

## **On semi-decussation of the optic nerves / by William Hyde Wollaston.**

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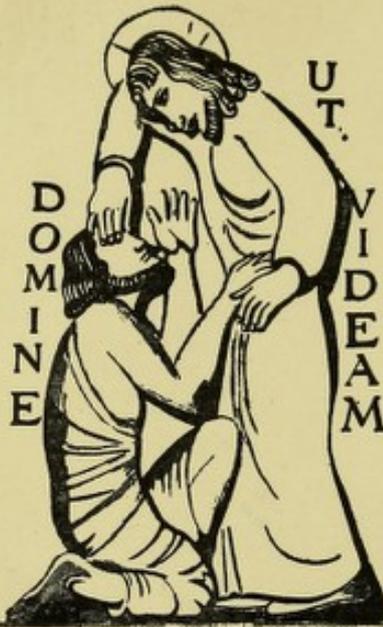


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It is curious to know  
that when the Author of  
this paper died of growing  
Paralysis in 184

there was found on dissection  
of the head, a tumour of  
the size of a hen's egg  
formed, & pressing upon  
the optic nerve.

He was attended by his  
old friend Dr. Souverville

Edinburgh



ON

SEMI-DECUSSATION OF THE OPTIC NERVES.

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BY

WILLIAM HYDE WOLLASTON, M. D.

V. P. R. S.

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FROM THE

PHILOSOPHICAL TRANSACTIONS.

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1824.

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*By Order of the President and Council,*

W. T. BRANDE, Sec. R. S.

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ON

SEMI-DECUSSATION OF THE OPTIC NERVES.

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*Read before the ROYAL SOCIETY, February 19, 1824.*

WHETHER we consider the astonishing subtlety of that medium, which renders visible to us objects existing at the most immeasurable distances from us, or that delicately constituted organ which, by its general structure, collects the rays of light, and by a nice adaptation of its parts concentrates their force on the sentient fibres of the retina, expanded over its inner surface, we can feel no surprise that such great talents should have been devoted to investigate the curious properties of the one, or that the structure of the other should have been examined with so much assiduity.

The keenness of inquiry manifested by the cultivators of anatomy in observing the most minute parts that have escaped the notice of their predecessors, shows that any addition to the common stock of our information on this subject will be gratifying to a certain portion of the members of this Society, and probably not uninteresting to ~~the~~ Society at large.

It is not my object, in the present paper, to examine either the *first* effect of the cornea in rendering the rays of light convergent, or the power of the crystalline lens in *finally* bringing them to a focus on the retina. It is not my intention

to investigate whether the adaptation of the eye to different distances is effected by alteration of the *form* of the lens from its own muscular structure, or by alteration of its *place*, from the agency of other muscles. Nor do I mean to consider either the *involuntary* motions of the iris dependent on the quantity of light present, or that *voluntary* contraction of it by which we adapt the aperture of the pupil for distinct vision at different distances, limiting thereby, what in optics is termed the spherical aberration of the lens.

The subject of my inquiry relates solely to the course by which impressions from images perfectly formed are conveyed to the sensorium, and to that structure and distribution of the optic nerves on which the communication of these impressions depends.

Without pretending to detect by manual dexterity as an anatomist, the very delicate conformation of the nerves of vision, I have been led, by the casual observation of a few instances of diseased vision, to draw some inferences respecting the texture of that part which has been called the decussation of the optic nerves, upon which I feel myself warranted to speak with some confidence.

It is well known that in the human brain these nerves, after passing forwards to a short distance from their origin in the thalami nervorum opticorum, unite together, and are, to appearance, completely incorporated; and that from this point of union proceed two nerves, one to the right, the other to the left eye.

The term decussation was applied to this united portion, under the supposition that, though the fibres do intermix, they still continue onward in their original direction, and

that those from the right side cross over wholly to supply the left eye, while the right eye is supplied entirely from fibres arising from the left thalamus.

In this opinion, anatomists have felt themselves confirmed by the result of their examination of other animals, and especially that of several species of fish, in which it is distinctly seen that the nerves do actually cross each other as a pair of separate cords, lying in contact at their crossing, but without any intermixture of their fibres.

In these cases it is most indisputably true, that the eye upon the right side of the animal does receive its optic nerve from the left side of the brain, while that of the left eye comes from the right side; but it is not a just inference to suppose the same continuity preserved in other animals, where such complete separation of the entire nerves is not found.

On the contrary, I not only see reason, from a species of blindness which has happened to myself more than once, to conclude, that a different distribution of nerves takes place in us, but I think my opinion supported by this evident difference of structure in fishes.

It is now more than twenty years since I was first affected with the peculiar state of vision, to which I allude, in consequence of violent exercise I had taken for two or three hours before. I suddenly found that I could see but half the face of a man whom I met; and it was the same with respect to every object I looked at. In attempting to read the name JOHNSON, over a door, I saw only SON; the commencement of the name being wholly obliterated to my view. In this instance the loss of sight was toward my left, and was the same whether I looked with the right eye or the left. This

blindness was not so complete as to amount to absolute blackness, but was a shaded darkness without definite outline. The complaint was of short duration, and in about a quarter of an hour might be said to be wholly gone, having receded with a gradual motion from the center of vision obliquely upwards toward the left.

Since this defect arose from over fatigue, a cause common to many other nervous affections, I saw no reason to apprehend any return of it, and it passed away without need of remedy, without any farther explanation, and without my drawing any useful inference from it.

It is now about fifteen months since a similar affection occurred again to myself, without my being able to assign any cause whatever, or to connect it with any previous or subsequent indisposition. The blindness was first observed, as before, in looking at the face of a person I met, whose *left* eye was to my sight obliterated. My blindness was in this instance the reverse of the former, being to *my right* (instead of the left) of the spot to which my eyes were directed; so that I have no reason to suppose it in any manner connected with the former affection.

The new punctum cæcum was situated alike in both eyes, and at an angle of about three degrees from the center; for, when any object was viewed at the distance of about five yards, the point not seen was about ten inches distant from the point actually looked at.

On this occasion the affection, after having lasted with little alteration for about twenty minutes, was removed suddenly and entirely by the excitement of agreeable news respecting the safe arrival of a friend from a very hazardous enterprise.

In reflecting upon this subject, a certain arrangement of the optic nerves has suggested itself to me, which appears to afford a very probable interpretation of a set of facts, which are not consistent with the generally received hypothesis of the decussation of the optic nerves.

Since the corresponding points of the two eyes sympathise in disease, their sympathy is evidently from structure, not from mere habit of feeling together, as might be inferred, if reference were had to the reception of ordinary impressions alone. Any two corresponding points must be supplied with a pair of filaments from the same nerve, and the seat of a disease in which similar parts of both eyes are affected, must be considered as situated at a distance from the eyes at some place in the course of the nerves where these filaments are still united, and probably in one or the other thalamus nervorum opticorum.

It is plain that the cord, which comes finally to either eye under the name of optic nerve, must be regarded as consisting of two portions, one half from the right thalamus, and the other from the left thalamus nervorum opticorum.

According to this supposition, decussation will take place only between the adjacent halves of the two nerves. That portion of nerve which proceeds from the right thalamus to the right side of the right eye, passes to its destination without interference; and in a similar manner the left thalamus will supply the left side of the left eye with one part of its fibres, while the remaining halves of both nerves in passing over to the eyes of the opposite sides must intersect each other, either with or without intermixture of their fibres.

Now, if we consider rightly the facts discovered by com-

parative anatomy in fishes, we shall find that the crossing of the entire nerves in them to the opposite eyes, is in perfect conformity to this view of the arrangement of the human optic nerves. The relative position of the eyes to each other in the sturgeon, is so exactly back to back, on opposite sides of the head, that they can hardly see the same object; they can have no points which generally receive the same impressions as in us; there are no corresponding points of vision requiring to be supplied with fibres from the same nerve. The eye which sees to the left has its retina solely upon its right side; and this is supplied with an optic nerve arising wholly from the right thalamus; while the left thalamus sends its fibres entirely to the left side of the right eye for the perception of objects situated on the right. In this animal, an injury to the left thalamus might be expected to occasion entire blindness of the right eye alone, and want of perception of objects placed on that side. In ourselves, a similar injury to the left thalamus would occasion blindness (as before) to all objects situated to our right, owing to insensibility of the left half of the retina of both eyes.

A disorder that has occurred within my own knowledge in the case of a friend, seems fully to confirm this reasoning, as far as a single instance can be depended upon. After he had suffered severe pain in his head for some days, about the left temple, and toward the back of the left eye, his vision became considerably impaired, attended with other symptoms indicating a slight compression on the brain.

It was not till after the lapse of three or four weeks that I saw him, and found that, in addition to other affections which need not here be enumerated, he laboured under a defect of

sight similar to those which had happened to myself, but more extensive, and it has unfortunately been far more permanent. In this case the blindness was at that time, and still is, entire, with reference to all objects situated to the right of his center of view. Fortunately, the field of his vision is sufficient for writing perfectly. He sees what he writes, and the pen with which he writes, but not the hand that moves the pen. This affection is, as far as can be observed, the same in both eyes, and consists in an insensibility of the retina on the left side of each eye. It seems most probable, that some effusion took place at the time of the original pain on that side of the head, and has left a permanent compression on the left thalamus. This partial blindness has now lasted so long without sensible amendment, as to make it very doubtful when my friend may recover the complete perception of objects on that side of him.

In reviewing the several phenomena that I have described, we find partial blindness occurring at the same time in both eyes. This sympathy from disease is readily explained, on the supposition that the parts which sympathise receive their nerves from the same source, while the opposite halves of the eyes, which are not at the same time similarly affected, are supplied from an opposite source; and the inference is immediate, that in common vision also the sympathy of corresponding points, which receive similar impressions from the same object, is dependent on the arrangement of nerves thus detected by disease.

We find moreover in the sturgeon, (and it is the same in some other fishes) whose eyes can scarcely see the same object at once, and have no corresponding points which ordi-

narily sympathise, that the two eyes do not receive any nervous fibres from the same source ; but one eye receives its nerve wholly from one side, and the other from the other side of the brain.

From the structure of these fish we learn distinctly, that the perception of objects toward one side is dependent on nerves derived from the opposite side of the brain ; and in the last case of diseased vision above related, we find apparent injury to one side of the brain, followed by blindness toward the opposite side of the point to which both eyes are directed.

A series of evidence in such apparent harmony throughout, seems clearly to establish that distribution of nerves I have endeavoured to describe, which may be called the semi-decussation of the optic nerves.

*On single vision with two eyes.*

So long as our consideration of the functions of a pair of eyes is confined to the performance of healthy eyes in common vision, when we remark that only one impression is made upon the mind, though two images are formed at the same moment on corresponding parts of our two eyes, we may rest satisfied in ascribing the apparent unity of the impression to habitual sympathy of the parts, without endeavouring to trace farther the origin of that sympathy, or the reason why, in infancy, the eyes ever assume one certain direction of correspondence in preference to squinting.

But, when we regard sympathy as arising from structure, and dependent on connection of nervous fibres, we therein see a distinct origin of that habit, and have presented to us a

manifest cause why infants first begin to give the corresponding direction to their eyes, and we clearly gain a step in the solution, if not a full explanation, of the long agitated question of single vision with two eyes.

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It may perhaps to some persons appear surprising, that so many as three instances of a disorder which they presume to be rare, should have been witnessed by one individual; but I apprehend, on the contrary, this half-blindness to be far more common than is generally supposed; and I might with as much reason express surprise at its having so far escaped notice,\* were I not aware how many facts commonly remain disregarded, merely for want of explanation. It is evident that I once, and for a long time, overlooked the inference that is to be drawn from this affection; and if the disorder had not happened to me a second time, I might never have reconsidered its cause.

Even since the preceding pages were written, I have met with two more cases of this disease. One of my friends has been habitually subject to it for sixteen or seventeen years, whenever his stomach is in any considerable degree deranged. In him the blindness has been invariably to his right of the

\* RICHTER, in the third volume of his *Elements of Surgery*, has a chapter on half-blindness, and part of it relates to what he terms *amaurosis dimidiata*. From one instance there given, he seems to have seen some cases similar to those I have described; but he has not noticed the corresponding affection of the two eyes, or considered the sympathy between them.

center of vision, and, from want of due consideration, had been considered as temporary insensibility of the right eye ; but he is now satisfied that this is not really the case, but that both eyes have been similarly affected with half-blindness. This symptom of his indigestion usually lasts about a quarter of an hour or twenty minutes, and then subsides, without leaving any permanent imperfection of sight.

I have not seen the subject of the 5th case, but I am informed that he has had many returns of this affection, generally attended with head-ach, and always lasting about twenty minutes, with very little variation.

ON THE  
APPARENT DIRECTION OF EYES IN A PORTRAIT.

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BY

WILLIAM HYDE WOLLASTON, M. D.

F. R. S. AND V. P.

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FROM THE

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## APPARENT DIRECTION OF EYES IN A PORTRAIT.

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*Read before the ROYAL SOCIETY, May 27, 1824.*

IT may seem, at first view, that portrait painting is not altogether a fit subject to be brought before the Royal Society, since the delicate touches by which the skill and feeling of an accomplished artist convey an expression of sense, and grace, and sensibility to the finished representation of the human form, cannot admit of such strict analysis as the ordinary subjects of our inquiry.

Nevertheless, since the rules of perspective, which are strictly mathematical, are perfectly within our province, it may be presumed that a question, in which some principles of that science are involved, may be considered a legitimate subject of communication ; that effects not anticipated on any received principles must deserve attention ; and that the explanation of them will be found to have some pretensions to utility.

When we consider the precision, with which we commonly judge whether the eyes of another person are fixed upon ourselves, and the immediateness of our perception that even a momentary glance is turned upon us, it is very surprising that the grounds of so accurate a judgement are not distinctly known, and that most persons, in attempting to explain the subject, would overlook some of the circumstances by which, it will appear, they are generally guided.

Though it may not be possible to demonstrate, by any decisive experiment on the eyes of living persons, what those circumstances are, still we may find convincing arguments to prove their influence, if it can be shown in the case of portraits, that the same ready decision we pronounce on the direction of the eyes is founded, in great measure, on the view of parts which, as far as I can learn, have not been considered as assisting our judgement.

Previous to a full examination of this question, one might imagine that the circular form of the iris would be a sufficient criterion of the direction in which an eye is looking, since, when the living eye is pointed to us, this part is always circular, but cannot appear strictly so, when turned in such a manner that we view it with any degree of obliquity. But, upon farther consideration, it is evident that we cannot judge of exact circularity with sufficient precision for this purpose, even when the whole circle is fully seen, and in many cases we see too small a portion of the circumference of the iris to distinguish whether it is circular or elliptic.

Moreover, in a portrait, although the iris be drawn most truly circular, and consequently will appear so when we have a direct view of it, still, in all oblique positions, it must be seen as an ellipse. And yet the eyes, as is well known, apparently continue to look at the spectator, even when he moves to view them very obliquely, and sees them of a form most decidedly elliptic.

The reason why the eyes of a portrait seem to follow us will be hereafter considered, but cannot be rightly explained until the circumstances, on which apparent direction in the front view depends, are fully understood.

If we examine with attention the eyes of a person opposite to us, looking horizontally within about twenty degrees on either side of us, we find that the most perceptible variation in the appearance of his eyes, in consequence of their lateral motion, is an increase and decrease of the white parts at the angles of each eye, dependent on their being turned to or from the nose.

In the central position of an eye, the two portions of white are nearly equal. By this equality, we are able to decide that a person is looking neither to his right nor to his left, but straight forward in the direction of his nose, as index of the general position of his face.

If, on the contrary, he turn his eyes to one side, we are immediately made sensible of the change by a diminution of the white of the eye on that side to which they turn, and by this test alone we are able to estimate in what degree they deviate in *direction from the face to which they belong*.

But *their direction with reference to ourselves* is perfectly distinct from the former ; and in judging of this it seems probable that, even in viewing real eyes, we are not guided by the eyes alone, but are unconsciously aided by the concurrent position of the entire face ; for in a portrait, the effect of this further condition admits of being proved by a distinct and decisive experiment.

If a pair of eyes be drawn with correctness, looking at the spectator, at such moderate deviation from the general position of the face as is usual in the best portraits, unless some touch be added to suggest the turn of face, the direction of the eyes seems vague, and so undetermined, that their direction will not appear the same to all persons ; and to the same

person they may be made appear directed either to him or from him by the addition of other features strongly marking that essential circumstance, the *position of the face*.

In the drawings which I am enabled to exhibit to the Society, I am indebted for assistance to the well known skill and obliging kindness of Sir THOMAS LAWRENCE, President of the Royal Academy, by whom the pair of eyes represented in the first plate were originally drawn from the life, intently looking at him. To these a turn of face has since been added according to the original design, so that the eyes, with this accompaniment, Fig. 1, appear decidedly looking at the spectator.

In Fig. 2. a set of features oppositely turned are so applied to the same eyes, that they look considerably to the right of the person viewing them.\*

In the former of these, the position of the face being at a certain angle to our left, the eyes, which are turned at an equal angle from that position, seem pointed to ourselves. In the latter, the deviation of the face from us being toward the same side as the turn of the eyes, gives additional obliquity to their apparent direction, and carries them far to the right of us, proving the influence of the stronger features, even in opposition to that of the minuter parts of the eyes themselves, which are not in correct drawing for this position.

With regard to the apparent position *of the face*, it is clear that, in forming our judgement, we must be influenced princi-

\* The effect of this change is so sudden, and so contrary to expectation, that, at first sight, many persons seem scarcely to credit the evidence of their senses, in supposed opposition to their former experience, and are inclined to imagine some present *deception* in the very phenomena best adapted to *undeceive* them as to the cause of the impression they receive.

pally by the nose and other parts of it that are most prominent, because these, in nature, are subject to the greatest changes of perspective form by any alteration of position; and we scarcely notice those smaller variations of figure, to which even parts least prominent are liable when seen very obliquely.

It must be obvious to the most superficial observer, that the same perspective form which correctly represents a certain pair of eyes in one position of the face, cannot be an exact representation of the *same* eyes in another; but in cases of such slight obliquity as is usually given to the eyes in a portrait that is intended to look at the spectator, the variation of the form of the lids from obliquity is less than the difference observable in the eyes of different persons. Hence it is that a pair of eyes drawn looking at us, will best admit of being warped from their intended direction by application of a new position of the other features of the face.

The converse of this experiment may also be made with success within the same limited extent. Eyes drawn originally looking a little to one side of us, may be made to look at us by applying other features in a suitable position. But although a change of twenty or perhaps thirty degrees may be effected, it is not to be supposed that a turn of ninety degrees can be produced. It would be absurd to imagine that an eye drawn in profile could be made to look full upon us, or that an eye looking nearly at us could be made to appear in profile.

If an attempt be made to carry the experiment beyond reasonable limits, so that the perspective form of the eyes is

glaringly ill-suited to that of the rest of the face, the effect is impaired by such obvious discordance, but is not altogether lost ; for though some persons much accustomed to drawing the human eye, who are in the habit of attending minutely to the shape of the lids, may not feel the full effect perceived by others, still the change of direction that *is* admitted by the generality of those who have nothing to warp their judgment, shows how little influence the eyelids really have in giving apparent direction, in comparison with the more prominent features.

In order to show how small an addition is sufficient to produce the effect, in Plate X. are four copies of another representation of the same pair of eyes made exactly alike by the admirably ingenious process of Mr. PERKINS. A strong plate of steel on which they were first engraved, having been subsequently hardened, gave an elevated impression of them to a soft steel roller, passed with great force repeatedly over the surface of the plate. The roller having next been hardened in its turn, became the tool for transferring four impressions to the same plate of copper, with the most unquestionable identity of representation in the four copies to each other. Nevertheless in two of these their apparent direction will be seen to differ by the mere position of the noses, and in the others a corresponding difference is effected solely by means of the upper half of the face.

For the sake of greater perspicuity, we have hitherto considered merely the cases of *lateral* turn of the eyes and face, at small angles of deviation to the right or left, by the balance of which, if in opposite directions, the eyes appear to look at us ; or, if the inclination of both be toward the same side of

us, then the eyes seem turned away from us by the sum of those angles.

The same principles apply also to instances of moderate inclination of the face upwards or downwards. For when the face is pointed downwards, the eyes that look at us must be turned upwards from the position of the face to which they belong. And, if to eyes so drawn an upward cast of features be substituted for the former, the eyes seem immediately to look above us.

When the turn of a pair of eyes partakes of both inclinations, so as to be in a direction laterally upwards, the alteration produced by changing the position of the face, affords the most striking exemplification of the force of this principle, as may be seen in Plate XI, and its companion.

But the effect thus producible is by no means limited to the mere extent of deviation, as a total difference of character may be given to the same eyes by due representation of the other features. A lost look of devout abstraction in an uplifted countenance may be exchanged for an appearance of inquisitive archness, in the leer of a younger face, turned downwards and obliquely toward the opposite side. The under eyelid, which in the former position conceals a portion of the ball of the eye, from an effect apparently of mere perspective, will in the latter seem raised with effort, and thus give the appearance of a smile to the same eyes, if supported by corresponding expression of the rest of the countenance. But it is needless to pursue the various modifications of which this experiment is obviously susceptible. The instances already given are sufficient to show that the apparent direction of the eyes to or from the spectator depends upon the

balance of two circumstances combined in the same representation, namely,

1st. The general position of the face presented to the spectator ; and,

2dly. The turn of the eyes from that position.

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With this previous knowledge of the influence which the general perspective of the face in a portrait, has upon the apparent direction of the eyes, we shall be prepared to examine why, if they look at the spectator when he stands in front of the picture, they follow, and appear to look at him, in every other direction.

If we consider the effect produced by our change of position with reference to any other perspective drawing, we find a similar permanence of apparent position of the objects represented with respect to ourselves, and corresponding change of direction with reference to the plane of representation, or to the room in which it hangs ; and we shall be able, in this case, distinctly to trace its origin in the simplest principles of perspective drawing.

When two objects are seen on the ground at different distances from us in the same direction, one will appear and must be represented exactly above the other. The line joining them is an upright line on the plane of the picture, and represents a vertical plane passing through the eye and these objects. When objects that are at different elevations are said to be in a line with us, the strict meaning is, that they are so placed that a vertical plane from the eye would pass

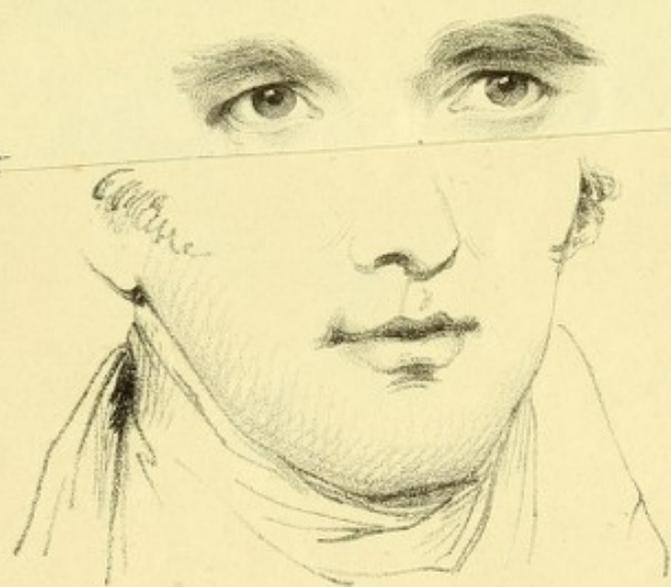
through them. Now, since the upright line (drawn or supposed to be drawn on the plane of the picture and representing a vertical plane) will be seen upright, however far we move to one side, and will continue to represent a vertical plane, it follows that the same set of objects, even in the most oblique direction in which the representation can be viewed, are still in the same vertical plane, and consequently will seem still to be in a line with us, exactly as in the front view: seeming as we move, to turn round with us, from their first direction, toward any oblique position that we may choose to assume.

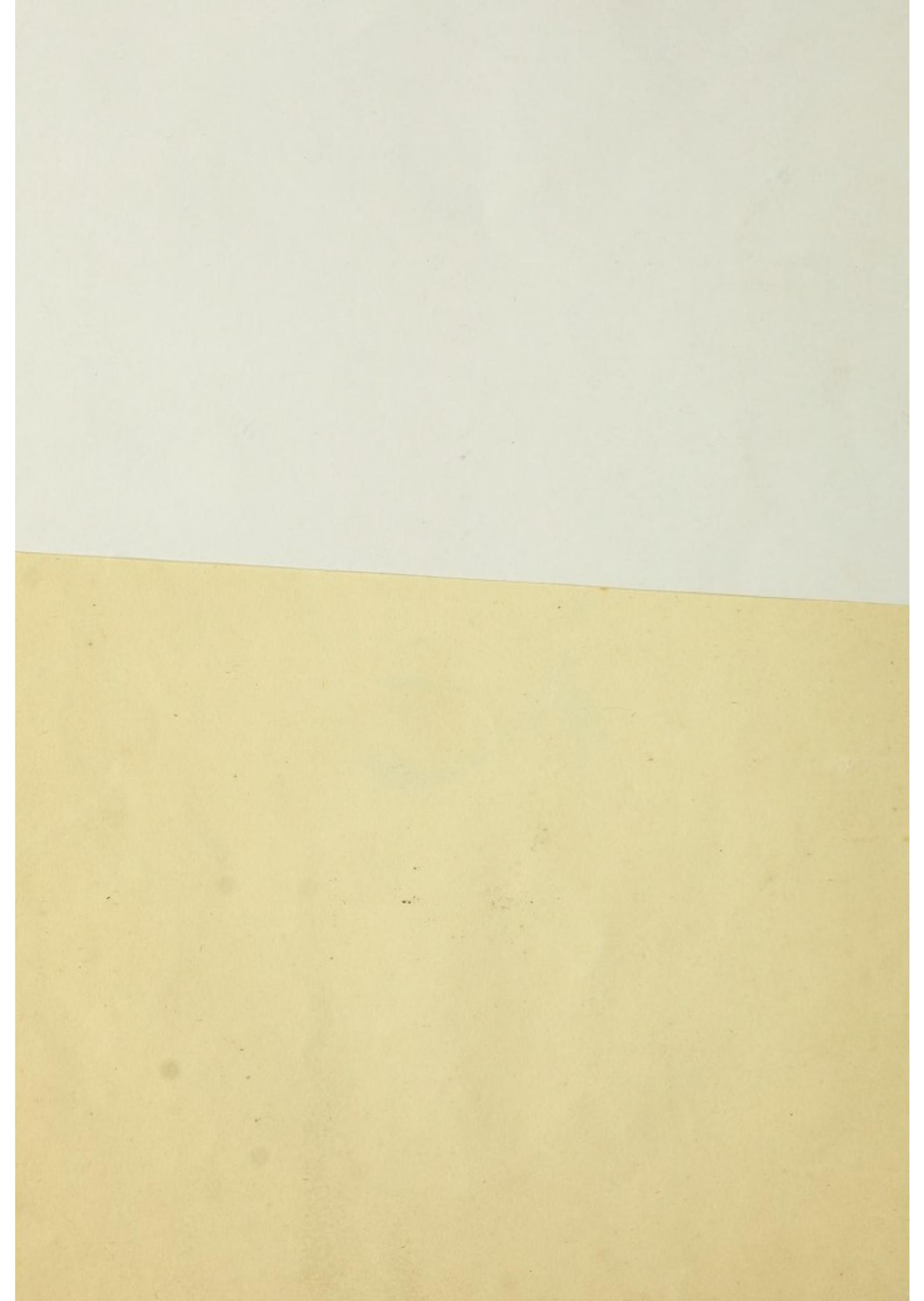
In portraits, the phenomena of direction with reference to the spectator, and corresponding change of apparent position in space when he moves to either side, depend precisely on the same principles. A nose drawn directly in front with its central line upright, continues directed to the spectator, though viewed obliquely. Or, if the right side of the nose is represented, it must appear directed to the right of the spectator in all situations; and eyes that turn in a due degree from that direction toward the spectator, so as to look at him when viewed in front, will continue to do so when viewed obliquely.

As an illustration of the permanent directions of the nose and eyes in a portrait, if a compass be represented, Plate XII. in front of the picture, in a square box, so placed that the sides appear in the same direction as the nose, the needle being set parallel to that of the eyes, will represent, in all positions from which it can be viewed, a line pointing in their apparent direction, and by its permanently vertical position will justly exhibit the same appearance which eyes do, of

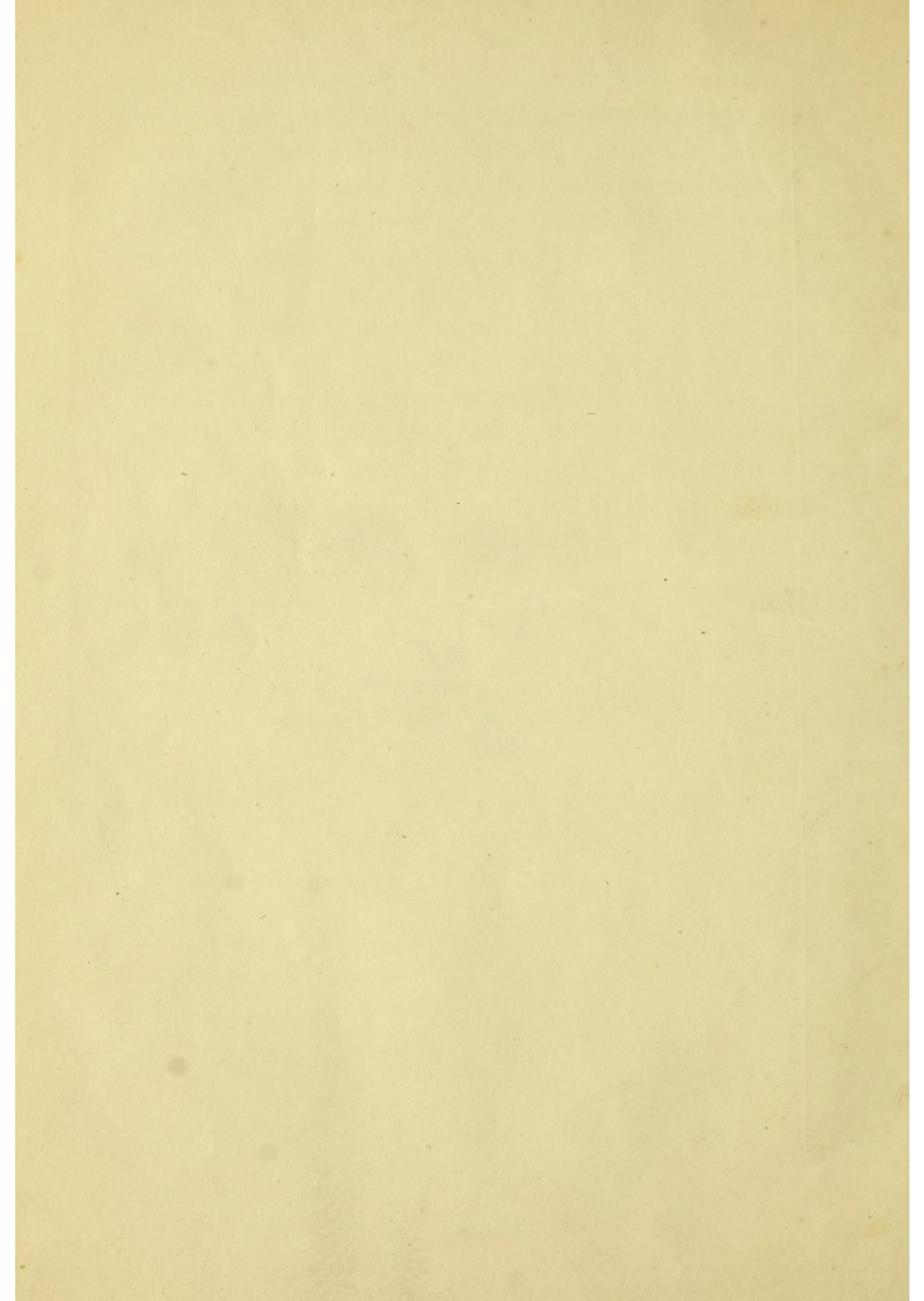
following the spectator to either side. In the same manner, if the eyes be turned toward one side, a corresponding needle would duly appear to retain its position toward the same side of the spectator, just as the box does in the former instance.

In any extended drawing the lines of direction admit of being clearly marked in the relative position of objects at different distances; but in portraits the circumstances are less distinct, for want of some visible mark indicating the direction of the eyes. But, if any object be represented in front of the picture, so that the center of one of the eyes may appear to be exactly over it, we have then a marked line of direction, which, by its permanently vertical position, renders the relation of the appearances in a portrait, to the corresponding phenomena in extended views, complete.









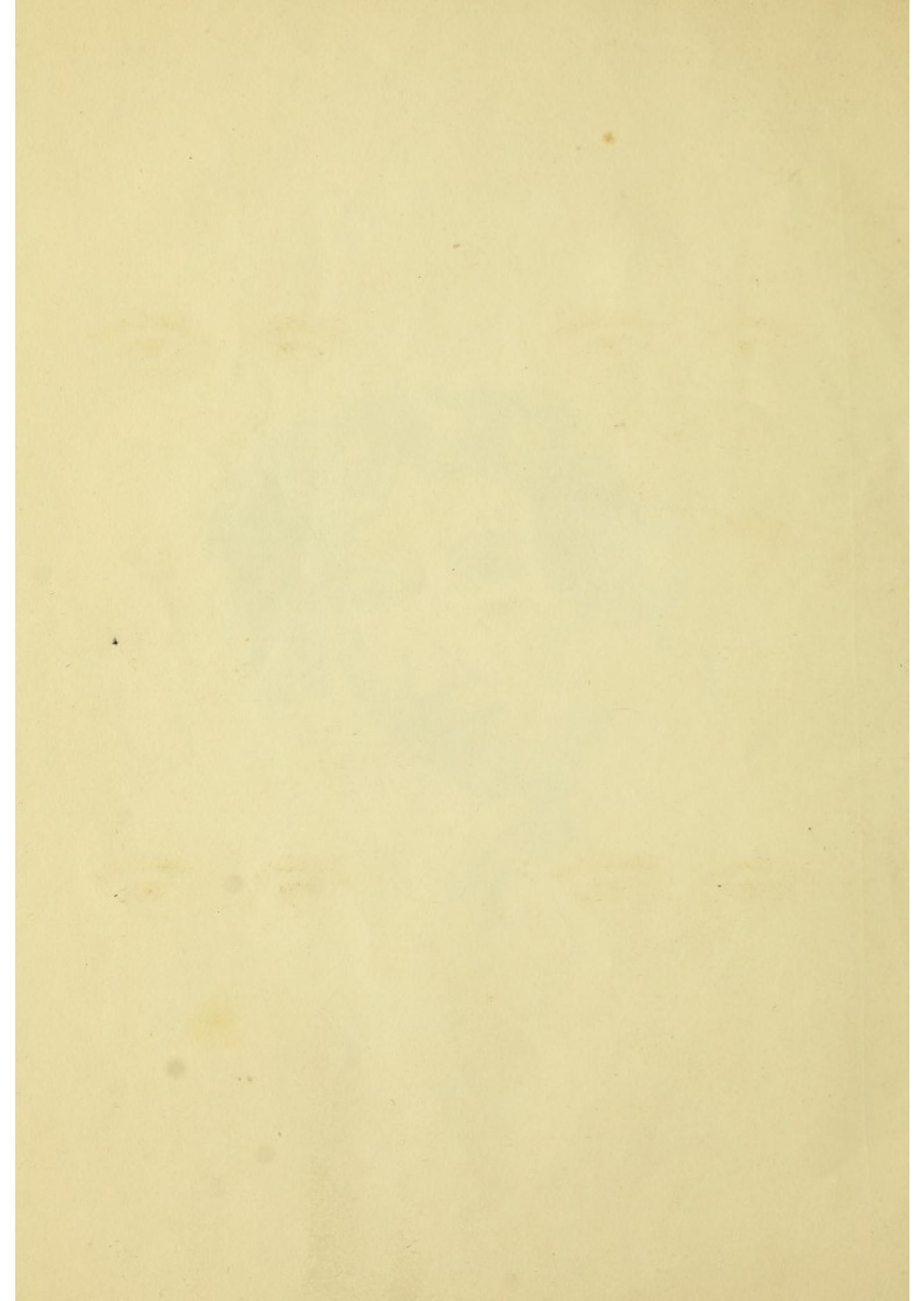




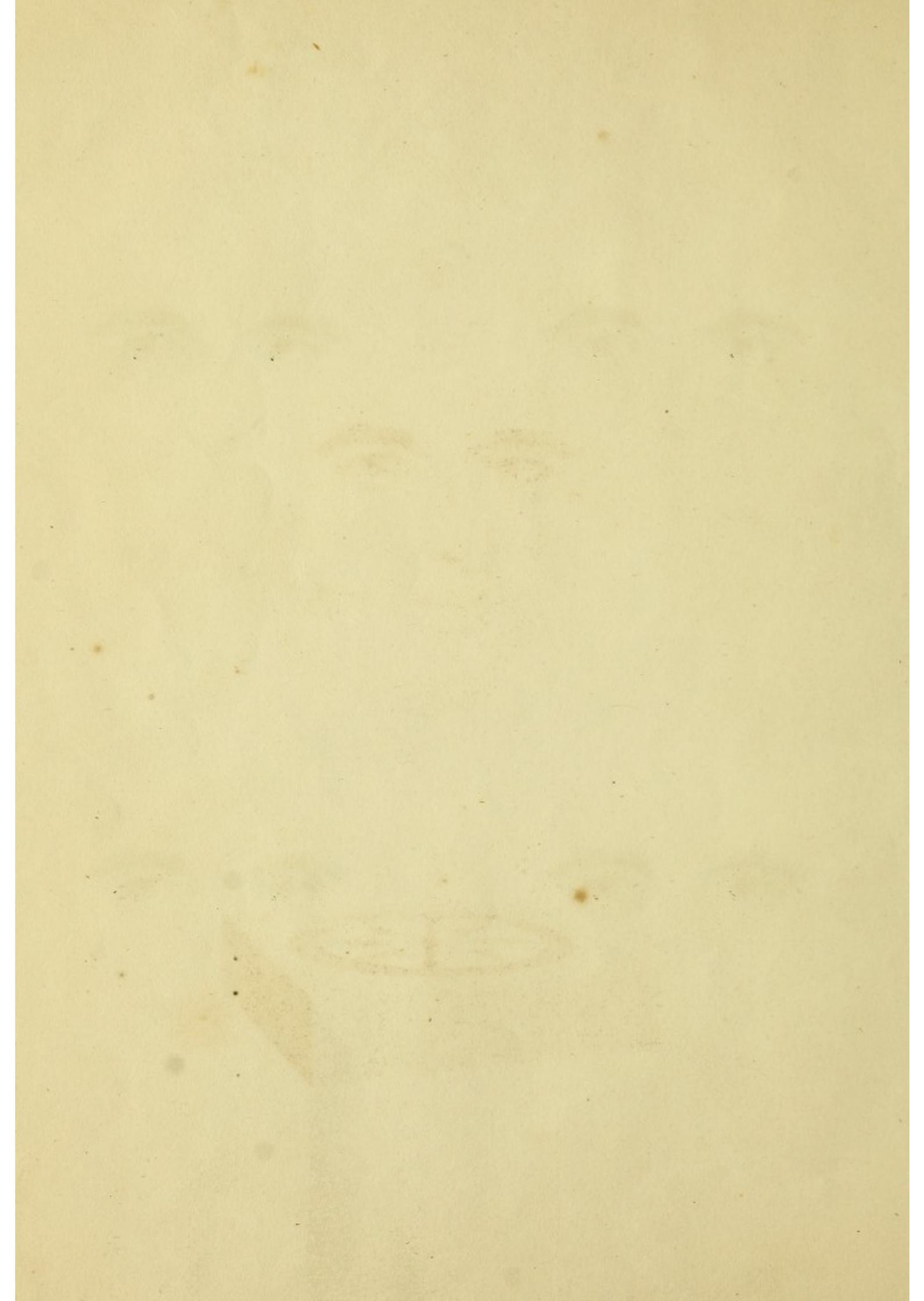


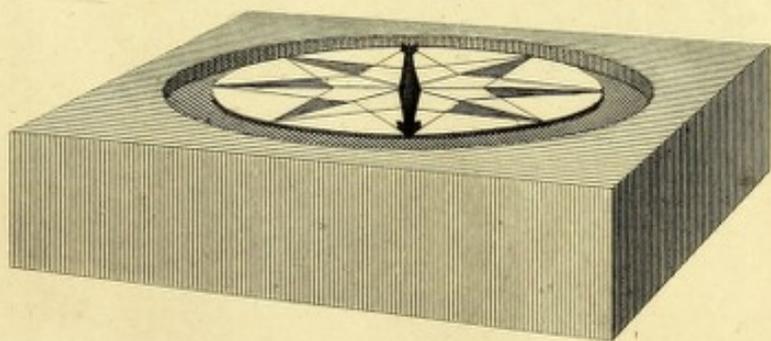
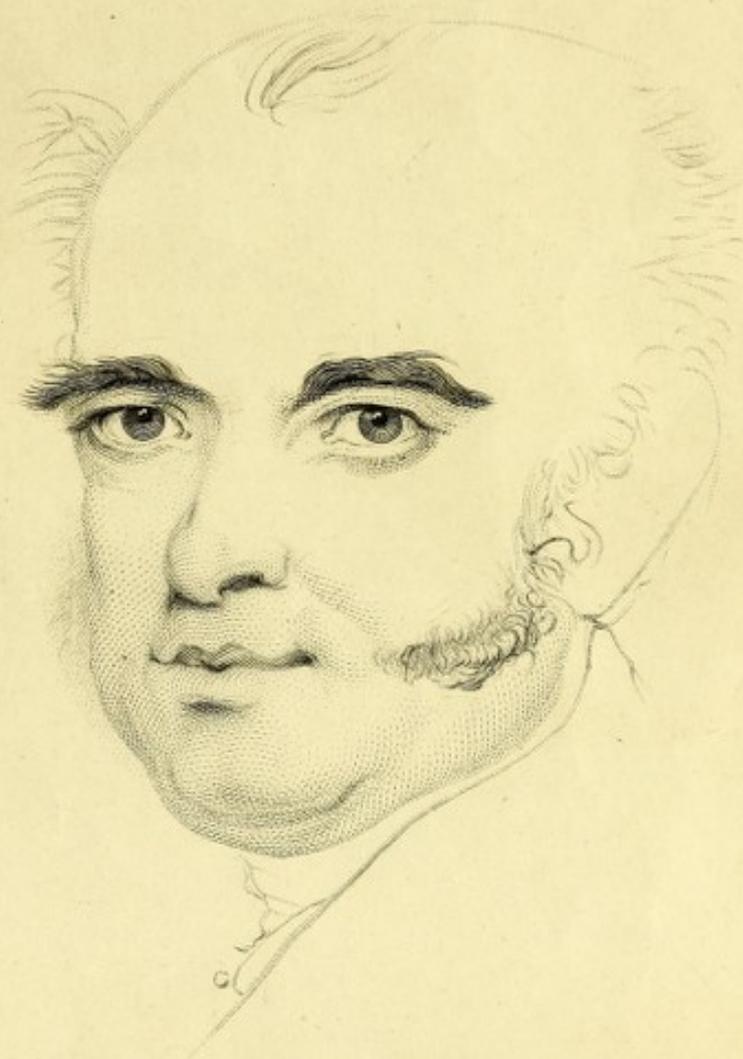


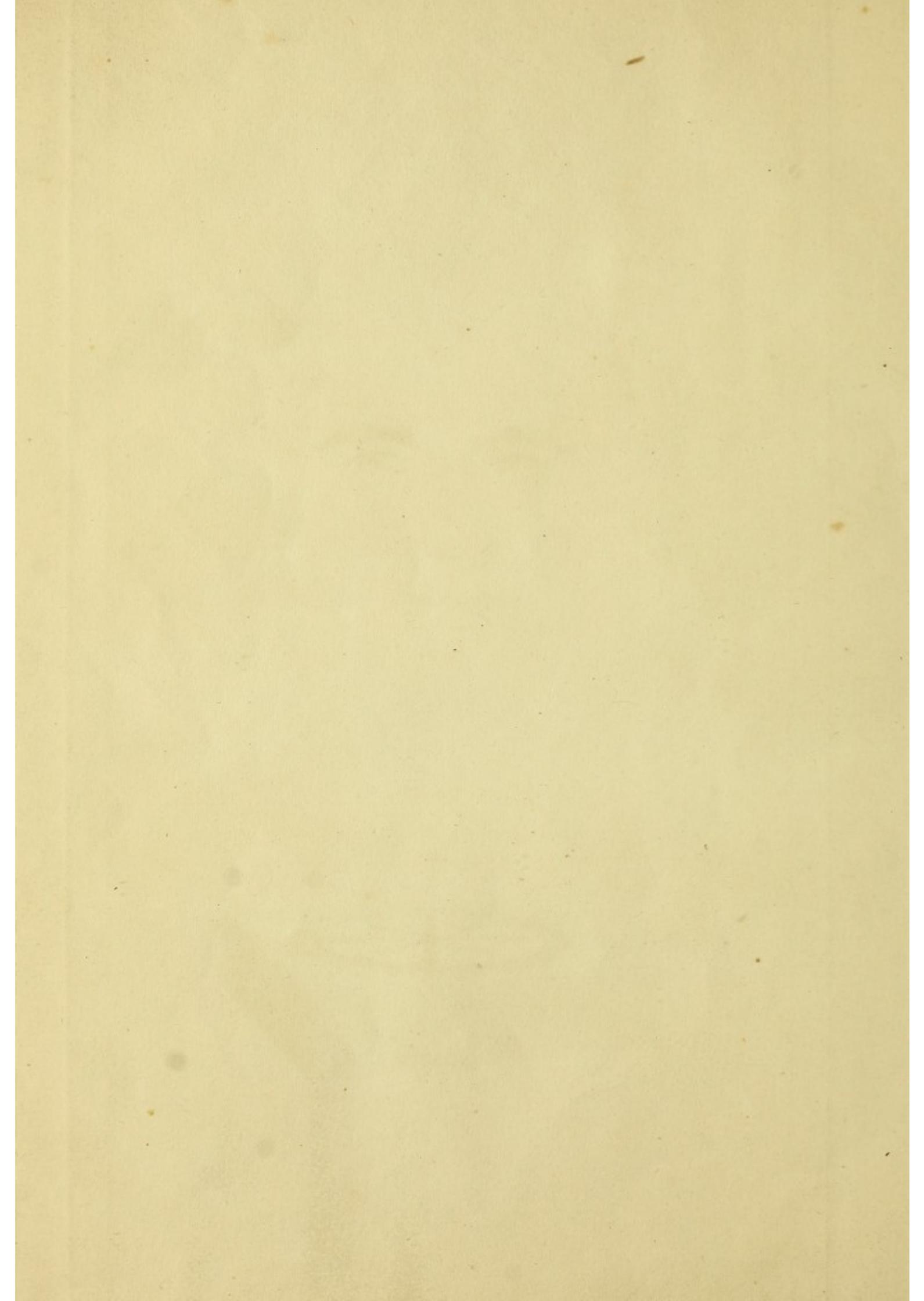












*Sir Edward Codrington,  
from the Author.*

ON

SOUNDS INAUDIBLE BY CERTAIN EARS.

BY

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M. D. P. R. S.

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*By Order of the President and Council,*

W. T. BRANDE, Sec. R. S.

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SOUNDS INAUDIBLE BY CERTAIN EARS.

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*Read before the ROYAL SOCIETY, June 29, 1820.*

IT is not my intention to occupy the time of this Society, with the consideration of that mere general dullness to the impression of all kinds of sound which constitutes ordinary deafness, but to request its attention to certain peculiarities that I have observed with respect to partial insensibility in different states of the ear, and in different individuals; for I have found that an ear, which would be considered as perfect with regard to the generality of sounds, may, at the same time, be completely insensible to such as are at one or the other extremity of the scale of musical notes, the hearing or not hearing of which seems to depend wholly on the pitch or frequency of vibration constituting the note, and not upon the intensity or loudness of the noise.

Indeed, although persons labouring under common deafness have an imperfect perception of all sounds, the degree of indistinctness of different sounds is commonly not the same; for it will be found upon examination, that they usually hear sharp sounds much better than low ones; they distinguish the voices of women and children better than the deeper tones in which men commonly speak; and it may be remarked, that the generality of persons accustomed to speak to those who are deaf, seem practically aware of this differ

ence, and, even without reflecting upon the motives which guide them, acquire a habit of speaking to deaf persons in a shriller tone of voice, as a method by which they succeed in making them hear more effectually than by merely speaking louder.

In elucidation of this state of hearing, which casually occurs as a malady, I have observed, that other ears may for a time be reduced to the same condition of insensibility to low sounds. I was originally led to this observation, in endeavouring to investigate the cause of deafness in a friend, by trial of different modes of closing, or otherwise lessening the sensibility of my own ears. I remarked that, when the mouth and nose are shut, the tympanum may be so exhausted by forcible attempt to take breath by expansion of the chest, that the pressure of the external air is strongly felt upon the membrana tympani, and that, in this state of tension from external pressure, the ear becomes insensible to grave tones, without losing in any degree the perception of sharper sounds.

The state to which the ear is thus reduced by exhaustion, may even be preserved for a certain time without the continued effort of inspiration, and without even stopping the breath, since by sudden cessation of the effort, the internal passage to the ear becomes closed by the flexibility of the Eustachian tube, which acts as a valve, and prevents the return of air into the tympanum. As the defect thus occasioned is voluntary, so also is the remedy; for the unpleasant sensation of pressure on the drum, and the partial deafness which accompanies it, may at any instant be removed by the act of swallowing, which opens the tube, and by allowing

the air to enter, restores the equilibrium of pressure necessary to the due performance of the functions of the ear.

In my endeavours to ascertain the extent to which this kind of deafness may be carried, some doubt has arisen, from the difficulty of finding sounds sufficiently pure for the purpose. The sounds of stringed instruments are in this respect defective; for unless the notes produced are free from any intermixture of their sharper chords, some degree of deception is very liable to occur in the estimate of the lowest note really heard. I can, nevertheless, with considerable confidence, say, that my own ears may be rendered insensible to all sounds below F marked by the base cliff. But as I have been in the habit of making the experiment frequently, it is probable that other persons who may be inclined to repeat it, will not with equal facility effect so high a degree of exhaustion as I have done. To a moderate extent the experiment is not difficult, and well worth making. The effect is singularly striking, and may aptly be compared to the mechanical separation of larger and smaller bodies by a sieve. If I strike the table before me with the end of my finger, the whole board sounds with a deep dull note. If I strike it with my nail, there is also at the same time a sharp sound produced by quicker vibrations of parts around the point of contact. When the ear is exhausted it hears only the latter sound, without perceiving in any degree the deeper note of the whole table. In the same manner, in listening to the sound of a carriage, the deeper rumbling noise of the body is no longer heard by an exhausted ear; but the rattle of a chain or loose screw remains at least as audible as before exhaustion.

Although I cannot propose such an experiment as a means of improving the effect of good music, yet, as a source of amusement even from a defective performance, I have occasionally tried it at a concert with singular effect; since none of the sharper sounds are lost, but by the suppression of a great mass of louder sounds, the shriller ones are so much the more distinctly perceived, even to the rattling of the keys of a bad instrument, or scraping of catgut unskilfully touched.

Those who attempt exhaustion of the ear for the first time, rarely have any difficulty in making themselves sensible of external pressure on the tympanum; but it is not easy at first to relax the effort of inspiration with sufficient suddenness to close the Eustachian tube, and thus maintain the exhaustion; neither is it very easy to refrain long together from swallowing the saliva, which instantly puts an end to the experiment.

I may here remark, that this state of excessive tension of the tympanum is sometimes produced by sudden increase of external pressure, as well as by decrease of that within, as is often felt in the diving-bell as soon as it touches the water; the pressure of which upon the included air closes the Eustachian tube, and, in proportion to the descent, occasions a degree of tension on the tympanum, that becomes distressing to persons who have not learned to obviate this inconvenience. Those who are accustomed to descend, probably acquire the art of opening the Eustachian tube by swallowing, or incipient yawning, as soon as the diving-bell touches the water.

It seems highly probable that, in the state of artificial

tension thus produced, a corresponding deafness to low tones is occasioned, but, as I never have been in that situation, I have not had an opportunity of ascertaining this point by direct experiment.

In the natural healthy state of the human ear, there does not seem to be any strict limit to our power of discerning low sounds. In listening to those pulsatory vibrations of the air of which sound consists, if they become less and less frequent, we may doubt at what point tones suited to produce any musical effect terminate; yet all persons but those whose organs are palpably defective continue sensible of vibratory motion, until it becomes a mere tremor, which may be felt, and even almost counted.

On the contrary, if we turn our attention to the opposite extremity of the scale of audible sounds, and with a series of pipes exceeding each other in sharpness, if we examine the effects of them successively upon the ears of any considerable number of persons, we shall find (even within the range of those tones which are produced for their musical effects) a very distinct and striking difference between the powers of different individuals, whose organs of hearing are in other respects perfect, and shall have reason to infer, that human hearing in general is more confined than has been supposed with regard to its perception of very acute sounds, and has probably, in every instance, some definite limit, at no great distance beyond the sounds ordinarily heard.

It is now some years since I first had occasion to notice this species of partial deafness, which I at that time supposed to be peculiar to the individual in whom I observed it. While I was endeavouring to estimate the pitch of certain sharp

sounds, I remarked in one of my friends a total insensibility to the sound of a small organ pipe, which, in respect to acuteness, was far within the limits of my own hearing, as well as of others of our acquaintance. By subsequent examination, we found that his sense of hearing terminated at a note four octaves above the middle E of the piano-forte. This note he seemed to hear rather imperfectly, but he could not hear the F next above it, although his hearing is in other respects as perfect, and his perception of musical pitch as correct as that of any ordinary ears.

The casual observation of this peculiarity in the organ of hearing, soon brought to my recollection a similar incapacity in a near relation of my own, whom I very well remember to have said, when I was a boy, that she never could hear the chirping that commonly occurs in hedges during a summer's evening, which I believe to be that of the gryllus campestris.

I have reason to think that a sister of the person last alluded to had the same peculiarity of hearing, although neither of them were in any degree deaf to common sounds.

The next case which came to my knowledge was in some degree more remarkable, in as much as the deafness in all probability extended a note or two lower than in the first instance. This information is derived from two ladies of my acquaintance, who agree that their father could never hear the chirping of the common house sparrow. This is the lowest limit to acute hearing that I have met with, and I believe it to be extremely rare. Deafness even to the chirping of the house cricket, which is several notes higher, is not common. Inability to hear the piercing squeak of the bat

seems not very rare, as I have met with several instances of persons not aware of such a sound. The chirping, which I suppose to be that of the *gryllus campestris*, appears to be rather higher than that of the bat, and accordingly will approach the limit of a greater number of ears; for, as far as I am yet able to estimate, human hearing in general extends but a few notes above this pitch. I cannot, however, measure these sounds with precision; for it is difficult to make a pipe to sound such notes, and still more difficult to appreciate the degree of their acuteness.

The chirping of the sparrow will vary somewhat in its pitch, but seems to be about four octaves above E in the middle of the piano-forte.

The note of the bat may be stated at a full octave higher than the sparrow, and I believe that some insects may reach as far as one octave more; for there are sounds decidedly higher than that of a small pipe one-fourth of an inch in length, which cannot be far from six octaves above the middle E. But since this pipe is at the limit of my own hearing, I cannot judge how much the note to which I allude might exceed it in acuteness, as my knowledge of the existence of this sound is derived wholly from some young friends who were present, and heard a chirping, when I was not aware of any sound. I suppose it to have been the cry of some species of *gryllus*, and I imagine it to differ from the *gryllus campestris*, because I have often heard the cry of that insect perfectly.

From the numerous instances in which I have now witnessed the limit to acuteness of hearing, and from the distinct succession of steps that I might enumerate in the

hearing of different friends, as the result of various trials that I have made among them, I am inclined to think, that at the limit of hearing, the interval of a single note between two sounds, may be sufficient to render the higher note inaudible, although the lower note is heard distinctly.

The suddenness of the transition from perfect hearing to total want of perception, occasions a degree of surprize, which renders an experiment on this subject with a series of small pipes among several persons rather amusing. It is curious to observe the change of feeling manifested by various individuals of the party, in succession, as the sounds approach and pass the limits of their hearing. Those who enjoy a temporary triumph, are often compelled, in their turn, to acknowledge to how short a distance their little superiority extends.

Though it has not yet occurred to me to observe a limit to the hearing of sharp sound in any person under 20 years of age, I am persuaded, by the account that I have received from others, that the youngest ears are liable to the same kind of insensibility. I have conversed with more than one person who never heard the cricket or the bat, and it appears far more likely that such sounds were always beyond their powers of perception, than that they never had been uttered in their presence.

The range of human hearing comprised between the lowest notes of the organ and the highest known cry of insects, includes more than nine octaves, the whole of which are distinctly perceptible by most ears, although the vibrations of a note at the higher extreme are six or seven hun-

dred fold more frequent than those which constitute the gravest audible sound.

Since there is nothing in the constitution of the atmosphere to prevent the existence of vibrations incomparably more frequent than any of which we are conscious, we may imagine that animals like the grylli, whose powers appear to commence nearly where ours terminate, may have the faculty of hearing still sharper sounds, which at present we do not know to exist, and that there may be other insects hearing nothing in common with us, but endued with a power of exciting, and a sense that perceives vibrations of the same nature indeed as those which constitute our ordinary sounds, but so remote, that the animals who perceive them may be said to possess another sense, agreeing with our own solely in the medium by which it is excited, and possibly wholly unaffected by those slower vibrations of which we are sensible.

I should be always most unwilling to occupy the time of this Society with idle speculations on mere possible modes of existence, and should not have called its attention to this subject, had I not observed several curious facts which I thought might prove interesting, and may serve to justify some latitude of conjecture beyond the strict evidence of our senses.

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