

An account of the mechanism of an automaton, or image playing on the German-flute: as it was presented in a memoire, to the gentlemen of the Royal-Academy of Sciences at Paris ... By M.V., inventor ... of the ... machine. Together with a description of an artificial duck, eating, drinking, macerating the food, and voiding excrements; pluming her wings, picking her feathers, and performing several operations in imitation of a living duck ... as also that of another image, no less wonderful than the first, playing on the tabor and pipe ... / Translated out of the French original, by J.T. Desaguliers.

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VAUCANSON

A N
A C C O U N T
O F T H E
M E C H A N I S M
O F A N
A U T O M A T O N,
O R

IMAGE playing on the *German-Flute* :
As it was presented in a *Memoire*, to the Gen-
tlemen of the ROYAL-ACADEMY of SCIENCES
at *PARIS*.

By M. VAUCANSON, *Inventor and Maker*
of the said MACHINE.

TOGETHER WITH
A DESCRIPTION of an artificial DUCK, eating,
drinking, macerating the Food, and voiding Excrements;
pluming her Wings, picking her Feathers, and performing
several Operations in Imitation of a living Duck: Contrived
by the same Person.

A S A L S O
That of another Image, no less wonderful than the first, playing
on the Tabor and Pipe; as he has given an Account of them
since the *Memoire* was written.

Translated out of the French Original, by J. T. DESA-
GULIERS, L. L. D. F. R. S. Chaplain to his Royal
Highbness the PRINCE of Wales.

L O N D O N: Printed by T. PARKER, and sold by Mr.
STEPHEN VARILLON at the *Long Room*, at the *Opera House*
in the *Hay-market*, where these Mechanical Figures are to be seen at
1, 2, 5, and 7, o' Clock in the Afternoon. 1742.

The TRANSLATOR to the READER.

THOSE who have neither seen, nor heard a true Account of M. VAUCANSON'S Machines, may wonder that I should take any Pains to promote the Advantage of Persons who are exposing any thing to publick View: As it would be very mean to cry up trifling Performances, and commend what amuses the great and small Vulgar, by Confederacy, such as the pretended Mathematical Figures, &c. But on the other hand, it is laudable to encourage those who are truly ingenious, by doing Justice to the most curious Peices of Art that perhaps have ever been perform'd; which I cannot do better than by translating into English this Memoire of Mr. VAUCANSON, that in a few Words gives a better and more intelligible Theory of Wind-Musick than can be met with in large Volumes. And here the Reader will also find a clear Explication of every Part of his Contrivances, which requires no small Skill to do with such Perspicuity, without Figures.

In giving this Paper an English Dress, I am still acting in my Province, which has been for many Years to explain the Works of Art, as well as the Phænomena of Nature.

J. T. DESAGULIERS.

P. S. Whilst this Memoire was printing, I received the Description of the Duck and that of the Figure playing on the Tabor and Pipe; which Mr. VAUCANSON describes in a Letter to a Friend. Therefore to do him Justice in every Respect, and for the Satisfaction of the Curious, I have subjoined the Translation of his Letter.

A N
A C C O U N T
O F T H E
M E C H A N I S M of an I M A G E

Playing on the *GERMAN FLUTE*, &c.

Presented to the Gentlemen of the *Royal Academy* of Sciences,

By Mr. *VAUCANSON*, the Inventor of it.

GENTLEMEN,

LESS sensible of the Applause of the Publick, than desirous of the Happiness of deterving yours, I come to discover to you, that it is only in following your Steps that I have been able to go on with some Success in the Track I have pursued, for the Execution of my Undertaking. You will know your Lessons in my Work. It is only raised on the solid Principles of Mechanicks, which I have taken from you.

To You I owe the Reflections I have made on the Sound of Instruments, on Mechanicks, and on the different Motion of the Parts wherewith Machines work. My Thoughts on the *German-Flute* will make the first Part of this *Memoire*: And in the Second, I shall do my self the Honour to give a Detail of the Pieces contain'd in my Work, their several Motions, and their Effect.

F I R S T P A R T.

My first Care has been to examine the Mouth of Wind-Instruments, to know well how to get Sound out of them, what Parts contribute to produce it, and how it may be modified.

You know, Gentlemen, that the Mouth of a *German Flute* differs from that of the other Wind-Instruments, such as the common Flute, the Flageolet, and the Organ-Pipe; because in these last the Wind introduced at a narrow Hole, but which is determined, strikes the Parts of the Body of the Instrument which are immediately under it, as the Bezel; and by the Quickness of its Return, and its Re-action upon the small Parts round about it, it suffers a violent Collision: Thus communicating its Vibrations to all the Parts of the Wood of the Flute, which in their Turn communicate them to the external Air round about them, it produces in us the Sensation of Sound.

But in the *German-Flute* the Mouth is undetermined, because in that Instrument the Wind passes through a greater or smaller Issue, made by the greater or less Opening of the Lips, as they approach towards, or recede from each other; as they come nearer to, or are further from the Hole of the Flute; or as they advance more or less over the said Hole.

All these Differences, which I reduce to four in the Mouth of the *German-Flute*, make it, in playing upon it, capable of a very great Number of Perfections, which are wanting in other Wind-Instruments, whose Mouth is determin'd; which I shall shew in explaining those Motions.

The Sound being first produced by the Vibration of the Air, and the small Parts of the Body of the Flute,

is only determined by the Quickness or Slowness of those Vibrations. If in an equal Time they are to be continued in a greater Number of the Parts of the Body struck, they will lose more of their Motion, and consequently of their Swiftmess; and thus, becoming slower in the same Time, they produce a less lively Sound; and this makes the deep or low Tones.

This happens when all the Holes of the Flute are stop'd. The Vibrations, which begin exactly at the Hole of the Mouth, must be communicated to all the Parts of the Wood at the same Time; therefore they are suddenly weaken'd, because their Force is divided among a great Number of Particles; which will make the Flute give the lowest Sound.

If you open the first Hole next the Bottom of the Flute, the Vibrations find an Issue sooner, which interrupts their Continuation in the rest of the Parts of the Body of the Flute: They have fewer Particles to strike, (the Pipe being shortned by opening the said Hole) thus, losing a little less of their Force, because there are now fewer Particles among which they must be divided, they will have a little more Swiftmess; and being quicker in the same Time, they will produce a less deep Sound, and that will be a Tone higher. The other Tones will rise gradually, as the upper Holes are unstopp'd.

When you come to unstop the Hole which is nearest to the Mouth, that Hole dividing the inward Space of the Flute into two equal Parts, the Vibrations will find an Issue in the Middle of the Way that they are to run, to continue to the End of the Pipe; therefore they will go out with as much more Force and Velocity, having only half the Particles, among which they must divide themselves; and consequently will produce a Sound as
high

high again, which will be the Octave. But as a Part of those Vibrations is always communicated to the other half of the Body of the Flute, the Wind must be forc'd a little, to produce in those Vibrations Accelerations, which by the Increase of their Motion will supply the Want of those that are lost in the other half of the Flute; then you will have a full Octave. That Note is also produc'd by stopping all the Holes of the Flute, as in that of the first Octave: But then you must double the Force of the Wind, to produce double Vibrations in the whole Body of the Flute, which amounts to the same Thing.

This is what is practis'd in the Tones of the second Octave, where the Position of the Fingers and Opening of the Holes is the same as in the First. You must blow with a double Force to produce double the Number of Vibrations in the same Time; which makes the second Octave: Because the more or less acute Sound consists in the greater or less Number of Vibrations in the same Time.

Again, the Wind must be given with a triple Force to produce the third Octave; but Vibrations, so suddenly redoubled, not finding sufficient Issue in the first Hole to hinder their going on in the rest of the Body of the Flute, because of their extreme Swiftness, we must be forced to open several Holes in the lower Part of the Flute; thus the Pipe being more open, the Vibrations will have a greater Issue and a full and open Sound will be form'd, without being oblig'd to give the Wind quite a triple Force.

By this changing of Openings, different from what is required in natural Sounds, an Issue may be given sooner or later, and greater or less, to produce Semi-Tones; which must also be done in the last high Sounds, where a quicker and greater Issue must be given, that the Vibrations

Vibrations may not lose their Velocity in communicating with too many Parts of the Body of the Flute.

What remains is to shew how the Wind is modified, and what are the Parts in a living Person which contribute to give it more or less Force.

The Pressure of Pectoral Muscles upon the Lungs drives the Air out of the Vesicles that contain it: When this come up to the Mouth thro' the *Trachea Arteria*, (or Wind-pipe) it goes out of it by the Opening which the Lips form as they are applied to the Hole of the Flute. The greater or less Force of the Wind depends, first, upon the greater or less Pressure of the Muscles of the Breast, which drive it out of its Receptacle; secondly, upon the greater or less Opening of the Lips at its going out: So that when you wou'd blow weakly, the Muscles then must act weakly, and the Lips making a large Opening, the Wind is driven slowly; and consequently its Return producing Vibrations equally slow, and still farther slacken'd by their Communication with all the Parts of the Wood of the Flute, low Sounds will be form'd.

But when you wou'd rise to the Octave, that is, produce Sounds as high again, the Muscles must act with a little more Force; and the Lips, coming nearer together, must a little diminish their Opening; then the Wind being more strongly compress'd, and having a smaller Issue, will double its Swiftneſs, and produce double Vibrations, and thereby give Notes as high again, that is, the Octave. As you rise gradually to the high Sounds, the Muscles will act with more Force, and the Opening of the Lips will be proportionably contracted, that the Wind, driven in a more lively Manner, and forced to go out at the same Time by a smaller Issue, may considerably increase its Swiftneſs, and consequently produce accelerated Vibrations, which make acute Sounds.

But

But the *German-Flute* (as I have already said) having this Difference from other Wind-Instruments, that its Mouth is undetermined, the Advantages that arise from it, are that the Wind may be modulated by the greater or less Opening of the Lips, and by their different Position upon the Hole of the Flute, and by the Performer's being able to turn the Flute inwards or outwards. By this Means the Sounds may be swell'd and diminish'd, soften'd, and strengthen'd, produce Echoes, and give Grace and Expression to the Tunes that are play'd; which Advantages are not to be found in those Instruments whose Mouth is determin'd: which I shall shew in explaining the Mechanism of the different Operations perform'd on the *German-Flute*

Sound consisting in the Vibrations of the Air produced by its Entrance into the Flute, and its Return upon that which succeeds it; if, by a particular Position of the Lips, it enters into the whole Bigness of the Hole of the Flute, that is, goes thro' the longest Chord of the Hole, or the true Diameter of it, (which is done by turning the Flute outwards) then it strikes a greater Number of the Particles of the Wood, and at its Return finding an Issue equally large, it communicates with a greater Quantity of external Air; and this produces the louder Sounds.

But when the Flute is turn'd inwards, the Lips cover more than half the Hole, the Wind going in thro' a smaller Opening, and being able to return only thro' the same, in order to communicate with the external Air, it can strike only a less Quantity of it, which makes the Sound soft. These two Differences may have several Degrees, which depend upon placing the Lips over a greater or less Chord of the Hole of the Flute, by turning it more inwards or outwards.

Therefore

Therefore when there is Occasion to swell a Note, first you turn the Flute inwards, that the Lips coming over the Edge of the Hole may suffer but a small Quantity of Wind to go in or out, which then is driven weakly to produce a weak Sound; then insensibly turning the Flute outwards, the Lips allow of a greater Passage and Return to the Wind, which at that Time is driven with greater Force, that it may be communicated to a greater Quantity of Air, and thereby increase the Sound; or diminish it anew, by insensibly turning the Flute inwards, as in the first Operation.

All these Variations of the Mouth may be perform'd in any one Sound whatsoever, whether it be an high or a low one; because the Wind, tho' driven with different Degrees of Velocity during the Note that you wou'd swell to soften, must always be so regulated as to produce the Vibrations which determine that Note: In the Beginning, when the Sound will be weak, because it will strike a less Quantity of external Air, yet it will have Vibrations equal to those that are produc'd in the Middle of the Note where the Sound encreases in Force, because it will be communicated to a greater Quantity of Air; the Vibrations not being stronger or weaker on Account of their Velocity, but on Account of the Quantity of the Parts that they act upon, and which they put in Motion.

Wou'd you produce a soft Sound to represent an Echo? Place the Lips over the Hole quite to its Edge, by turning the Flute much inwards: then the Sound being able to be communicated but to a small Quantity of external Air, thro' so small an Hole, makes us hear a Sound that seems to be afar off, by its striking our Organs weakly.

These are Conveniences which cannot be found in Instruments whose Mouth is determined and invariable.

What remains to explain is that stroke of the Tongue, which is absolutely necessary for playing on all Wind-Instruments.

The tonguing an Instrument is nothing else than a short Interruption of the Wind, by the Interposition of the End of the Tongue in the Passage of the Lips.

These, GENTLEMEN, have been my Thoughts upon the Sound of Wind-Instruments, and the Manner of modifying it. Upon these Physical Causes I have endeavour'd to found my Enquiries; by imitating the same Mechanism in an *Automaton*, which I endeavour'd to enable to produce the same Effect in making it play on the German Flute. The Parts which compound it, their Situation, their Connection, and their Effects, will be the Subject of the second Part of this *Memoire*, as I first propos'd.

S E C O N D P A R T.

The Figure is about six Foot and an half high, sitting upon a Piece of a Rock, placed on a square Pedestal, four Foot and an half high, and three Foot and an half wide.

In the forepart of the Pedestal (the Pannel being open'd) on the right Hand there is a Movement, which by Means of several Wheels mov'd by a Weight, carries round underneath a steel Axel or Arbor, two Foot and a half long, with six Cranks in its Length at equal Distances, but looking different Ways. To each Crank are fasten'd Strings which terminate at the End of the upper Boards of six Pair of Bellows, two Foot and an half long, and six Inches wide each, placed at the Bottom of the Pedestal, where their lower Boards are made fast, so that as the Arbor turns, the six Pair of Bellows rise and fall successively one after another.

In

(II)

In the hind Part of the Pedestal, above each Bellows, there is a double Pulley, whose Diameters are unequal, namely, one of three Inches and the other of an Inch and an half; which is done to give the Bellows a greater Rise, because the Strings joyn'd to them go round the great Diameter of the Pulley, and those that are fasten'd to the Arbor which draws them, wind round the small Diameter.

On the great Diameter of three of these Pullies on the right Hand, there are also wound three Strings, which, by Means of several little Pullies, terminate at the upper Boards of three Pair of Bellows placed in the upper Part of the Pedestal, before and at the Top.

Each String, as it stretches, when it begins to draw the Board of the Bellows, to which it is fix'd, moves a Lever placed above, between the Axis and the double Pullies in the middle Part of the lowest Space of the Pedestal. That Lever, by Means of different leading Pieces terminates at the Valve of the lower Board of each Bellows, and keeps it raised, that the Air may go thro' without any Resistance, whilst the upper Board, as it rises, encreases the Cavity of the Bellows. By that Means, besides gaining Force, we avoid the Noise which that Valve commonly makes, as the Air causes it to tremble when it comes into the Bellows: Thus the nine Bellows are moved without any Shake, or Noise, and with but a small Force.

These nine Bellows communicate their Wind, in three different and separate Pipes. Each Pipe receives that of three Pair of Bellows: The three which are in the lower Part of the Pedestal on the right Hand forwards communicate their Wind to a Pipe which runs up along the upright Piece of the Pedestal on the same Side; and these three Bellows are loaded with a Weight of four Pounds each: The three which are on the left Hand in the same

Row, give their Wind thro' a Pipe like the former, which rises along the upright Piece on the same Side; and those below are only loaded with two Pounds each: The three Pair of Bellows, which are in the upper Part of the Pedestal, give their Wind thro' a Pipe which runs horizontally under them, and are loaded only with the Weight of their upper Boards.

These three Pipes, by different Elbows, end in three small Receptacles in the Breast of the Figure. There they re-unite into one, which goes up thro' the Throat, or Wind-Pipe, and widening, makes a Cavity in the Mouth terminated by two Lips which bear upon the Hole of the Flute: These Lips give the Wind a greater or less Issue, as they are more or less open; for the Performance of which, as well as that of coming forward or being drawn back, there is a particular Piece of Mechanism.

Within the forementioned Cavity there is a little moveable Tongue, which by its play can open or shut the Passage of the Wind that goes thro' the Lips of the Figure.

By this Mechanism has the Wind been conducted to the Flute; and by the following Contrivances it has been modified.

In the anterior Face of the Pedestal on the Left, there is another Movement, which by is Wheel-work, turns a Cylinder two Foot and an half long, and sixty four Inches in Circumference: This Cylinder or Barrel is divided into fifteen equal Parts, of an Inch and an half each.

In the posterior Face of the Pedestal in the upper Part of it, there is a Key-Frame, drawing or bearing on the Barrel, made of fifteen very moveable Levers, whose Ends on the Inside have a little Nib or lifting Piece of Steel, which answers to each Division of the Barrel.

At the other of these Levers are fasten'd Wires and Chains of Steel, which lead to the different Receptacles of Wind, to the Fingers, to the Lips, and to the Tongue of the Figure.

Those

Those which answer to the different Receptacles of Wind, are three in Number, and their Chains rise perpendicularly behind the Back of the Figure, quite up to the Breast, where they end, being each fix'd to the Valve of one of the Receptacles: And this Valve being open, suffers the Wind to pass into the Pipe of Communication, which rises, as I have already said, thro' the Wind-pipe into the Mouth.

The Levers which answer to the Fingers, are seven in Number, and their Chains also rise perpendicularly quite up to the Shoulders; and there they make an Angle or Bend, to go thro' the upper Part of the Arm to the Elbow, where they bend again to run along the Arm as far as the Wrist, where each of them ends in a Joynt fix'd to a Tenon made by the End of the Lever contain'd in the Hand, imitating the Bone which the Anatomists call *Metacarpus*, which, in the same Manner, makes a Joynt with the Bone of the first *Phalanx*: So that the Chain being drawn, the Finger may rise.

Four of these Chains are inserted in the right Arm to move the four Fingers of that Hand; and three in the left Arm for three Fingers, there being only three Holes which answer to that Hand.

The end of each Finger is arm'd with a Skin or Leather, to imitate the Softness of the natural Finger, that the Holes may be exactly stopt.

The Levers of the Key-Frame, which answer to the Motion of the Mouth, are four in Number: The Steel Wires which are fasten'd to them make Leaders to go to the Middle of a Ratchet within; and there are fasten'd to Chains, which rise perpendicularly parallel to the Back-Bone in the Body of the Figure, whence passing thro' the Neck, they come into the Mouth, where they are fasten'd to those Pieces, which being
fix'd

fix'd to the Lips within, give them four different Motions: The one opens them to give the Wind a greater Issue; the next contracts the Passage in bringing them nearer together; the third draws them back; and the fourth makes them advance over the Edge of the Hole.

There is but one Lever more upon the Key-Frame, to which is likewise fasten'd a Chain which rises like the rest, and ends in the Tongue, which is in the Cavity of the Mouth, behind the Lips, to stop the Hole, occasionally, as I said before.

These fifteen Levers answer to the fifteen Divisions of the Barrel, by their Ends which have the Steel Elbows or lifting Pieces, at an Inch and an half Distance from each other: When the Barrel turns, the Bars of Brass fix'd upon its divided Lines meet with the lifting Pieces, and keep them raised a longer or a shorter Time, according as those Bars are longer or shorter: And as the Ends of all those lifting Pieces, make one right Line, parallel to the Axis of the Barrel, cutting all the Lines of Division at right Angles; every Time that a Bar is fix'd at each Line, and that all the Ends of those Bars make amongst them also a right Line, and parallel to that which is form'd by the lifting Pieces of the Levers, each End of a Bar (as the Barrel turns) will touch and raise at the same Time the End of a Lever; and the other Ends of the Bars likewise forming a right Line parallel to the first, will, by the Equality of the Length of the Bars, each let fall its Lever at the same Time. One may easily see by this, how all the Levers may act, and at the same Time concur to the same Operation, if it be necessary.

When there is only Occasion for some of the Levers to act, you place Bars only at those Divisions which answer to those Levers which you wou'd have to move:

You

You may even determine the Time, by placing them nearer to or farther from the Line form'd by the lifting Pieces ; and their Action may end sooner or later, according to the different Length of the Bars.

The End of the Axis of the Barrel on the right Hand is terminated by an endless Screw with single Threads, distant from one another a * Line and an half, containing twelve Threads, which make an Inch and an half in Length, equal to the Divisions of the Barrel.

Above this Screw a Piece of Brass is fix'd to the Pedestal Frame, which holds a Pivot of Steel of about one Line Diameter, that falls in between the Threads of the Screw, and serves instead of a Nut to it; so that the Barrel in turning is obliged to follow the same Direction as the Threads of the Screw, being guided by the Steel Pivot which is fix'd: Thus as the Barrel turns round, each Point of it will describe a Spiral Line, and consequently make a progressive Motion from Left to Right.

By this Means each Division of the Barrel, determined at first under each End of a Lever, will change its Point at every Revolution, because it will recede from it a *Line* and an half, which is the same Distance as the Threads of the Screw.

Therefore the End of the Levers fasten'd to the Key-Frame remaining unmoveable, and those Points of the Barrel, to which they answered at first, moving away each Moment from the Perpendicular, by forming a spiral Line, (which by the progressive Motion of the Barrel, is always directed to the same Point, that is to the End of each Lever) it follows that the End of each Lever meets every Moment new Points upon the Bars of the Barrel; which are never repeated, because they form Spirals between them, which make twelve Turns upon the

* A Line is the twelfth Part of an Inch.

the Barrel, before the first Point of the Division can come under another Lever than that under which it was first determin'd.

It is in this Space of an Inch and an half that all the Bars are placed, which Bars themselves also form spiral Lines, that the Lever (under which each of them must pass during the twelve Turns of the Barrel) may act.

As one Line changes in Respect of its Lever, all the other Lines change in Respect of theirs; thus each Lever has twelve Lines of Bars of sixty four Inches in Length, which all go under it, and which all together make a Line of seven Hundred and sixty-eight Inches long. Upon this Line are fix'd all the Bars sufficient for the Action of the Lever during the whole Play.

What remains is to shew, how these different Motions have contributed to produce the Effect which I propos'd in this *Automaton*, comparing them with those of a living Person.

To make it produce Sound from the Flute, and form the first Note, which is *D* below. I begin first to dispose the Mouth; for which End I fix upon the Barrel a Bar under the Lever, which answers to those Parts of the Mouth that serve to increase the Opening of the Lips. Secondly, I fix a Bar under that Lever which serves to draw back those Lips. Thirdly, I fix a Bar under that Lever which opens the Valve of that Receptacle of Wind, which is supplied by the small Bellows that are not loaded. Lastly, I fix a Bar under the Lever which moves the Tongue, to give a Stroke with the Tongue; so that these Bars in the same Time touching the four Levers, which serve to produce the foresaid Operations, the Flute will sound *D* below.

By the Action of the Lever, which increases the Opening of the Lips, the Action of a living Man is imitated, who increases that Opening for the low Sounds.

By

By the Lever which draws back the Lips, I imitate the Action of a Man who removes them farther from the Hole of the Flute, by turning it outwards.

By the Lever which gives Wind from the unloaded Bellows, I imitate the weak Wind which a Man gives, when he drives it out of the Receptacle of his Lungs, by only a light Compression by the Muscles of his Breast.

By the Lever which moves the Tongue, in unstopping the Hole thro' which the Lips let the Wind pass, I imitate the Motion of a Man's Tongue, when he pulls it back from the Hole to give Passage to the Wind to articulate such a Note.

It will then follow, from those four different Operations, that by giving a weak Wind, and making it pass thro' a large Issue in the whole Bigness of the Hole of the Flute, its Return will produce slow Vibrations, which must be continu'd in all the Parts of the Body of the Flute, because all the Holes will be shut, and, according to the Principle settled in my first Part, the Flute will give a low Sound: and this is confirm'd by Experience.

If I wou'd make the Flute sound the Note above, namely *E*, to the four first Operations for *D*, I add a fifth; I fix a Bar under the Lever, which raises the third Finger of the Right Hand to unstop the sixth Hole of the Flute; and I make the Lips to come a little nearer to the Hole of the Flute, by fixing or making a little lower the Bar of the Barrel which held up the Lever for the first Note, namely for *D*. Thus, giving an Issue to the Vibrations sooner, by unstopping the first Hole from the End, as I said above, the Flute must sound a Note above; which is also confirm'd by Experience.

All these Operations will be continued pretty nearly the same in the Notes of the first Octave, where the same Wind is sufficient for forming them all. It is the diffe-

rent Opening of the Holes, by raising the Fingers, which characterises them: All that is requir'd is to fix on the Barrel Bars under the Levers which must raise the Fingers to form such a Note.

In order to have the Notes of the second Octave, we must change the Situation of the Mouth, that is, we must place a Bar under that Lever which serves to push the Lips beyond the Diameter of the Hole of the Flute, and thereby imitate the Action of a living Man, who in that Case turns the Flute a little inwards.

Secondly, we must fix a Bar under that Lever, which bringing the Lips towards one another diminishes their Opening; as a Man does to give a less Issue to the Wind.

Thirdly, a Bar must be fix'd under the Lever which opens the Valve of that Receptacle that contains the Wind coming from those Bellows which are loaded with two Pounds; because the Wind being then driven with more Force, acts in the same Manner as that with which a living Man blows by a stronger Action of the Pectoral Muscles. Besides, Bars must be plac'd so as to run under the Levers necessary to raise the Fingers requir'd.

From all these Operations it will follow, that a Wind driven with more Force, and going thro' a smaller Passage, will double its Swiftneſs, and consequently produce double the Number of Vibrations; and these make the Octave.

As you rise up to the higher Notes of this second Octave, the Lips must still be brought closer, that the Wind in the same Time may encrease its Velocity.

In the Notes of the third Octave, the same Levers that go to the Mouth act as in those of the second, with this Difference, that the Bars are a little higher: Which makes the Lips advance quite over the Edge of the Hole of the Flute, so as to leave but a very small Hole. You must only add a Bar under that Lever
which

which opens the Valve of the Receptacle which has its Wind from the most loaded Bellows, that is those that are press'd down with four Pounds. Consequently the Wind, blown with a stronger Compression, and going thro' a Passage still smaller, will increase its Velocity in a triple Ratio; whereby you will have the triple Octave.

In all these different Octaves some Notes are harder to produce than others; and then they must be managed by bringing the Lips over a greater or a less Chord of the Hole of the Flute, and by giving a stronger or a weaker Wind, which is the same that a Man does to sound the same Notes, being oblig'd to manage his Wind, and to turn the Flute inwards or outwards, more or less.

It is easy to conceive that all the Bars fix'd upon the Barrel must be longer or shorter, according to the Time that each Note must have, and according to the different Situation necessary for the Fingers: which I shall not particularize here, lest I should exceed the Limits of a short *Memoire*, such as I proposed give.

I wou'd only have it observed, that in swelling of Notes, I have been oblig'd, during the same Note, insensibly to substitute a strong Wind to a weak, and a weaker to a stronger, and at the same Time to vary the Motion of the Lips; that is, to put them into the proper Situation for each Wind.

For a soft Sound, that is to imitate an Echo, I have been oblig'd to advance the Lips over the Hole of the Flute, and send a Wind sufficient for forming such a Tone; but whose Return, by such a small Issue as its Entrance into the Flute, can only strike a small Quantity of external Air; which, as I have said, produces an Echo.

The Quickness and Slowness of different Airs have been measur'd upon the Barrel, by Means of a Lever; one End of which being arm'd with a Steel Point serv'd to mark the Barrel, as the Lever was struck upon. At the

other End of the Lever was a Spring, which immediately raised the Point up again.

The Movement was set a going, which turn'd the Barrel with a Velocity proportionable for the several Tunes.

At the same Time a Person play'd on the Flute the Tune whose Time was to be measured; whilst another Person beat Time upon the End of the Lever, whose Point mark'd the Barrel, and the Distances between the Points prick'd on were the true Measure for the Tunes to be mark'd. Then the Intervals were sub-divided into as many Parts as the Measure had Times or Bars.

The Fear of tiring you, GENTLEMEN, has made me pass over a great many little Circumstances, which tho' easy to suppose are not so soon executed: the Necessity of which appears by a View of the Machine, as I found it in the Practice.

GENTLEMEN, after having drawn from your *Memoires* the Principles which have guided me, it wou'd be no small Satisfaction to me, if I could flatter myself to see you acknowledge, that I have happily applied those Principles in the Execution of my Work. In the Approbation that you will deign to give it, I shall find the most glorious Reward of my Labour, and shall have greater Encouragement to pursue Hopes yet more flattering, which make my utmost Ambition.

AN ABSTRACT of the Register of the ROYAL-ACADEMY of SCIENCES.

April 30, 1738. N. S.

THE Academy having heard Mr. VAUCANSON's Memoire read, containing the Description of a wooden Statue, copied from the Marble Faune of Coysevaux, that plays on the German-Flute; on which it performs twelve different Tunes, with an Exactness which has deserv'd the Admiration of the Publick, and of which great Part of the Academy has been Witness; they have judg'd this Machine to be extremely ingenious, and that the Author of it has found the Means of employing new and simple Contrivances, as well for giving the Fingers of that Figure the necessary Motions, as for modifying the Wind which goes into the Flute by encreasing or diminishing its Velocity,

Velocity, according to the different Notes; by varying the Position of the Lips, and moving a Valve which performs the Office of the Tongue; and lastly, by imitating by Art all that is necessary for a Man to perform in such a Case. Besides, Mr. VAUCANSON's Memoire is written with all the Perspicuity and Exactness that the Subject is capable of; which shews the Author's Skill and great Knowledge in the different Parts of Mechanicks. In Witness whereof I have sign'd the present Certificate. Paris, May 3, 1738. N. S.

FONTENELLE, Perpetual Secretary of the
ROYAL-ACADEMY of SCIENCES.

The Approbation of the Royal Censor.

I Have, by Order of my Lord Chancellor, read a Manuscript entitl'd, The Mechanism of an Automaton playing on the Flute, presented to the Gentlemen of the Royal-Academy of Sciences, by Mr. VAUCANSON, Author of this Machine. Mr. VAUCANSON explains in his Memoire those physical Principles that he has employed for the Invention and Execution of his Automaton, which is one of the most wonderful Productions of Art: It imitates a true Player on the Flute so perfectly, that the Publick continues to see and hear it with Admiration. Therefore we believe that the Impression of Mr. VAUCANSON's Memoire will be very useful to satisfy fully the Curiosity of the Publick. Paris, June 12, 1738.

H. P I T O T

Mr. VAUCANSON's Letter to the ABBE De Fontaine.

MY second Machine, or Automaton, is a Duck, in which I represent the Mechanism of the Intestines which are employed in the Operations of Eating, Drinking, and Digestion: Wherein the Working of all the Parts necessary for those Actions is exactly imitated. The Duck stretches out its Neck to take Corn out of your Hand; it swallows it, digests it, and discharges it digested by the usual Passage. You see all the Actions of a Duck that swallows greedily, and doubles the Swiftness in the Motion of its Neck and Throat or Gullet to drive the Food into its Stomach, copied from Nature: The Food is digested as in real Animals, by Dissolution, not Trituration, as some natural Philosophers will have it. But this I shall treat of, and shew, upon another Occasion.

The Matter digested in the Stomach is conducted by Pipes, (as

in an Animal by the Guts) quite to the Anus, where there is a Sphincter that lets it out.

I don't pretend to give this as a perfect Digestion, capable of producing Blood and nutritive Particles for the Support of the Animal. I hope no body will be so unkind as to upbraid me with pretending to any such Thing. I only pretend to imitate the Mechanism of that Action in three Things, viz. First, to swallow the Corn; secondly, to macerate or dissolve it; thirdly, to make it come out sensibly changed from what it was.

Nevertheless, it was no easy Matter to find Means for those three Actions, and those Means may perhaps deserve some Attention from those that may expect more. They will see what Contrivances have been made use of to make this artificial Duck take up the Corn, and suck it up quite to its Stomach; and there in a little Space to make a Chymical Laboratory to decompound or separate the Integument Parts of the Food, and then drive it away at Pleasure thro' Circumvolutions of Pipes, which discharge it at the other End of the Body of the Duck.

I don't believe the Anatomists can find any thing wanting in the Construction of its Wings. Not only every Bone has been imitated, but all the Apophyses or Eminences of each Bone. They are regularly observ'd as well as the different Joints: The Bending, the Cavities, and the three Bones of the Wing are very distinct. The first, which is the Humerus, has its Motion of Rotation every Way with the Bone that performs the Office of the Omoplat, Scapula, or Shoulder-Blade: The second Bone, which is the Cubitus of the Wing, has its Motion with the Humerus by a Joint which the Anatomists call Ginglymus; the third, which is the Radius, turns in a Cavity of the Humerus, and is fasten'd by its other Ends to the little End of the Wing, just as in the Animal. The Inspection of the Machine will better shew that Nature has been justly imitated, than a longer Detail, which wou'd only be an anatomical Description of a Wing. To shew that the Contrivances for moving these Wings are nothing like what is made use of in those wonderful Pieces of Art of the Cock mov'd by the Clock at Lyons, and that at Strasbourg, the whole Mechanism of our artificial Duck is exposed to View; my Design being rather to demonstrate the Manner of the Actions, than to shew a Machine. Perhaps some Ladies, or some People, who only like the Outside of Animals, had rather have

have seen the whole cover'd; that is, the Duck with Feathers. But besides, that I have been desir'd to make every Thing visible; I wou'd not be thought to impose upon the Spectators by any conceal'd or juggling Contrivance.

I believe that Persons of Skill and Attention, will see how difficult it has been to make so many different moving Parts in this small Automaton; as for Example, to make it rise upon its Legs, and throw its Neck to the Right and Left. They will find the different Changes of the Fulcrum's or Centers of Motion: they will also see that what sometimes is a Center of Motion for a moveable Part, another Time becomes moveable on that Part, which Part then becomes fix'd. In a Word, they will be sensible of a prodigious Number of Mechanical Combinations.

This Machine, when once wound up, performs all its different Operations without being touch'd any more.

I forgot to tell you, that the Duck drinks, plays in the Water with his Bill, and makes a gurgling Noise like a real living Duck. In short, I have endeavour'd to make it imitate all the Actions of the living Animal, which I have consider'd very attentively.

My third Machine, or Automaton, is the Figure playing on the Tabor and Pipe, which stands upright on its Pedestal, dress'd like a dancing Shepherd. This plays twenty Tunes, Minuets, Rigadoons, and Country-dances.

One wou'd at first imagine that the Difficulty in making of this has been less than in the Figure playing on the German-Flute. But, without making a Comparison between the two Machines, to praise one more than the other; I would have it observ'd, that here an Instrument is play'd upon, which is very cross-grain'd and false in itself; that I have been forc'd to articulate Sound by Means of a Pipe of three Holes only, where all the Tones must be perform'd by a greater or less Force of the Wind, and half stopping of Holes to pinch the Notes: That I have been oblig'd to give the different Winds, with a Swiftness which the Ear can hardly follow; and that every Note, even Semi-Quavers, must be tongued, without which the Sound of this Instrument is not at all agreeable. In this the Figure out-does all our Performers on the Tabor-Pipe, who cannot move their Tongue fast enough to go thro' a whole Bar of Semi-Quavers, and strike them all. On the contrary, they slur above half of them; but my Piper plays a whole Tune, and tongues every Note. What a Combination of Winds have I been oblig'd to make
for

for that Purpose? In carrying on my Work, I have made Discoveries of Things which could never have been so much as guess'd at. Cou'd it have been thought, that this little Pipe shou'd, of all the Wind-Instruments, be one of the most fatiguing to the Lungs? For in the playing upon it, the Performer must often strain the Muscles of his Breast with a Force equivalent to a Weight of 56 Pounds: For I am oblig'd to use that Force of Wind, that is, a Wind driven by that Force or Weight, to sound the upper B, which is the highest Tone to which this Instrument reaches: Whereas one Ounce only is sufficient to sound the first Note, or produce the lowest Tone, which is an E. Hence will appear, how many different Blasts of Wind I must have had to run thro' the whole Compass of the Tabor-Pipe.

Moreover, as the different Positions of the Fingers are so few, some wou'd be apt to think that no more different Winds wou'd be necessary than the Number of Notes on the Instrument; but the Fact is otherwise: that Wind, for Example, which is able to produce a D following a C, will never produce it, if the same D is to be sounded next to the E just above it; and the same is to be understood of all the other Notes. So that upon Computation it will appear that I must have twice as many different Winds, as there are Tones, besides the Semi-Tones, for each of which a particular Wind is absolutely necessary. I own freely, that I am surpriz'd myself to see and hear my Automaton play and perform so many and so differently varied Combinations: And I have been more than once ready to despair of succeeding; but Courage and Patience overcame every Thing.

Yet this is not all: This Pipe employs but one Hand; the Figure holds a Stick in the other, with which he strikes on the Tabor single and double Strokes, Rollings varied for all the Tunes, and keeping Time with what is play'd with the Pipe in the other Hand. This Motion is none of the easiest in the Machine; for sometimes we must strike harder, sometimes quicker, and the Stroke must always be clean and smart, to make the Tabor sound right. The Mechanism for this consists in an infinite Combination of Levers, and different Springs, all moved with Exactness to keep true to the Tune: But these wou'd be too tedious to give a particular Account of. In a Word, this Figure in its Contrivance is something like that which plays on the German-Flute; but differs from it in many of the Means of its Operations.

F I N I S.

