I took off ſome of the fire till the drop of water would dry away but in 2 ſeconds, and then the Engine was very tite again. I let the fire go out of it ſelf, and found that the Vinegar had drawn a very little tincture from the Antimony, though the heat had been much ſtronger and longer than in the former Experiment for the tincture of Salt of Tartar.

A while after when I would empty the pot, I found that the Antimony was come into a lump as if it had been melted, and that the upper part was red, and the bottom blackiſh; ſo that it ſeems the tincture had been drawn and then precipitated.

We did alſo take notice of a great difference between Spirit of Wine and diſtilled Vinegar; for in *Exper.* 1. the heat had given ſuch a great ſtrength to the Spirit of Wine to expand it ſelf, that moſt of it had run over from the pot which was thereby above half emptied: but on the contrary, the Spirit of Vinegar had been ſo little able to expand it ſelf, that the preſſure in the Engine being equal, if not ſtronger than that in the pot, this was not at all emptied, but ſtill full to ', though the heat had been ſtronger than upon the Spirit of Wine, and the preſſure in the Engine had been equal in both Experiments.

EXPERIM. III.

Auguſt 9. I put ſome Roſemary into a long glaſs pot, but it was held up by a Wyre-Diaphragme, ſo that it was diſtant from the bottom by a third part of the length of the pot: I kindled fire towards the top of the En-

gine, that the bottom remaining cold, the vapors of the Roſemary might condenſe in the bottom of the pot: I continued the fire till the drop of water upon the cover would evaporate in 6 ſeconds; but the bottom was almoſt cold. Afterwards I found that the Roſemary had yielded ſome red water and pretty fragrant, about the weight of a dram, and beſides that two or three drops of eſſential Oyl of a very ſweet ſmell, and of a contexture ſomewhat like Butter, being thicker than Oyl uſeth to be.

This way of diſtilling is to be preferred to the ordinary ways: 1. Becauſe there is no danger of loſing any thing. 2. Becauſe the vapors may deſcend more eaſily than get up: So that being put in motion by the gentle heat of the *Balneum Mariæ*, and preſently falling down by their heavineſs, they can preſerve their own nature much better than when, being expoſed to a fire leſs kind, they muſt receive from it a motion ſtrong enough to raiſe them to a conſiderable height, which can hardly be done without altering their nature. 3. In ordinary Diſtillations there ſticks always ſome Oyl to the head, which doth not come into the receiver; but here there is no ſuch danger, ſince there is no head, the receiver ſerving for both, doth immediately receive all the vapors that are freed from the ſubject.

The Diaphragma I made uſe of for theſe Diſtillations is expreſt *Fig.* 3.

BB. *Is the Diaphragma made out of Wyres.*

AAAAAA. *Are three little feet to keep it up at ſome diſtance from the bottom.*

CC. *Is another Wyre faſtned to the Centre of the Diaphragma, and reaching to the top of the Glaſs, that after the Operation is made, we may draw out the Diaphragma with the matters above it, and leave the diſtilled Liquor alone in the Glaſs.*

We might alſo order our Veſſels to be caſt after a Circular ſhape, as in *Fig.* 4. for ſetting one end in the

fire, and the other end in cold water, all the vapors would condense there, and the volatile Salts might stick in the middle, as in ordinary Distillations. We might also order our Vessels, as in *Fig.* 5. where the Pot GG hath its aperture II out of the Engine AA: so that the said Pot might be quite filled with the matter to be distilled: for applying a deep cover BB to the aperture II, the vapors will all descend and be condensed in the said cover.

The Pot must be strongly soddered to the Engine at the aperture SS to keep in the water contained in the space TTTT between the Pot and the Engine.

The little Pipe HH must be shut with a Screw instead of weight, as you see in the Figure.

There should be some kind of Iron box fastned to the Engine AA to keep fire to it.

Lastly, The whole thing ought to hang almost *in Æquilibrio* by the Appendices CC upon the two Pillars RRRR, that it might easily be turned upside down.

By that way we may save the trouble of opening the *Balneum Mariæ*, and so there will be no necessity to let it cool at all, because we may look into the Pot at any time, and put new materials into it, without giving any way to the water in the space TTTT to fly out. And besides, the cover BB may be made of glass, and so we can observe the progress of the distillation. We may also (for Operations that require to be made in great quantities) tye four or five such Engines together in a great Iron ring, and place the fire in the middle of them: so that the same fire will heat them all at the same time. By this means perhaps Bread may be baked very cheap and very good with Sea-coals. And such an Engine, though never so great, may easily be filled and emptied by turning it upside down, because it hangs *in Æquilibrio*; but I confess I have not yet tryed it so far.

EXPERIM. IV.

August 10. I took three ounces of Cinamon, and having

ving ſet them in the ſame manner, as the Roſemary lately ſpoken of, I continued the fire till the drop of water would dry away in a minutes time; but I found afterwards that almoſt nothing was drawn out of the Cinamon. I put the ſame Cinamon in again, and I continued the fire till the drop of water would dry away in 2 ſeconds upon the cover; but the bottom of the Engine was laid in cold water, which I did renew from time to time, ſo that the ſaid bottom got very little heat: that time I got about five drams of a whitiſh liquor with ſome ſmall drops of Oyl ſwimming at the top; there was alſo ſome Oyl ſticking to the ſides of the glaſs, and being ſeparated with a Knife, did alſo ſwim at the top of the liquor. It is ſomewhat probable, that the Oyl drawn after that way, is not ſo heavy as that which is brought hither from the *Eaſt-Indies*, and ſo mingling with the Phlegm, it makes it whitiſh; and that Phlegm having Oyl mixt with it is ſo fragrant, that it doth aromatize, there being allowed a greater quantity than of pure Oyl.

EXPERIM. V.

Auguſt 12. I put Aniſeeds into a glaſs pot, and ſome leaves of Roſemary into another, then I poured water into both of them to ſwim over the matter. I had a mind to know whether the eſſential Oyl would not be extracted as the Gelly is extracted from bones. I thought that the particles of water, inſinuating between the parts of the Plants, would give occaſion to the particles of Oyl to get looſe, and that theſe would afterwards gather at the top of the water. I continued the fire till a drop of water would evaporate in 10 ſeconds, and then I put it out. I found the matter much more fragrant than before, eſpecially the Roſemary, but I found no Oyl.

Auguſt 13. I repeated the ſame Experiment with Roſemary in one pot, and Cinamon in the other: I increaſed the fire till the drop of water did evaporate in 3 ſeconds,

and presently I took it off. The Vessels being cooled, I found the Rosemary rather of a stinking than of a sweet smell: from whence I concluded, that the excess of heat had spoiled it, since in the former Experiment a lesser heat had made it more fragrant: So I cannot tell whether by several Experiments we might not meet with some degree of heat that would make it much better and apt to yield more Oyl by distillation, and more easily than usually it doth.

The Cinamon being a harder body was not spoiled at all; but I do not believe that it would be profitable to prepare it so, unless we could find a degree of heat more fit for it.

This is all I have done about Chymistry, to which I think I may add, that this Engine may, without doubt, be of good use in those Operations that require a gentle and equal heat on all sides; because the hottest water ascending continually, will communicate the heat every where: it will be good also to keep the same degree of heat for a great while, because the great quantity of water to be heated and cooled will hinder the inequalities of the fire from being so remarkable upon the included matters. For example: If the fire comes to be somewhat stronger one time than another, it will come to pass, that the strength of the fire will be abated before it hath done any great effect upon the Engine and all the water contained in it; and so when the fire comes to be weaker than it ought to be, yet the heat will be kept a great while in the Engine, that you may have time to make a better fire. This consideration hath given me a mind to apply it for hatching Chickens, and I verily believe that the thing would succeed: I would set the Ball of an Hermetically sealed Weather-glass under a Hen amongst the Eggs, and so the Pipe of the said Glass reaching out of the Nest, may shew the degree of heat necessary for that Operation: then I would include that same Weather-glass in an Engine so accommodated with glass windows, that people might see what passeth in it; the

Eggs

Eggs in glass pots well stopt should be included in the same Engine, and so we may observe the degree of heat by the other glass, that it be just the same with that when it was under the Hen, and also may see when the Chickens are hatcht, because this Operation is very gentle, and requires neither great pressure nor heat. Engines for that purpose may be made of Lead, so that they will be big and cheap. I had a mind also to try whether the pressure might hasten the formation of a Chicken as well as it doth the coction of meat; but I have given over such designs, seeing I could find no leisure to go through with them.

CHAP. VII.

Experiments for Dyers.

EXPERIM. I.

BEcause in the second Experiment of the fifth Chapter I had some thoughts that the Gooseberries had drawn a fine purple colour from the Pewter, I had a mind to see whether Currants, being red already, would not make a finer colour: Therefore

August 3. I put several small Pewter Plates into a glass pot with squeezed Currants: I continued the fire till the drop of water would dry away in 3 seconds, with an inward pressure twelve times as strong as the ordinary pressure of the Air. I found afterwards that Currants, instead of making a finer colour than Goose-berries, had but a pale liquor, and much taste of Empyreume.

I had at the same time put some black Cherries into another pot, and I found the colour of their juyce mightily abated: this made me guess that fire doth very much alter the colours of most Bodies it works upon, by giving colour to those that had none, and taking it from those that

that were coloured afore: and I believe that in *Chap.* 5. *Exper.* 2. the Gooſe-berries that were burſt againſt the Pewter had got more colour than the reſt, meerly becauſe they had endured more heat: Therefore it is like enough, that if by means of this Engine we apply much heat without waſting the Bodies away, we may uſe for ſeveral Tinctures ſuch Materials as we could never have done by the ordinary ways.

EXPERIM. II.

Auguſt 4. I took Juyce of Lemmons, and incloſed it with ſome ſmall Pewter Plates in a glaſs pot; and having increaſed the fire till the drop of water would evaporate in 10 ſeconds, with an inward preſſure three times ſtronger than the ordinary preſſure of the Air, I found that the Juyce of Lemmons had drawn no tincture from the Pewter, though it be much more acid than that of ripe Gooſe-berries.

Auguſt 7. I repeated the ſame Experiment with the ſame Juyce of Lemmons, and I increaſed the fire till the drop of water would dry away in 3 ſeconds, with the inward preſſure twelve times ſtronger than the ordinary preſſure of the Air: I left ſome fire to keep the heat longer, and I found that the Juyce of Lemmons had got no taſte of Empyreume, nor taken any tincture from the Pewter, but it lookt a little yellowiſh: from thence I was more fully perſwaded, that the colour of the Gooſe-berries *Chap.* 5. *Exper.* 2. had not been drawn from the Pewter.

I had put at the ſame time ſome ſqueezed Gooſe-berries into another pot, and I found them to be burnt ſo much, that one could hardly ſwallow them: their colour was reddiſh, but nothing near ſo fine as that *Chap.* 5. *Exper.* 2. ſo that it appears, that the exceſs of heat may be very hurtful: having ſtained my hands with that burnt Juyce, it ſtuck ſo faſt, that I could not get it off in five days, though I waſht it with Sope pretty often, ſo that perhaps ſuch liquor may prove a good Vehicle to make colours penetrate and ſtick well.

EXPE-

EXPERIM. III.

August 16. Mr. *Mayre* a Dyer brought me some pulverized *rubia tinctorum*, we put it into two glass pots with some pieces of cloth and water; and to one of them we added a little Brandy: we increased the fire till the drop of water would dry away in 3 seconds, with an inward pressure 12 times stronger than the ordinary pressure of the Air; this was done in half an hours time: I took off the fire quickly, and the Vessels being cooled, we found the red colour spoiled and turned yellow: the pieces of cloth had their texture quite destroyed, and might be torn very easily, though in the ordinary way such cloth may be boiled for several hours together without danger.

From this Experiment we saw that the *rubia tinctorum* nor the cloth cannot endure such a strong heat.

Mr. *Mayre* had a mind afterwards to see whether Cochenille would give all its tincture without being grinded; therefore he put three grains of Cochenille very entire into a glass pot with three ounces and half of water, and at the same time he put into another pot some coarse Cochenille that is sold eight times cheaper than the other, and therefore he put eight times greater quantity of it in proportion to the water. Having increased the fire, as in the former tryal with *rubia tinctorum*, we found in the first glass that one of the grains of Cochenille had been quite dissolved, and that the two remaining had lost all their colour, and were turned black: the liquor was of a fine red colour; but in the second pot the tincture was stronger and deeper.

From this Experiment it appears, that by the help of this Engine one may save all the labour of grinding the Cochenille and all the wasting of it, and perhaps coarse Cochenille will give much more tincture than usually it doth.

I made a tryal with these Liquors to know whether the Pneumatick Engine would help Tinctures to penetrate better into the cloth: I put a piece of cloth into one of the

the liquors, and having set it so *in Vacuo*, I saw, according to my expectation, that a great many bubbles of Air got out of the cloth, so that I was in great hopes that the tincture getting into the place of that Air, would penetrate every where: yet having let in the Air again, and expreſt the humidity from the cloth, I found that all the colour was gone too: from whence I concluded, that it is not enough to have the colour insinuate between the hairs of the cloth, but that it must get into the hairs themselves; and this cannot be done, unless all the little particles every hair is made of, be rarified and expanded by heat, which is much more powerful for that than any *Vacuum* can be.

EXPERIM. IV.

August 18. I put two pieces of cloth into two glass pots; to one of them I added some tincture of coarse Cochenille, and to the other Juyce of Prunes distilled after the manner described *Chap. 6. Exper.* 3. I preſt the fire till the drop of water would dry away in 42 seconds, with an inward preſſure six times stronger than the ordinary preſſure of the Air: then I took off the fire quickly for fear the cloth should be spoiled: the Vessels being cooled, I found both the pieces of cloth good still and well dy'd, the Juyce of Prunes having penetrated as well as the tincture of Cochenille; but the tincture of it was of a deeper red and nearer to a brown colour: the Juyce it self was much altered, for it was Violet before: it was grown also much more liquid and watry.

From this Experiment it appears, that this Engine keeping things for a great while in a great heat without damage, and hindring the most subtile parts from getting away, as usually they do, may be fit to insinuate into cloth such liquors as are reckoned to be too thick and glutinous, as the Juyce of Plums is; because for dying there is no need of good taste.

Mr. *Mayre* thinks there would be no need of an inward pot, and so I believe the aperture of the outward

Engine

Engine might be left leſſer than the cavity, as you may ſee *Fig.* 6. Yet if they would dye cloth in it, the aperture HH ſhould be left wide enough to convey the cloth into the cavity AA, and this Engine ſhould alſo hang *in Æquilibrio* by its Appendices CC for the conveniency of filling and emptying the ſame.

CHAP. VIII.

Experiments upon harder Bodies, as Amber, Ivory, &c.

I Have made other Experiments upon harder bodies, as Amber, Ivory, Cow's horn, Tortoiſe-ſhells; but becauſe I have found nothing yet that may be brought to uſe, I will not be tedious in relating the Particulars of thoſe Experiments; therefore I ſhall only ſet down ſome few obſervations which they afforded.

1. Amber could never be melted whatever degree of heat I made uſe of, though I filled the Engine with Pitch and Sand inſtead of water; and I preſt the cover with eight Screws inſtead of two. I could indeed ſeparate ſeveral ſubſtances from it, as Balſam, Fumes, and Terreſtreities; but that cannot be called melted Amber, ſince it hath loſt ſeveral proprieties belonging to Amber: for if we diſſolve theſe ſubſtances with Spirit of Turpentine, they cannot be brought to any conſiderable hardneſs by evaporating the Spirit, and an indifferent heat will ſoften them again.

2. Mr. *Boyle* having given me ſome Copal Gum to try what it would do, I found indeed that it could be melted without being much altered; but when I would apply the ſame to facilitate the melting of Amber, I found that it would not do: I would, for the ſame purpoſe, make uſe of Gum Tragacanth, Maſtich, and Roſin, but it was all in vain: ſo that I believe one may be ſure

that the melting of Amber requires a stronger and quicker heat than this Engine can give.

3. Though Cows horn seems to be a more glutinous matter than bones are, I could never make any gelly or glue with it, though I have put the same over and over again in the Engine upon the fire, even four times successively.

4. I could never make Ivory soft and glutinous, though I have boiled it several ways, and in several *Menstruums*, as Grease, Oyl, Beer, and Water; I could draw a fine and transparent Gelly from it, but the body remained brittle.

5. Tortoise-shell cannot be softned by boiling in Oyl; but in Spirit of Wine it swells, and hath a great many cavities like a Sponge.

6. Cows horn and Tortoise-shell having been with water exposed to a heat that drys away the drop of water in 3 seconds, with an inward pressure twelve times stronger than the ordinary pressure of the Air, they come to be so soft, that they do not grow hard again but in three or four days time; and this perhaps might be of some use, and give more conveniency to work those Materials than when they are heated only after the ordinary way; but I must confess that they will afterwards be more brittle than before: and I have seen once two pieces of Tortoise-shell that had been by boiling so well glued to one another, that after they were hardned again, they would rather break in other places than be separated.

CHAP.

CHAP. IX.

A Calculation of the price that a good big Engine may come to, and of the profit it may afford.

BEcause people are loth to meddle with new Inventions, lest the expence should be greater than the profit to be got by them, I will subjoyn here a calculation of the price which a good Engine may come to, and of the profit that may be got by it.

I have been at an Iron-mongers house, and there I caused a cast Iron Pipe to be weighed: This being six inches in Diameter and two foot long, and, without doubt, strong enough to endure an inward pressure twenty times stronger than the ordinary pressure of the Air; This Pipe, I say, did weigh but 57 pounds: so that such another Pipe 12 inches in Diameter, and as strong proportionably to its bigness, will weigh but about 228 pounds: But let a covered Vessel weigh 250, yet it will not come to 48 shillings, seeing the Merchants can with good profit afford such Metal at two pence half penny a pound.

Now if the cover and the Vessel were ground to one another, and that in a Country where Work-men are cheap, the grinding will scarce come to two shillings.

Then the Iron pieces DD with four Screws (lest two should not do enough) and the Iron rod LM may be afforded much under five shillings, especially if made in the Country and in numbers.

Five shillings would also be a great deal too much for setting the Pipe HH, and fitting a Valve to it.

The inward Pot GG of cast Iron, or glass, or stone-pot might also be got under 20 shillings strong enough and big enough to hold 80 pounds of water: I confess it would be a hard matter to make a Glass so big; but instead of one they may make three or four to be set in the same Frame one above the other: So that we may

be ſure that a Merchant may with good profit afford ſuch Engines ready in good condition at 4 *l.* ſterling apiece.

Now ſuch an Engine is able to make above 50 pounds of the Gelly at a time, and may do the ſame quantity at leaſt twice in 24 hours, (for I have tryed that my great Engine, which is 6 inches in diameter, may in leſs than an hours time be heated enough to make Gelly of Bones) therefore one may make 100 pounds of Gelly every day.

Now in *Paris* where people conſtantly keep Gelly ready to ſell, the price of it is 20 pence a pound; but in *London*, where they make none, unleſs it be beſpoken, Apothecaries uſe to ſell it at 2 ſhillings a pound; therefore it would be a very good thing for the Publick, if any one would ſell Gellies for a groat a pound: yet at that price the aforeſaid Engine would make Gelly for above 33 ſhillings every day.

The fire will not come to ſix pence, and the bones with ſome Harts-horn might be got cheap enough too, ſince it is not neceſſary to ſhave them for this Engine, and a little Sugar ſerves for Gellies: yet let the expence come to 13 ſhillings a day, there will be ſtill 20 ſhillings profit for the Owner of the Engine, and ſo in four days time he will be fully requited for his firſt expence, and one man alone may at the ſame time keep five or ſix ſuch Engines at work for ſeveral uſes, whereof ſome perhaps will prove more profitable than the making of Gellies: Therefore we muſt not queſtion but thoſe that will ſet upon ſuch things, may make their own profit very well, and at the ſame time do a great ſervice to the Publick. I have not therefore thought it right, in a thing of ſo general uſe, that a man by virtue of a Patent ſhould hinder other people from working that may perhaps have more skill in doing things good and cheap; and I have inſtructed Mr. *Mayor*, a Founder, in *Old Bedlam* how to make theſe Engines of caſt Braſs, ſo that any body may ſee them and buy them of him.

Poſtſcript.

POSTSCRIPT.

DOctor *Edm. King*, Fellow of the Royal Society, having got one of these Engines, for a greater security and conveniency, caused the rod LM to be fitted in L with a Joynt, so that it must always fall upon the Pipe HH, and there is no danger that the Valve P may slip off and spoil the Operation: he hath also caused a Brick Furnace to be built on purpose, so that I have lately tryed whether by that means the expence of coals would be less than in my Chimney-corner (see *pag.* 6.) but I have found, contrary to my expectation, that the expence is much greater in his Furnace: the reason of which probably is, because in his Furnace the coals did not at all touch the Engine, but remained at a little distance below, as in ordinary Sand-Furnaces the coals do not touch the Pot; but in my Chimney the coals touch the Engine almost all along, and thereby may the better heat it. It is therefore likely, that it would be better to build Furnaces, so as to have the coals touch the Engine all along one side: It would be better also to have them made of Iron plates, because a Brick Furnace requires much fire to be throughly heated, unless it be kept at work constantly.

Mean while the Doctor hath made several Experiments with his Engine, having this conveniency, that there is no need of blowing the fire. Besides many good dishes of Meat and Fish, he hath prepared several Medicines, and found that in this Engine the Operation may be performed in less than the tenth part of the time that is required in his other Furnaces; and yet some of them are much stronger than ordinary.

We have seen that Harts-horn in Winter time, being boiled with twelve times as much water, will turn it all to a Gelly: so do the bones with above four times as much water, which is at least as much again as I had found

found in Summer time. *Upon this occasion I will mention two other Particulars which do not succeed in cold, as in hot weather: The first is the Fermentation of Bones spoken of* Chap. 3. Exp. 8. *which is not so well performed in Winter. The second is the quantity of fire required in such Operations; for I have found by my Engine that Mutton may be very well drest, and the bones softned with five ounces of coals in Summer time; but in Winter the same effect cannot be produced with less than six ounces and half.*

We have seen that it is not necessary to put in the Engine all the water to be congealed; but putting equal weight of bones and water, after the Operation your water being mingled with three times as much fresh water, will turn it all to a Gelly: so the Gelly to be made with an Engine, and therefore the profit to be got by it, is much greater than I have said *Chap.* 9.

I have found that an old Hat, very bad and loosely made, being imbibed with Gelly of Bones, is become very firm and stiff: so that it is likely, if such Liquor should be used in making Hats, they would be extraordinary good.

The Doctor's Engine having already given occasion to these Experiments, I doubt not but when the thing is made common, a great many more Uses of it will be found in a short time.

FINIS.