

Views of astronomy : seven lectures delivered before the Mercantile Library Association of New York in the months of January and February, 1848 / by J.P. Nichol ; reported for the New-York Tribune by Oliver Dyer.

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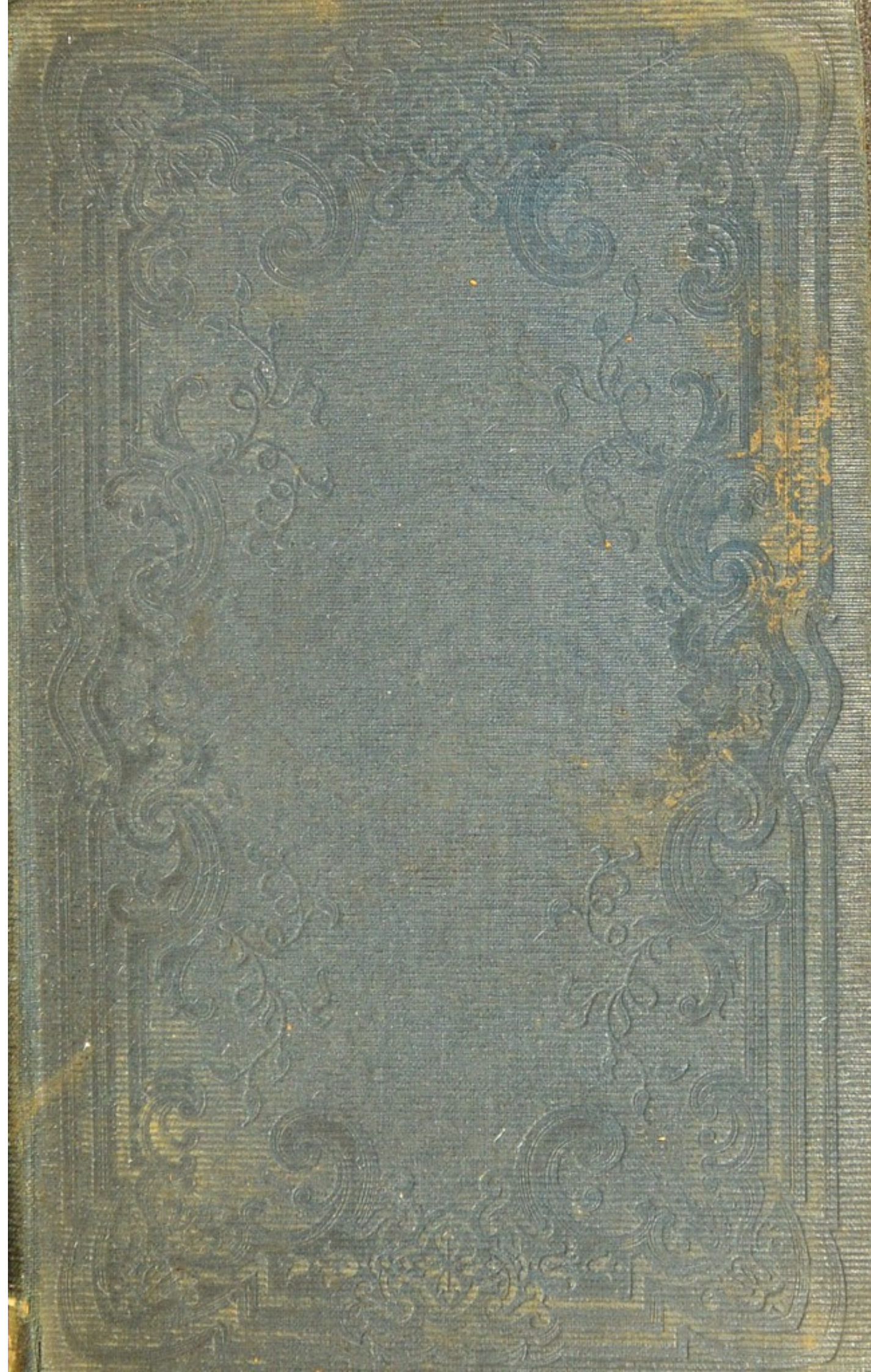
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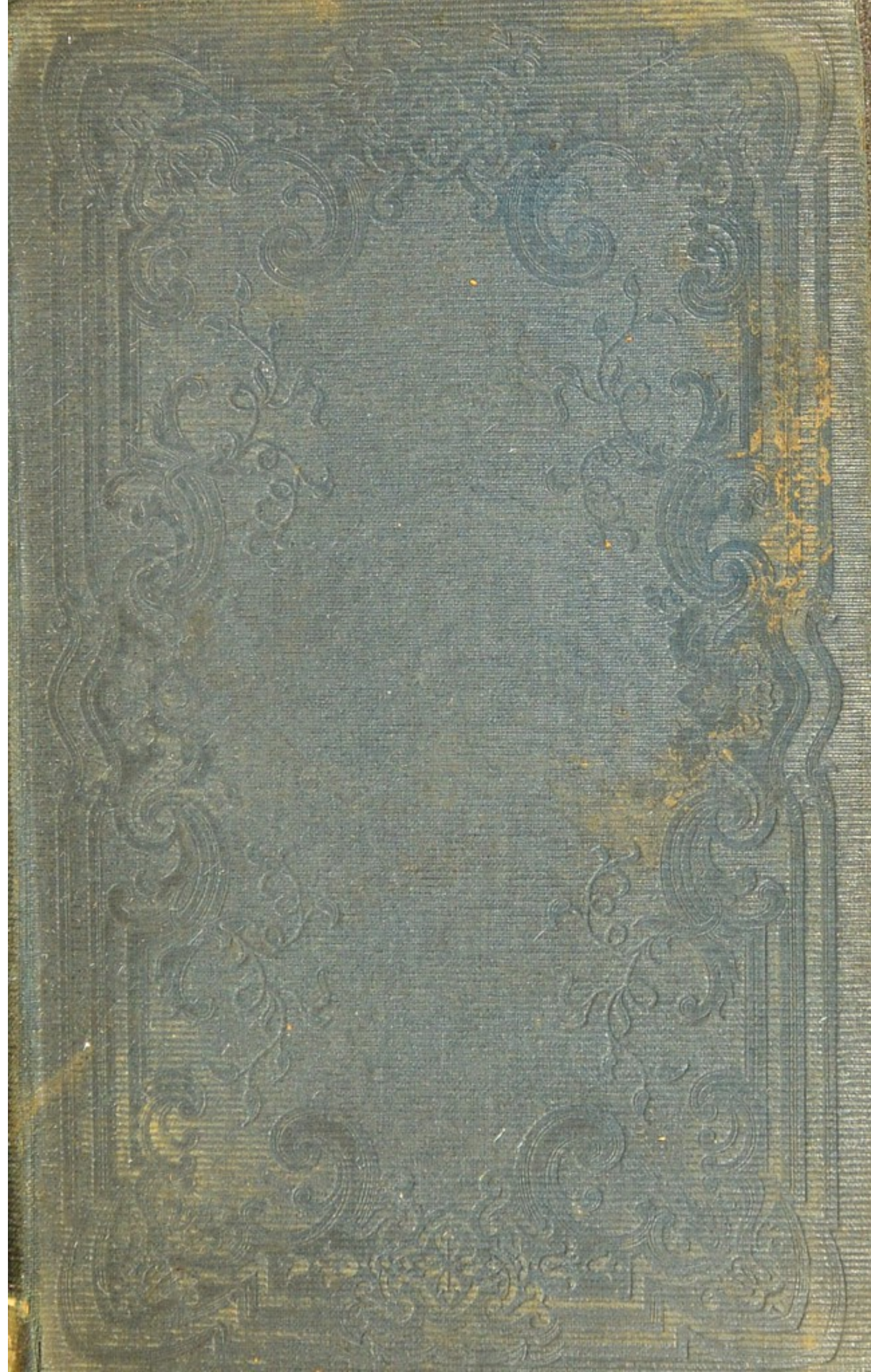
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VIEWS
OF
ASTRONOMY.

SEVEN LECTURES

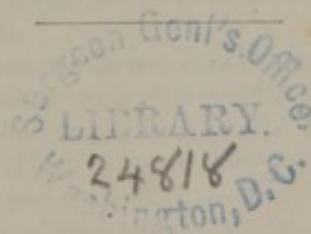
DELIVERED BEFORE THE MERCANTILE LIBRARY ASSOCIATION OF NEW-YORK
IN THE MONTHS OF JANUARY AND FEBRUARY, 1848.

BY

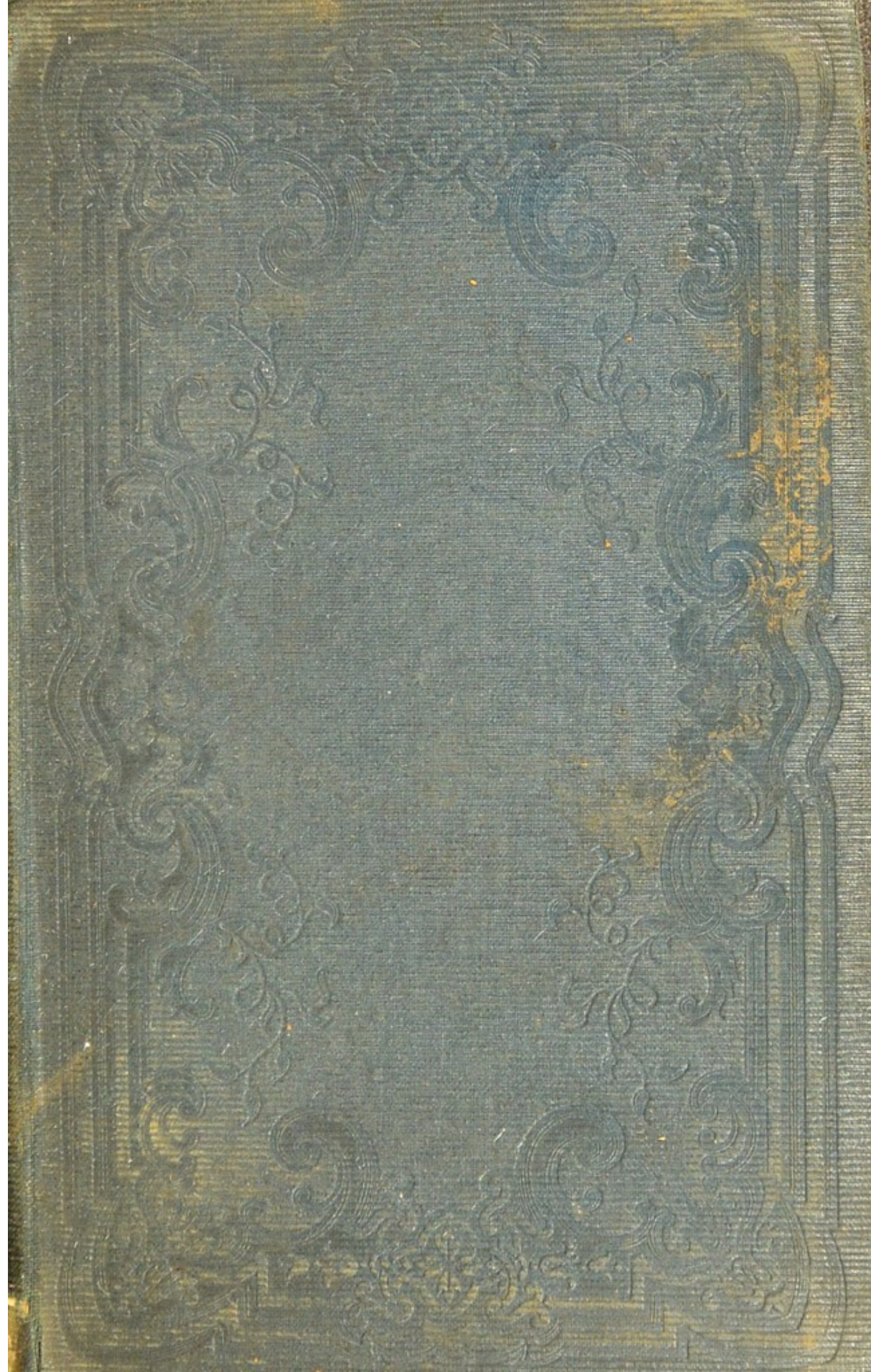
J. P. NICHOL, LL.D.

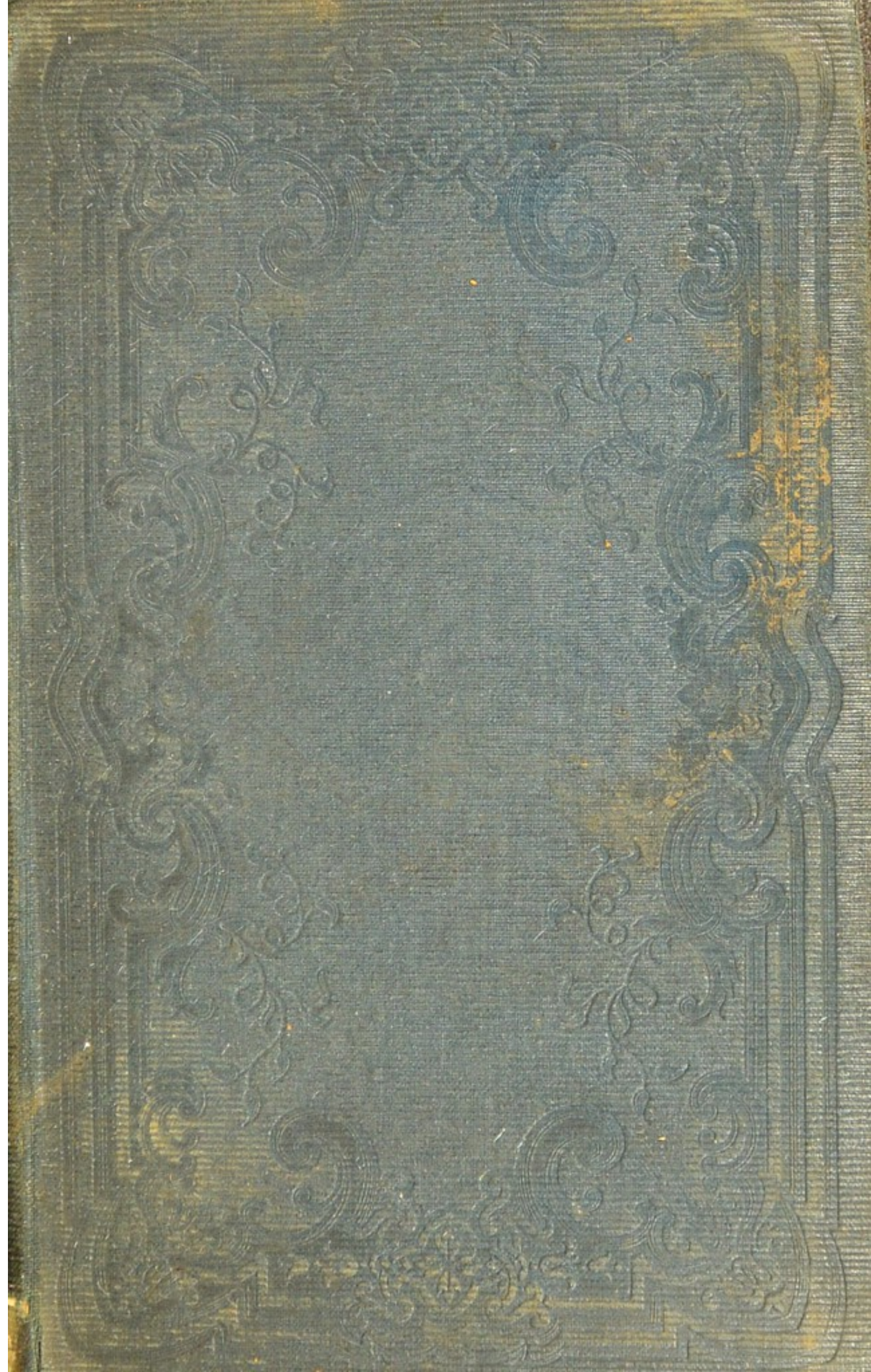
PROFESSOR OF ASTRONOMY IN THE UNIVERSITY OF GLASGOW.

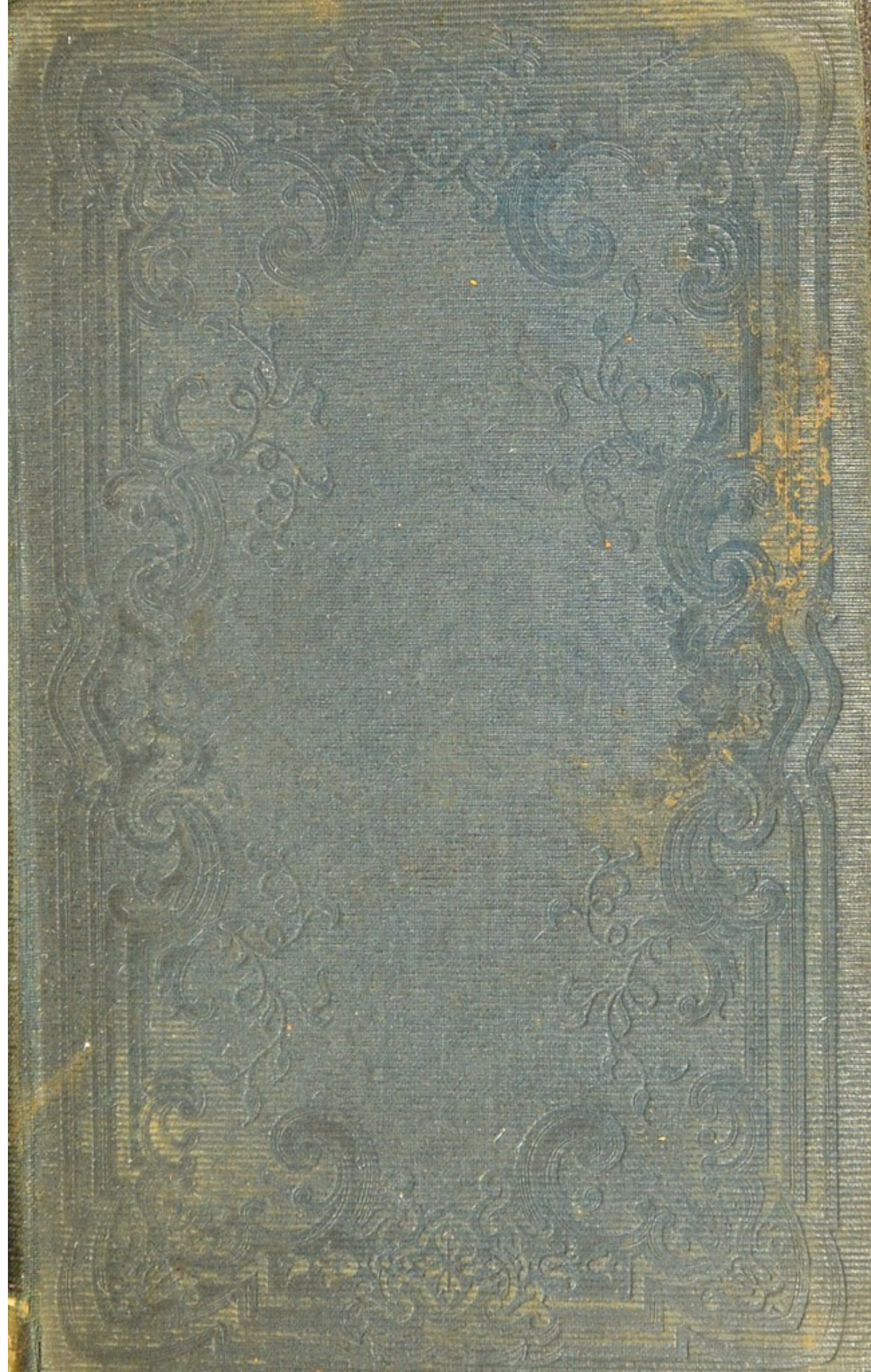
REPORTED FOR THE NEW-YORK TRIBUNE
BY OLIVER DYER, PHONOGRAPHIC WRITER.

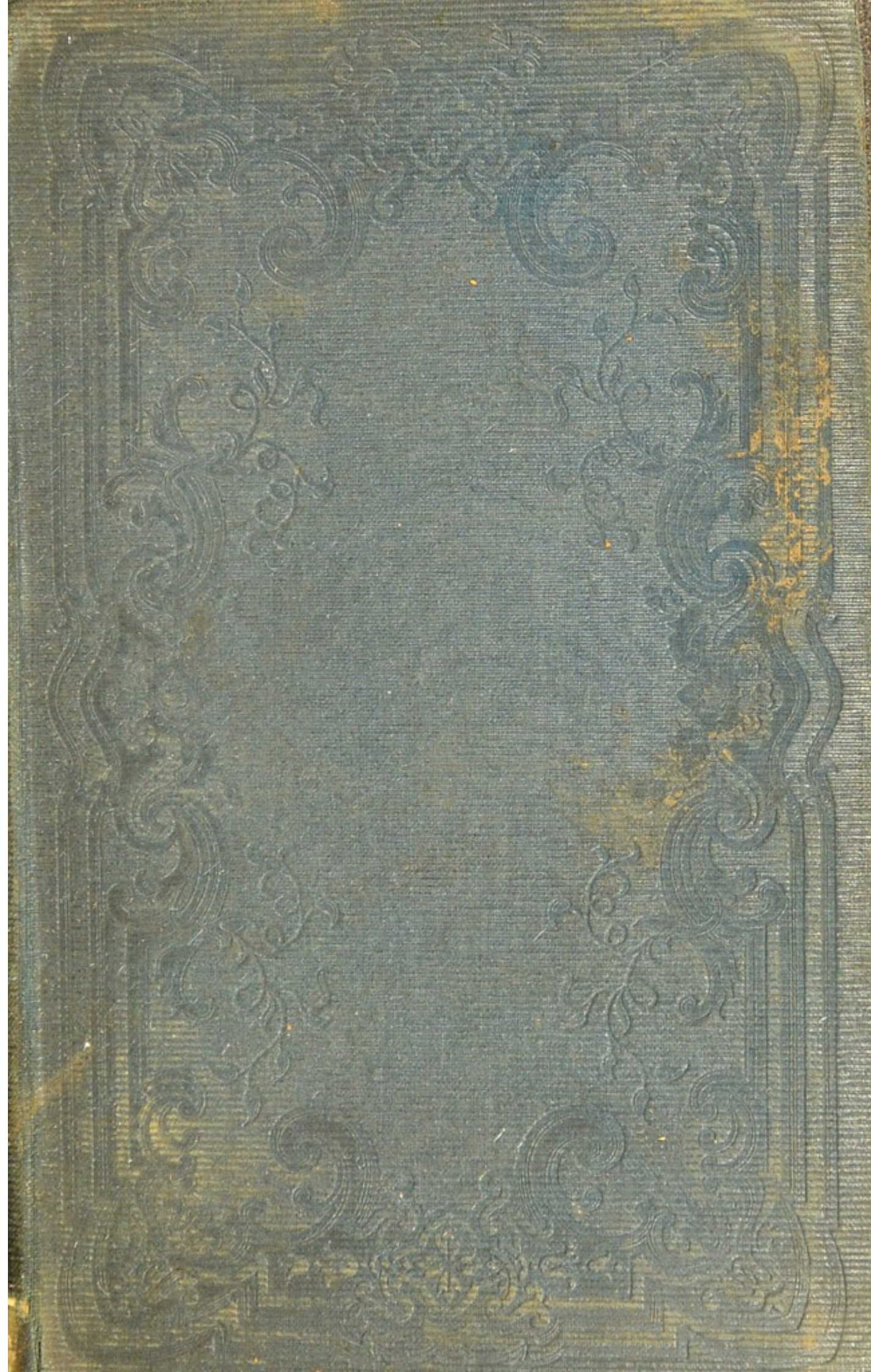


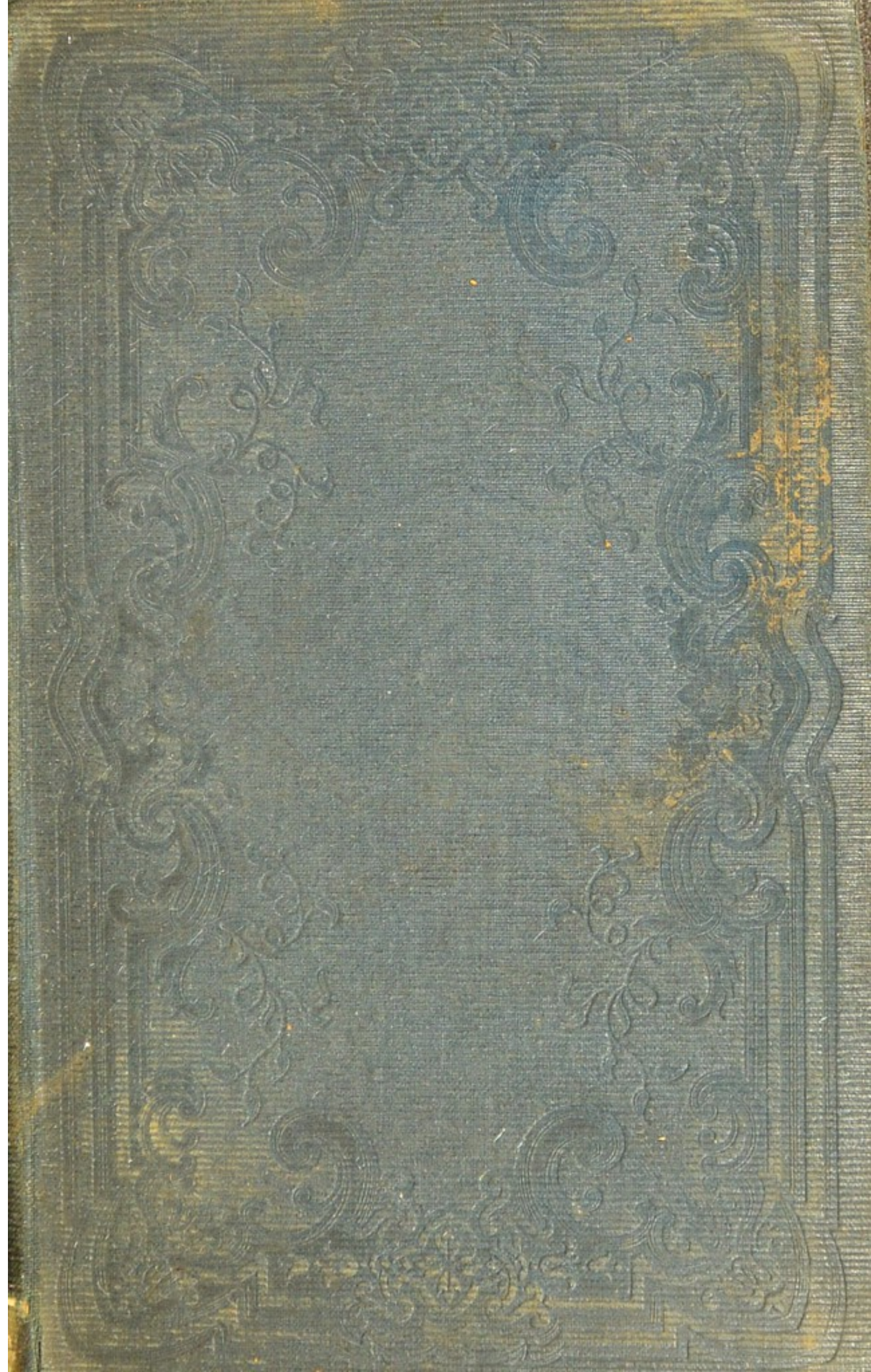
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1848.











on one side of the heavens in that great range called the Milky Way. Now the question is, what is the cause of this? Why do we find this great milky belt, so to speak, passing over our sky in one direction and not in another? It seems to me that if we look at this question calmly this conclusion must necessarily occur to us, namely: that in that part of the sky alone, where we see the Milky Way is there a bed of stars diffused throughout the unfathomable depths of space. If it were otherwise, if this bed of stars was found to be diffused throughout all regions of the heavens, then, certainly, that peculiar appearance that strikes us as we look at the Milky Way would be found as the background of all the heavens. In every range we would see the stars of the first, second, third and fourth magnitudes; then, when we arrived at that part of the heavens where we could not distinctly trace the individual stars, we would find a background filled with this dim, milky light.

It seems then that our first notion, namely, that these stars stretch away throughout space is not a true one—that this Milky Way manifests to us a peculiar structure. Now the question is, what is that structure? how can we ascertain what that structure is? Belonging to the great bed of stars in the midst of which we are, we find, on looking at the heavens, that stars of the first, second and third magnitude are tolerably equally scattered throughout all space. It is only when we come to stars of the very smallest magnitude that we find a derangement of this distribution. What does this indicate to us? It seems to indicate the following, namely: that as far as the naked eye can reach, these stars, on to the very smallest magnitude, are pretty equally scattered throughout our skies; but that if we get beyond their region, peculiarities of constitution come into view, and we begin distinctly to see that we do not belong to a universal, but to a certain, definite and distinct class or mass of orbs with which we are connected—a mass of orbs with boundaries almost inconceivable, but still a definite and distinct mass.

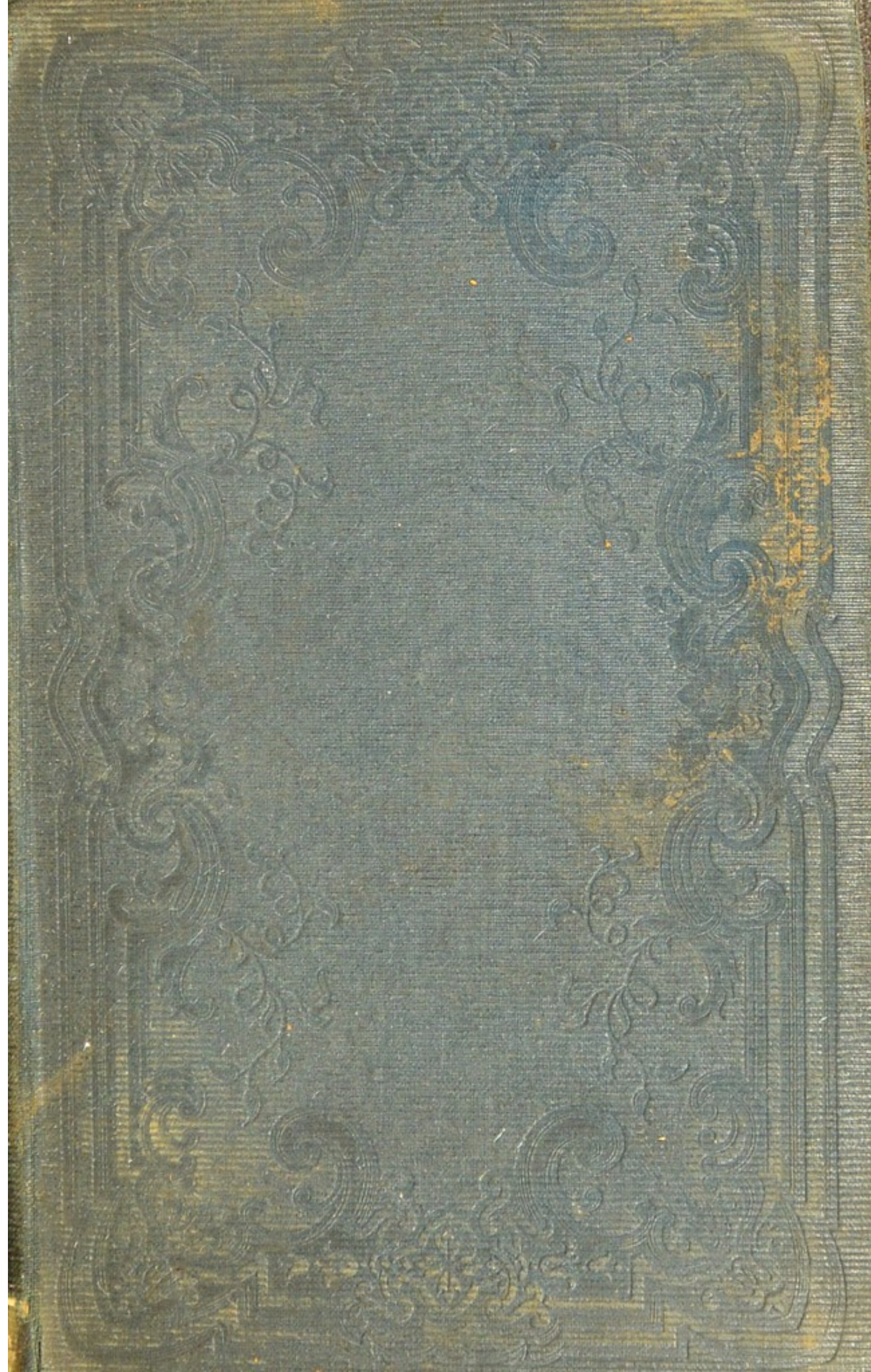
The idea that I have thrown out may yet be pushed a little farther. It may be shown that if these stars were diffused through all space, our heavens would on every side blaze with a splendor so bright that the Sun would not be visible to us at noonday. It is clear, then, that such cannot be the characteristic of our skies. It cannot be that these orbs we are discerning are spread infinitely throughout space, but, on the contrary, in all likelihood they are forming a great cluster or bed of stars of a peculiar and distinct shape. These thoughts which I have just laid before you were first seized by the illustrious Sir William Herschel, and although his conclusions cannot be placed before you as infallible, yet his first ideas lead us in our first progress toward a view of the heavens. Herschel's first conception with reference to the nature of the heavens was the following. He said, "It is clear that this great multitude of fixed stars is not what it was formerly supposed—the *infinite* heavens.—This great mass of stars is simply a vast cluster or congeries, and nothing more." When this great idea had dawned upon him, he asked, "Is it possible to ascertain what is the description, the general character, of that vast bed of orbs in the midst of which we are?" The notion was certainly a very great and marvelous one, but still he was enabled to come to a conclusion not very far, I believe, from what we now think to be the true one. The idea upon which he worked was the following: He said, "Suppose that this room is filled with persons, and that they are pretty equally dispersed over it. Now suppose that I turn my eyes in a certain direction and count the number of persons that I see

before me, and then direct my eyes to another part of the room and again count the number of individuals that meet my gaze: then, being certain that these persons were pretty equally scattered throughout the room, I would be enabled to infer from the number of persons located in the sections of the room to which I had directed my investigations, how far I must be from the edge of the room in this or that direction." This was Herschel's idea, and he turned his great telescope in every direction round the heavens, judging how many stars he saw in every place, and he found in this manner how far he supposed he was from every portion of the edge of the cluster. The mode in which he attempted to make out a scheme of the character of the heavens was this.

[The lecturer here drew a diagram upon the black-board resembling a luminous body from which rays of light emanated in every direction—the rays varying in extent in such a manner as to form a sort of elongated spheroid indented at the edges.]

Suppose this (pointing to the luminous body) is the Sun, and these lines (pointing to the rays) indicate the directions in which his telescope was turned, and their lengths indicate the number of stars he observed. Well, he turned his telescope all round through our heavens and drawing a sketch of this kind, he then joined the edges of these different lines, making a figure like this. And he said "this, in all likelihood, is something of the shape of the great cluster of stars in which we are."—His idea, perhaps, is better represented thus. Let the audience in imagination follow me. Suppose we had it in our power to move up through the Milky Way and pass along through that congeries of stars till we lose our connection with the Siderial system. The following phenomena would be observed: We should pass on from our present congeries, still moving, as it were, amid an infinite number of orbs, till, by-and-by, we should have no stars in advance of us and the only systems would be behind us. Suppose we should go still farther out amid these awful recesses till this vast scheme of ours would take on gradually and gradually the shape of a mere speck lying against the dim of the far heavens. Such would be the general aspect of that mass of stars with which we are in immediate connection. [Applause.]

The investigation which led Herschel to the conception that this was the scheme of our heavens, was the following—and you will perceive at once that it was subject to two great errors: On trying to find out a view of the skies, he had the conception constantly in his mind, that the stars were pretty equally scattered through all space. Now, to return to my illustration: suppose that I were to count the persons in different directions around the room, and inferring from that how far I was from all sides of the room, I would necessarily rest upon the conviction that the people were equally scattered throughout the room. So Herschel said that the great mass of stars throughout the heavens were pretty equally distributed. Now, since his time it has been ascertained that this is not true. It has been found that all around us, so far from the stars being pretty equally scattered, they are, quite on the contrary, thin, as if in a desert. Herschel was, therefore, wrong in his opinion of the scattered condition of the orbs around us. There was another thing in which he was erroneous. You will observe that when looking all around in the sky, he could never have supposed that he was entitled to draw the conclusion with respect to the depths of the orbs in any direction, unless he knew, or had reason to believe, that his telescope enabled him to go to the end, or at least nearly to the end, of our system in that direction. Suppose, again, that I was here counting the



tinged belt, it would be a mere succession of brilliant, separate orbs or clusters stretching out through the whole heavens, but perfectly distinct and separate." He even went so far as to say, in one of his great moods, that "this great breaking up of the Milky Way looked to him like the movements of the vast Chronometers of the Universe; that there were passing onward the distinct movements of the mighty Hand which marks the progression of the material Universe." To speculations like these one can add no adequate illustration. They are clearly beyond any sphere to which our human machinery can ascend.

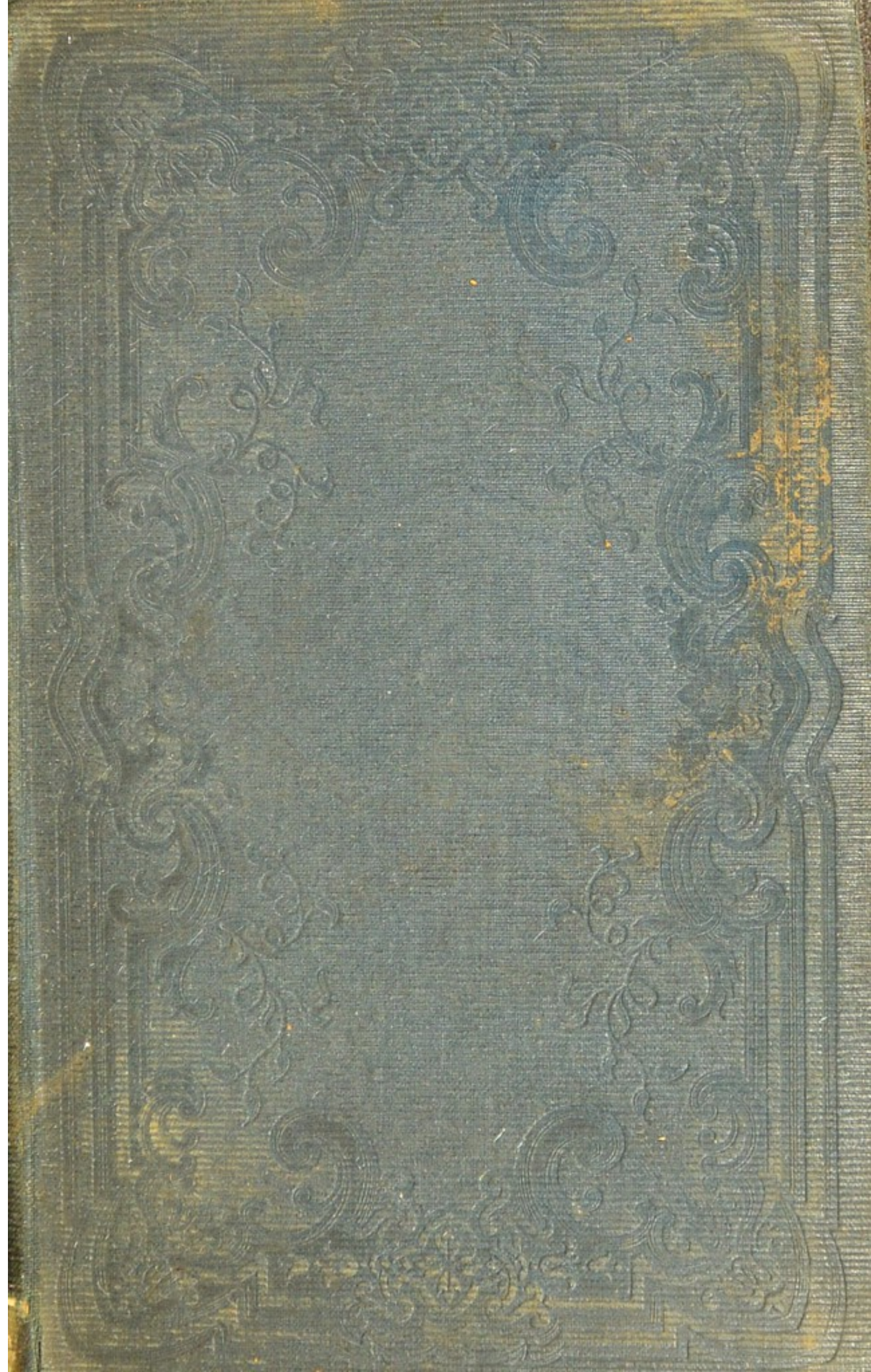
The process of change in these nebulae being probably beyond the existence of the individual and the duration of the human race, the character of that change can never be evolved except by a close comparison of all the forms which it involves, which will engage the energies of all the observatories of the earth. This comparison must not be undertaken even for the gratification of an enlightened curiosity, but for the purpose of elucidating one of the greatest questions that ever occupied the attention of man. In this investigation your own great telescopes at Cambridge at Cincinnati and other places must assist, not, as I said before, for the gratification of curiosity, but with the view of having mapped down these great nebulous changes, that we may get at the law which governs the movements of these wondrous bodies.

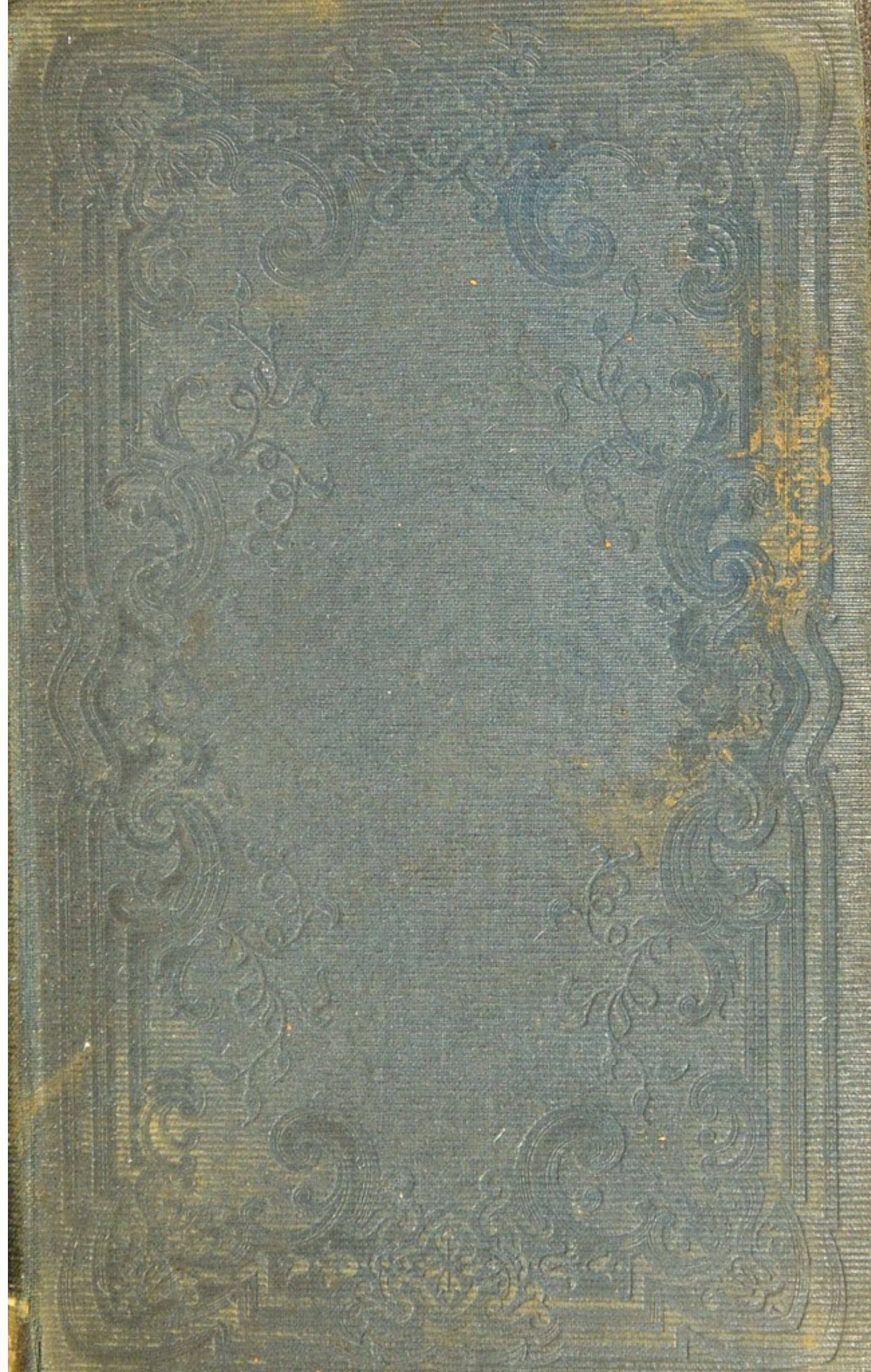
Ladies and gentlemen: I have endeavored to give

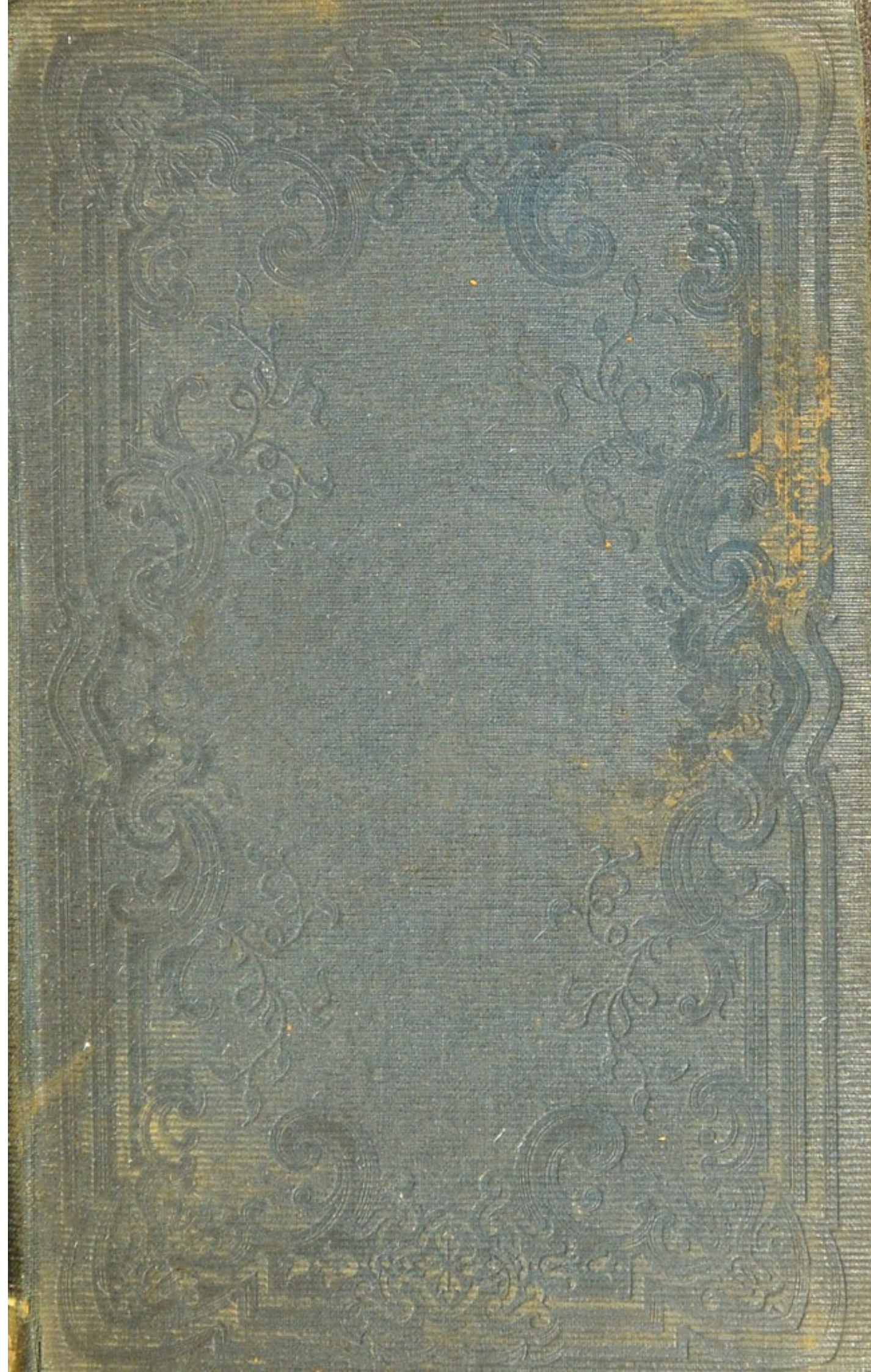
you some idea of the nature of the gorgeous Universe amid which every moment of our existence is passed. How strange that this Universe is only yet cognizable by one human sense! that the veil of the Sun's light entirely conceals its wonders from our view—that had the light of that Sun not been veiled by the curtain of night we had lived amid it and never have known of the existence of the Stellar Universe. May it not then be true that during midnight, when these infinite orbs appear to us from their unmeasured depths—may it not be true that through veils as thin we are withheld now from the consciousness of other Universes vast even as the world of stars! But in reference to an idea so lofty, let me use the language of a great mind:

Mysterious Night! when our first parent knew
Thee by report divine, and heard thy name,
Did he not tremble for this lovely frame,
This glorious canopy of light and blue?
Yet 'neath a curtain of translucent dew
Bathed in the rays of the great setting flame,
Hesperus and the hosts of Heaven came,
And, lo! Creation widened in man's view.
Who would have thought such darkness lay concealed
Amid thy rays, O Sun! or who could find
What fly and leaf and insect had revealed,
That to such countless orbs thou mad'st us blind?
Why do we then shun death with anxious strife?
If Light can thus deceive, why may not Life?

The Lecturer resumed his seat amid the general applause of the audience.







ties. I shall not mock your imaginations by proposing to conduct them to still higher regions, away from the contemplation of the separate clusters up to the Universe as in aggregate, in which each stupendous group is only an individual. I shall not speak of these as related even like the single stars or of the awful motions and careers which must spring out of such relationship; but retiring at once from grandeurs it is not yet given to the human eye to contemplate, and from heights too dizzy for the firmest reason, let me conclude with one remark on a question that profoundly interests us all. Looking at these mighty motions occupying the infinitudes of space and apparently carrying on the great Universe through a course of majestic and ever varying developments, one cannot resist the inquiry, what are the forces that shape and sustain them? I do not mean the mere technical definition of these forces, but what is their relation to the Divine Mind? What true notion indeed have we of force in itself? When we speak of the power or force of gravitation, for instance, what is it that we really mean? Has the word a distinct idea attached to it, or do we merely deceive and confuse ourselves by a phrase.—We use the word power to express something that upholds an order, but on a close analysis of the material Universe we do not find aught existing there beyond simple sequence. Events follow each other in a regular order, and beyond this the Universe itself informs us of nothing. We can-

not, however, get rid of the feeling that this order must be supported by something corresponding to an action of power or force, and therefore we feel impelled to inquire still more closely, whence we obtain our idea of power? Now it appears that this conception is obtained wholly from our experience of our mental actions. It is in fact synonymous with our conception of a free spiritual act, and therefore it seems necessary in order that the Universe be comprehensible that we recognize Deity not merely as the Creator but as the ever-present Preserver, Sustainer and efficient Cause of all phenomena.

This then, awful though it is, is the true, ultimate, scientific idea of the Divine Omnipresence. Law is not even the Almighty's minister; the order of the material world however close and firm is not merely the Almighty's ordinance. The forces if so we name them, which express that order are not powers which he has evoked from the silences, and to whose guardianship he has entrusted all things that so he himself might repose. No! above, below and around them is God, there his universal presence speaking to finite creations through finite forms a language which only the living heart can understand. In the rain and sunshine, in the soft zephyr, in the cloud, the torrent and the thunder, in the bursting blossoms and the fading branch, in the revolving season, and the rolling star there is the Infinite Essence and the mystic development of his Will. [Great and continued applause.]

LECTURE III.

The Solar System....Its Plan and Mechanism....Laws governing Motion....Gravitation....Centrifugal and Centripetal forces....Copernicus....Newton....Galileo....Kepler....Euler, Clairaut and D'Alembert....Les Bernouillies....Maclaurin....Lagrange and Laplace....Adams and Leverrier....Discovery of Uranus....Its strange movements....Discovery of the Planet NEPTUNE....Sublime position of Leverrier before the Royal Academy of Paris....Concluding remarks.

Prof. NICHOL remarked, previous to commencing his lecture, that he had, after mature consideration, concluded that it would be advisable to divide the lecture announced for the evening into two lectures, as it would be impossible for him to do the subjects which he wished to present to the audience anything like justice in one lecture. After the applause with which this announcement was received had subsided the eloquent Professor spoke as follows:

LADIES AND GENTLEMEN: I proceed to expose, as arising out of the mechanism of our Planetary System, through effect of Man's profound and triumphal exploration of its secrets, a discovery than which the entire annals of Physical Science probably present none more brilliant or apparently strange—to endeavor to remove the difficulties and doubtfulness with which that remarkable achievement has seemed to some to be surrounded—and, if I can, to clear away all obscurities connected with its history.

I feel persuaded that it were needless, even at

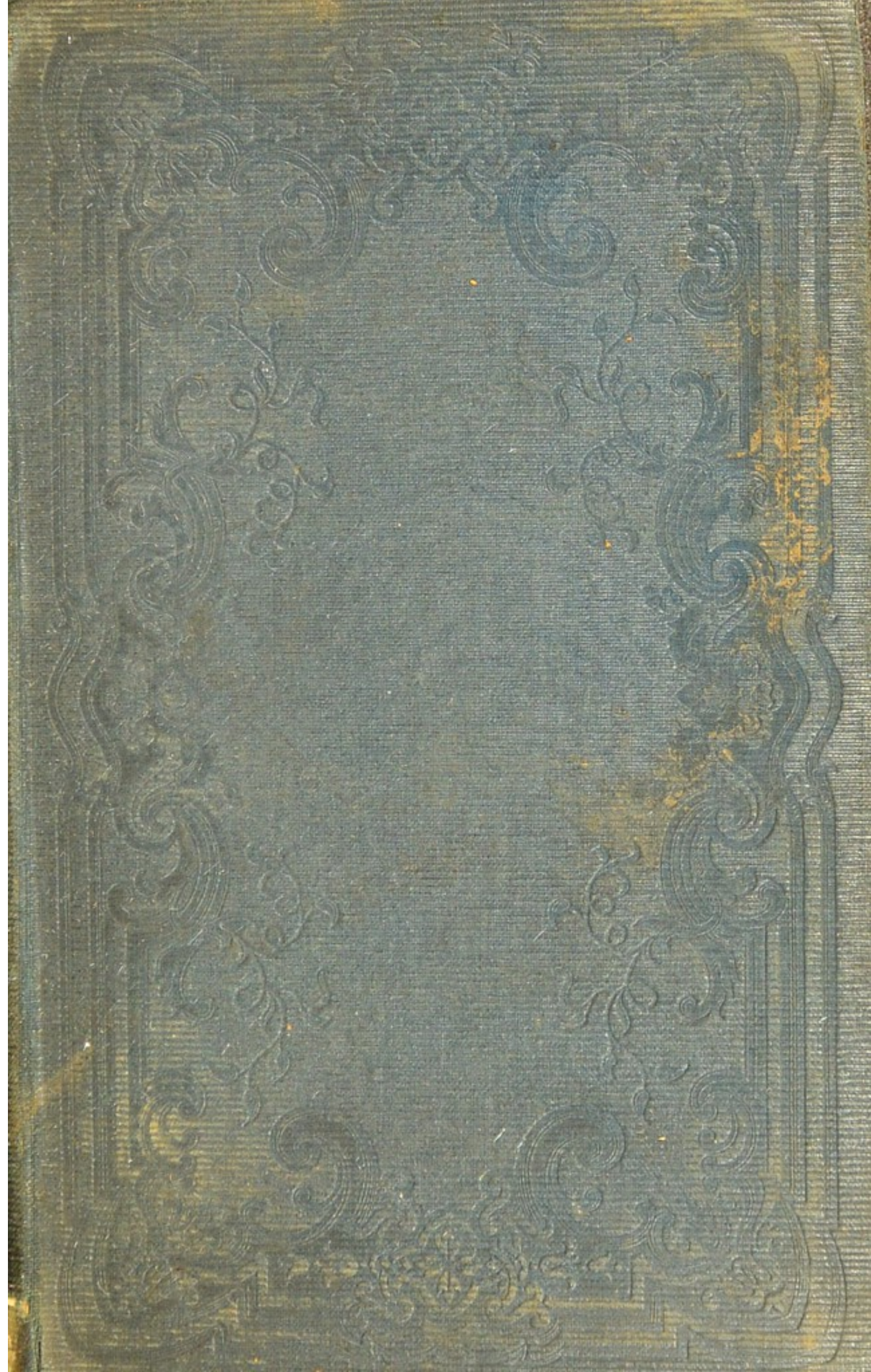
the outset, to dwell with any special attention on the outline or general constitution of our Planetary Scheme, for they have for the most part passed, as the ages have coursed along, among the details of common knowledge; but since the entire discoveries, whose steps we shall seek to follow, is but a deduction from that constitution, I do trust I will be pardoned if, even here, I seek for the sake of future distinctness to exhibit to you as succinctly as possible the most important of the elementary facts relating to our System to which we shall require frequently to appeal.

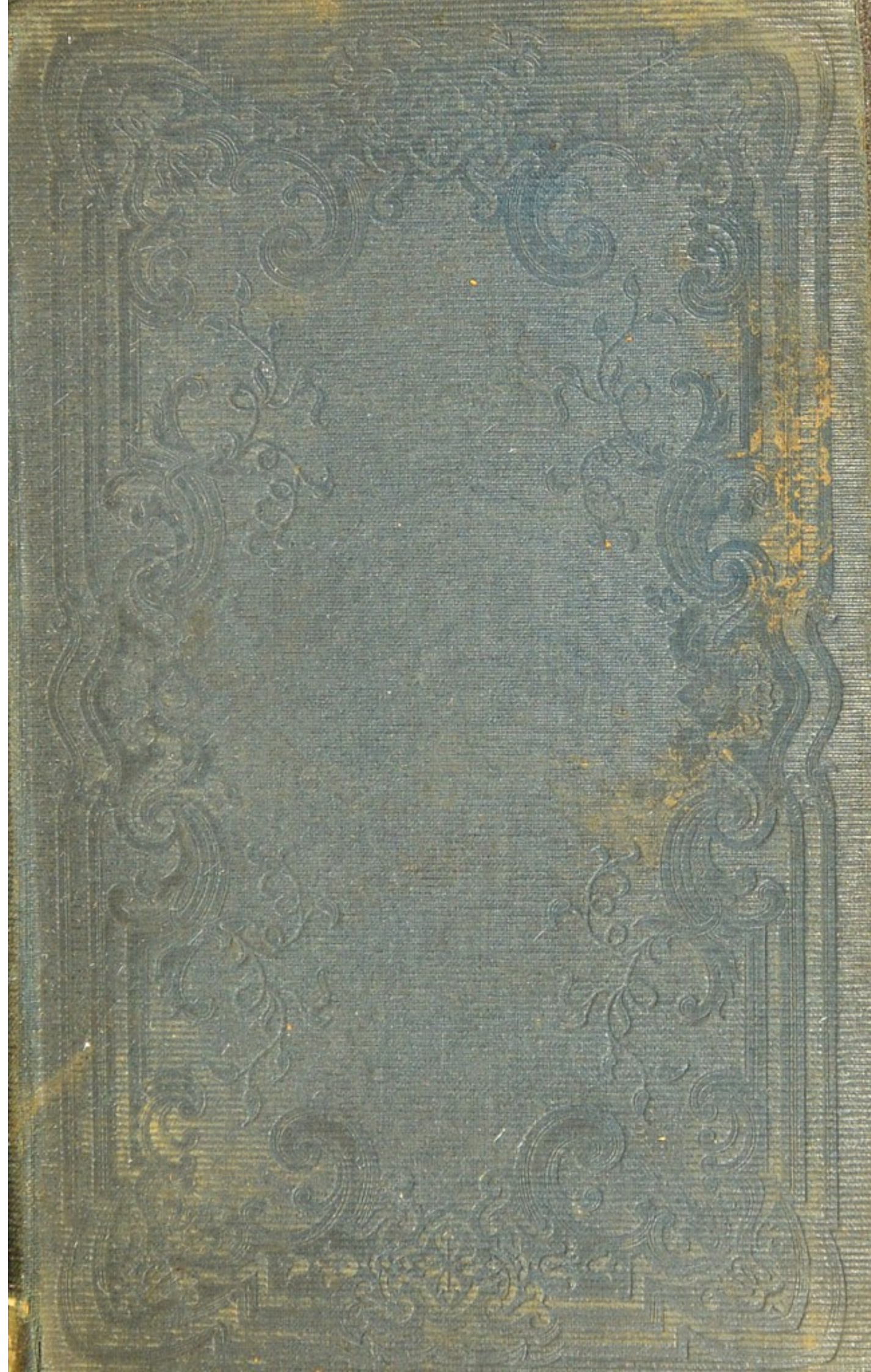
I need not more than refer to the Planetary System, which, as we first describe it, is alike simple and majestic. Resting in one portion of Space, from which his lustre is diffused through the profundities which environ him, is the Sun—our magnificent Luminary, ranking in glory and corresponding in destiny with the myriads of the fixed stars.—Around this orb, which illumines, cherishes and upholds them, those smaller worlds—of which our Earth is one—roll, with admirable and unwavering regularity, at divers distances and in stated periods. Nearest of all, as shown in the diagram,

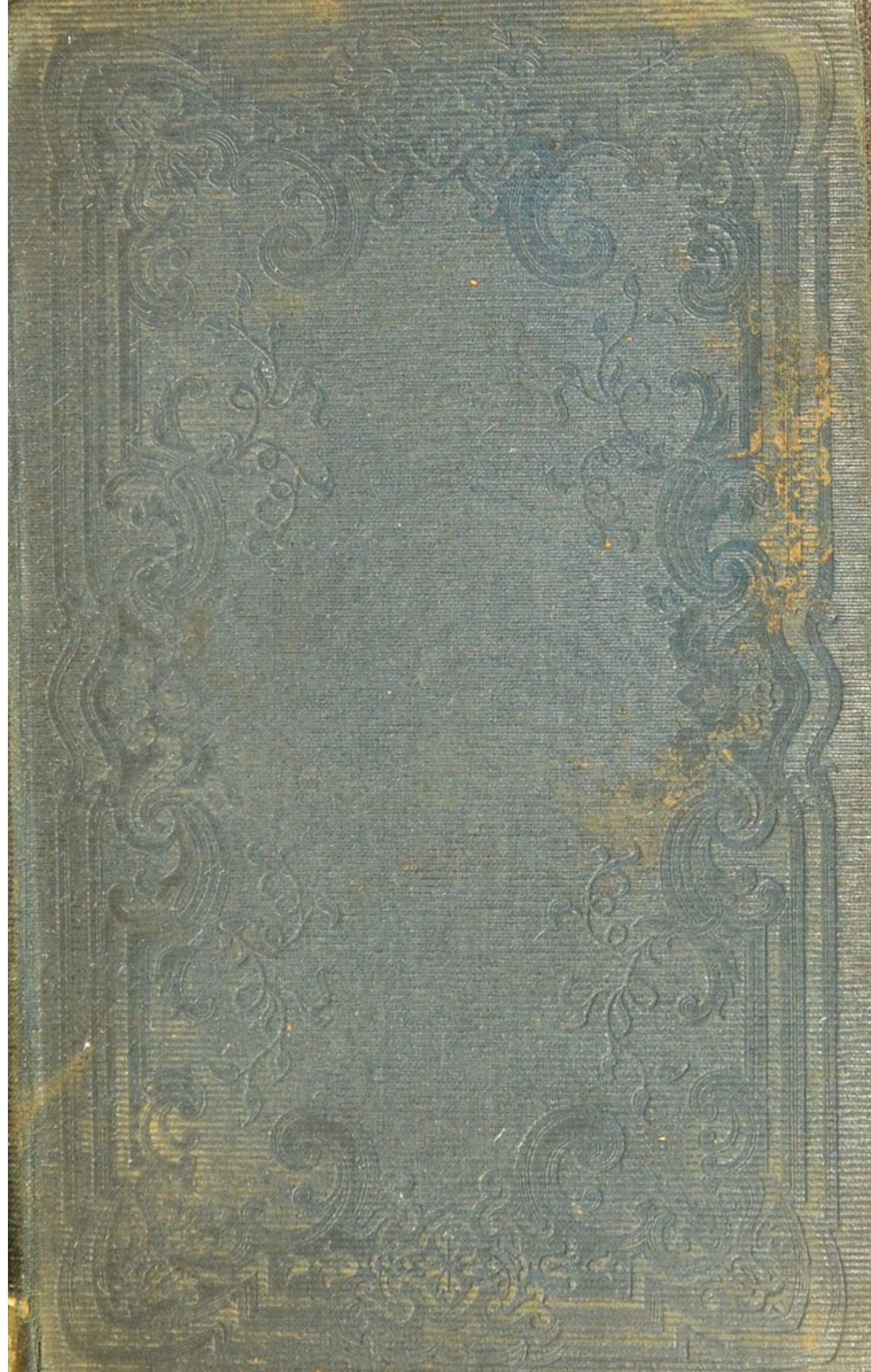


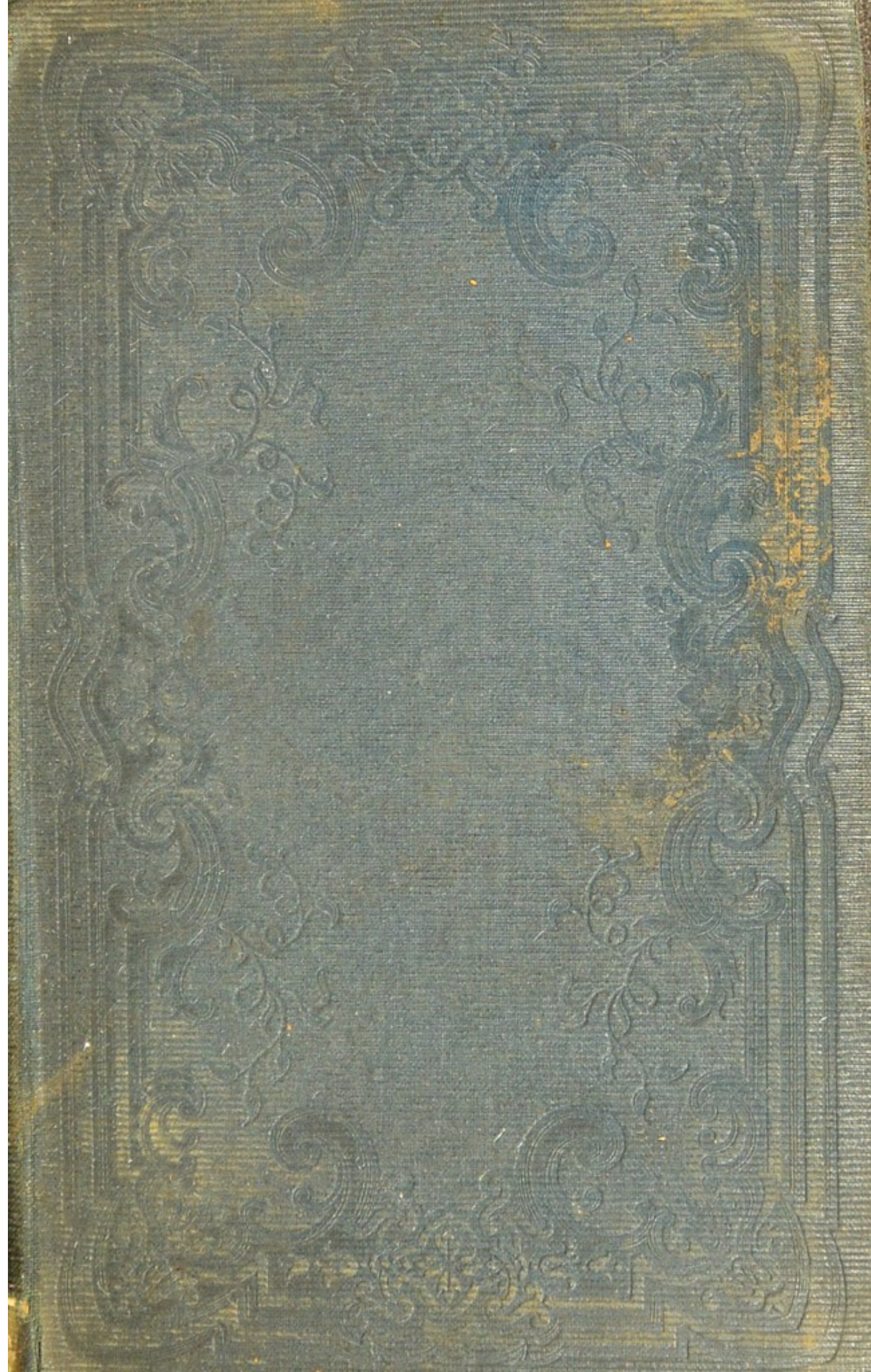
is placed the planet Mercury; next in remoteness we describe the brilliant Venus; then our Earth with its Moon; then Mars; then that complex group of small planets, [Asteroides,] remarkable through their extreme diminutiveness, and also because the orbits in which they move so nearly approach each other, that one mean distance might almost be taken as indicating the position of them all; behind these lies Jupiter, with his satellites—the noblest and most beautiful among the secondary constituents of our System; then Saturn, with his Moons and remarkable Ring; and finally, the planet Uranus, which, until the advent of these latter revelations, we deemed to be at the outer limit of Planetary existence—the remotest of the regular globes attendant on our Sun.

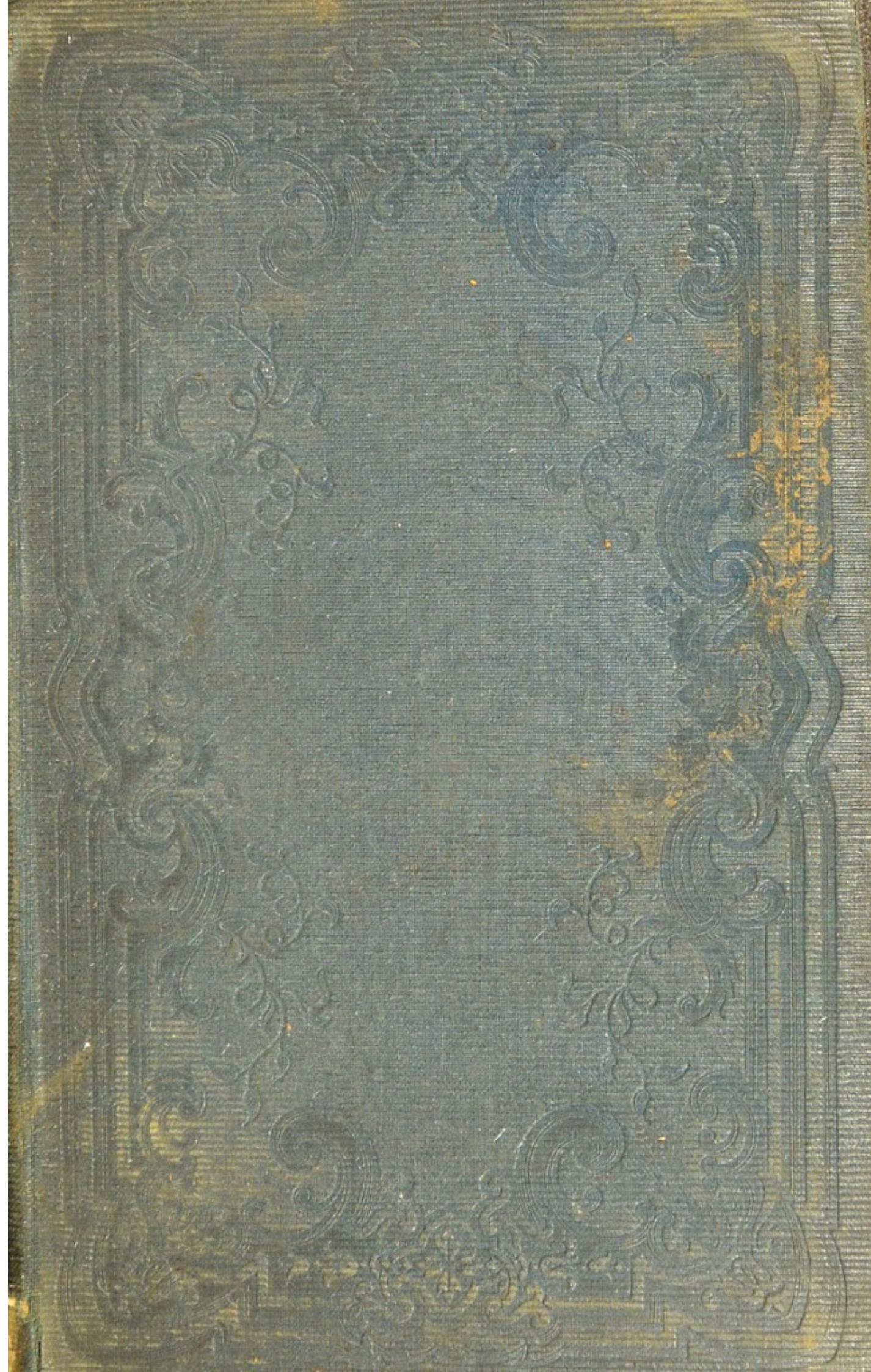
This plan, so simple in itself, was not easily discovered by mankind, and was not arrived at till after long years of perplexity and toil. The discovery of it gave immortality to the name of COPERNICUS. This discovery, grand and sublime though it was, did not satisfy the ever active human mind. The question speedily became, not merely in what order are these various orbs located, and in what manner do they move?—but, Can that mechanism as a whole, be reconciled with any known mechanical principles—are these arrangements of the Heavens indicative of the presence of Laws whose efficacy we discern among the changes more immediately around us? It was the answer to this question that bestowed immortality upon the great Englishman, SIR ISAAC NEWTON. Prior to his time—

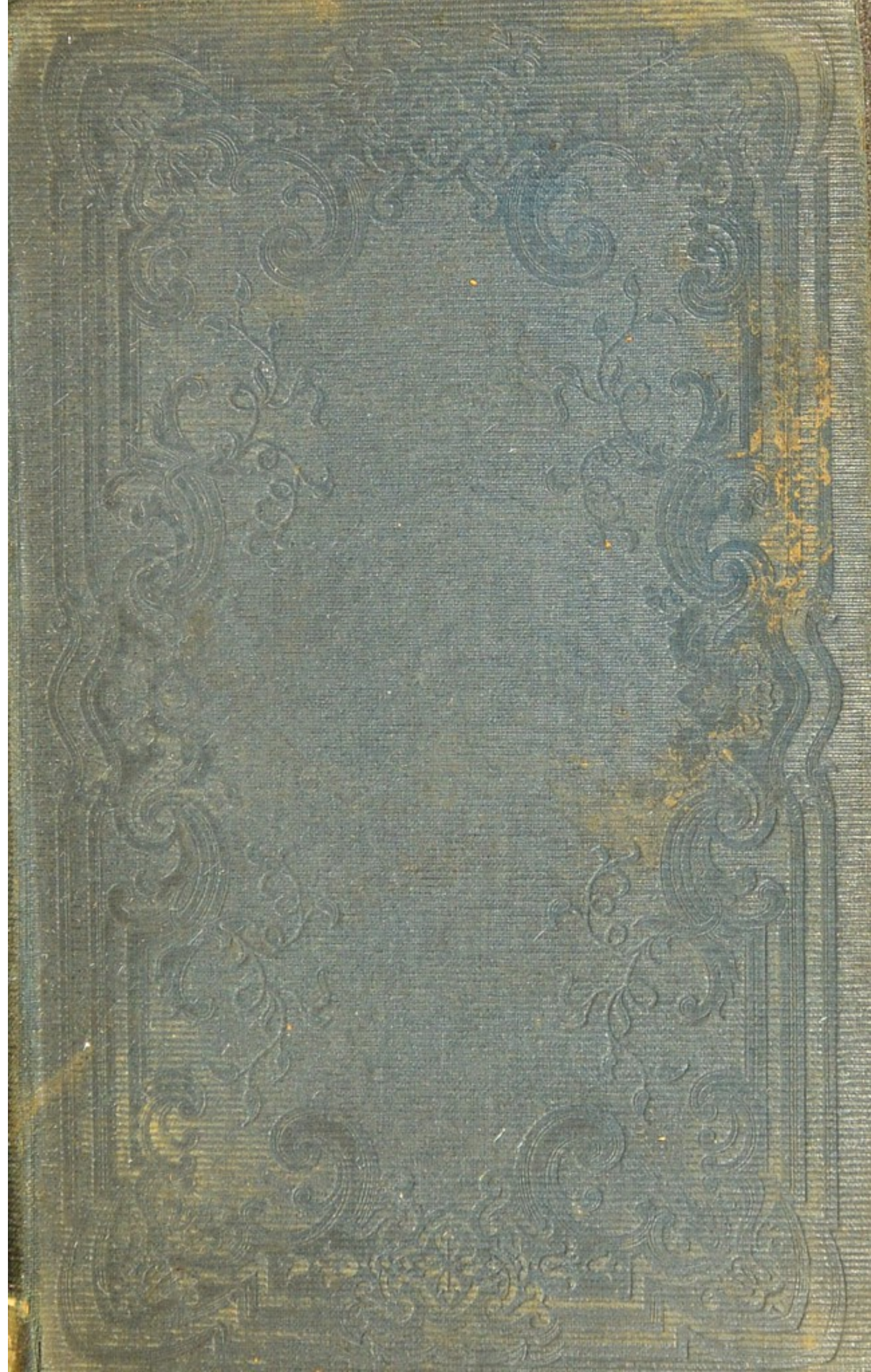


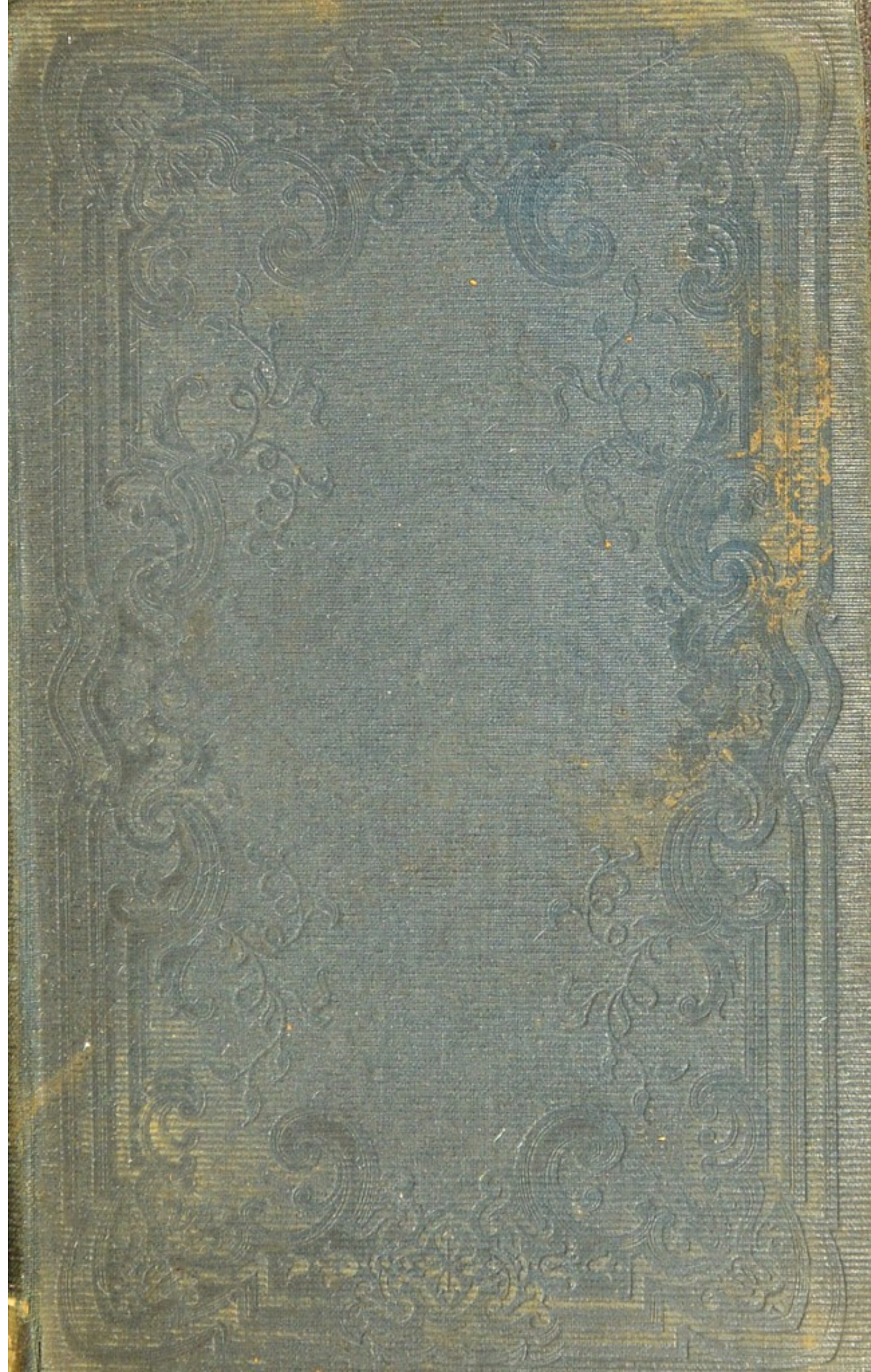












greatly facilitate farther inquiry. LEVERRIER's first conclusion was as follows :

"There is in the whole Ecliptic only one region in which the perturbing planet can be supposed to be placed, so that it account for the irregular movements of Uranus. On the first of January, 1800, its mean longitude must have been between 243° and 252° ."

My hearers will readily appreciate the extent of new knowledge acquired by this step. By our first and fundamental assumption, the new planet had to be sought only in the Ecliptic—in that one great circle around the Heavens, and not indifferently, in any place of the dazzling vault. The meaning of the foregoing numbers is as follows: To fix or refer easily to the place of a star in the ecliptic, we suppose that whole circle divided into three hundred and sixty equal parts, named degrees; and we begin to reckon these from a determined point, viz. the first point of Aries—passing all round that great circle. Observe now the limitation previously made; the place of the unknown planet was confined by it *within the brief space of NINE DEGREES, in a circle consisting of 360° .*

This important limitation conducted immediately to a much more distant enunciation of the planet's place. LEVERRIER soon discerned that the necessity of satisfying all the relations of the unknown quantities would not permit an uncertainty as to the planet's place of even these nine degrees, and having determined the limits of its mass, he reached the following proposition:

"That all the observed motions of Uranus could be accounted for by the perturbing action of a planet, the elements of whose orbit were primarily assumed, whose longitude on 1st January, 1800, is 252° , and whose eccentricity and the longitude of its perihelion were determined by processes he had just explained."

The mass of the planet he had between the mass of Uranus, and one three and a half times as large.

From the previous theorem it followed that on the 1st of January, 1847, the heliocentric longitude of the required orb must be 325° ;—an astonishing approximation, with which most men would have been satisfied; but it only informed LEVERRIER that a farther accuracy might yet be obtained!

On the 31st of August, 1846, LEVERRIER produced his last great paper to the Institute. During his former researches, or previous to his having selected any part of the ecliptic as more likely than the others to contain the new Planet, he had confined himself to consideration of a certain number of the facts ascertained in regard of Uranus—selected because of their fitness to yield a first approximation; but to give his work the utmost precision of which it was susceptible, he now employed the whole of the nineteen old observations made between 1690 and 1771, and a very large number of the two hundred and sixty-two places found in the records of the observations of Greenwich and Paris between 1781 and 1845;—each of these separate facts giving a distinct *equation of condition*, as it is termed, or a numerical value of certain combinations of the unknown quantities, viz. the correction of the elements of the orbit of Uranus; and the mass, and the elements of the orbit, of the Planet sought for. No fewer than *nine* unknown quantities were involved in this work; and he reduced his equations ultimately to the number of *thirty-three*. The treatment of these, again involved immense toil; and it was while undergoing this last labor that LEVERRIER had the mortification to observe that before his calculations could possibly close, the planet, in its apparent course through the sky, would have passed for the year from a position the most favorable for its being seen. His labors at length were terminated; and he an-

nounced finally to the French Academy the following elements:

Radius of the orbit,	36.154 times that of the Earth.
Period of revolution,	217.387 years.
Mean longitude,	318.47
January 1, 1847,	1
Mass,	9300

From which, an easy computation showed, that the true heliocentric longitude on 1st January, 1847, must be

$$326^{\circ} 32' \\ \text{instead of } 325^{\circ}$$

as roughly given by his first approximation. How singular that scene in the Academy! A young man, not yet at life's prime, speaking unflinching of the necessities of the most august Forms of Creation—passing onwards where eye never was, and placing his finger on that precise point of Space in which a grand Orb lay concealed; having been led to its lurking-place by his appreciation of those vast harmonies, which stamp the Universe with a consummate perfection! Never was there accomplished a nobler work, and never work more nobly done! It is the eminent characteristic of these labors of LEVERRIER, that at no moment did his faith ever waver: the majesty of the enterprise was equalled by the resolution and confidence of the Man. He trod those dark spaces as COLUMBUS bore himself amid the waste Ocean; even when there was no speck or shadow of aught substantial around the wide horizon—holding by his conviction in those grand verities, which are not the less real because above sense, and pushing onward toward his New World! (Great applause.)

We touch on the close of this long and noble endeavor, viz: the actual discovery of the Planet.—There are several points connected with this act, which it is of extreme importance that my readers rightly understand. The discovery of a planet by the telescope can be made only in one of two ways—by the observation of one of those two features which alone distinguish such a body from a fixed star, viz: its possession of a *palpable disc*, or its having *planetary motion*:

If the orb is of sufficient magnitude to exhibit a measurable disc to the telescope employed in the research, its discovery is comparatively easy; for the feature in question wholly separates it from the class of the Fixed Stars. These mighty orbs, although of the magnitude of Suns, are seated so profoundly in space, that to the largest instrument with which we have yet examined them, they appear with a brilliance augmented indeed in proportion to the size of the telescope, but still only as *points*, severed essentially from those small orbs whose dimensions we can descry and compare, and which are our companions and neighbors. It was this attribute which revealed Uranus to HERSCHEL; and LEVERRIER threw out the idea that the actual mass of Neptune, and the augmented power of the Instruments that can now be pressed into service of such a research, favored the expectation that, by its possession of a visible disc, and therefore without any overpowering labor, this new Planet would be found. In several parts of this remarkable work, Discovery seems to have been attended by a propitious chance; and although, as we shall afterward see, the grounds of LEVERRIER's expectations were here fallacious, his prediction of the actual *apparent* size of Neptune approached surprisingly to the truth. This disc, however, although definite and measurable, is so small as to be almost illusory; and it was not by it that the Planet was discerned.

Unaided by any visible disc, the Explorer has only one other resource: among the multitude of small stars in the quarter of the Heavens where

the unknown orb is conceived to lie, he requires to ascertain whether any one has a planetary motion. But this cannot be discerned by a single inspection. The motion at remotenesses like those with which we are now being conversant, must be so slow, that, for the brief time of one night, or even of several nights, it may be virtually equivalent to stillness; so that it cannot be detected save in one way, viz: the careful comparison of the state of the Heavens on one night, with their state on some other night, separated from the first by a considerable interval. Now, this comparison is not easily accomplished—nay, it involves great labor; it requires that *an accurate map* be made of all the small stars in the region of the sky under scrutiny, *at these two several times*; and to do this—to map the small stars in any region of the sky even once, involves a labor so great—taking the necessary exactitude into account—that LEVERRIER gladly expected the desired result from the visibility of a *disc*, and Fortune was again favorable!

For many years a great enterprise has been in the act of being performed by the Academy of Berlin—chiefly through the instigation of the illustrious BESSEL. Convinced of the great importance of the work, especially with regard to such discoveries as this—the Academy undertook the mapping—with all the precision which our modern Instruments render possible—of the small stars along the entire *Zodiac*, or along that belt of the sky, where—from the analogy of the other parts of our system—new planets might be expected to be seen. The labor required to achieve this was enormous; and it was divided among a great number of persons, having requisite instruments. Now, it so happened that the map of that precise region where the new planet was expected, had been completed by Dr. BREMIER; and it was printing, or just printed, at Berlin:—I believe that the Observatory of Berlin had obtained the proof-sheet. The Astronomers of this Institution were thus in a position of power regarding such inquiries, enjoyed by no other Observatory in existence: they had simply to notice BREMIER's Map and then the Sky—observing if there was a discrepancy between the two pictures, that could be accounted for by the planetary motion of some one star: so that—with their renowned sagacity, and the excellence of their instruments—an inspection of the Heavens on one clear night might accomplish the resolution of this great problem. And thus it even was; the Planet was discovered actually by M. GALLE, on the very eve-

ning of the day on which he received the letter of LEVERRIER indicating its place. (Applause.)

As ascertained by M. Galle, the heliocentric longitude of the body for the epoch of 1st January, 1847, would be

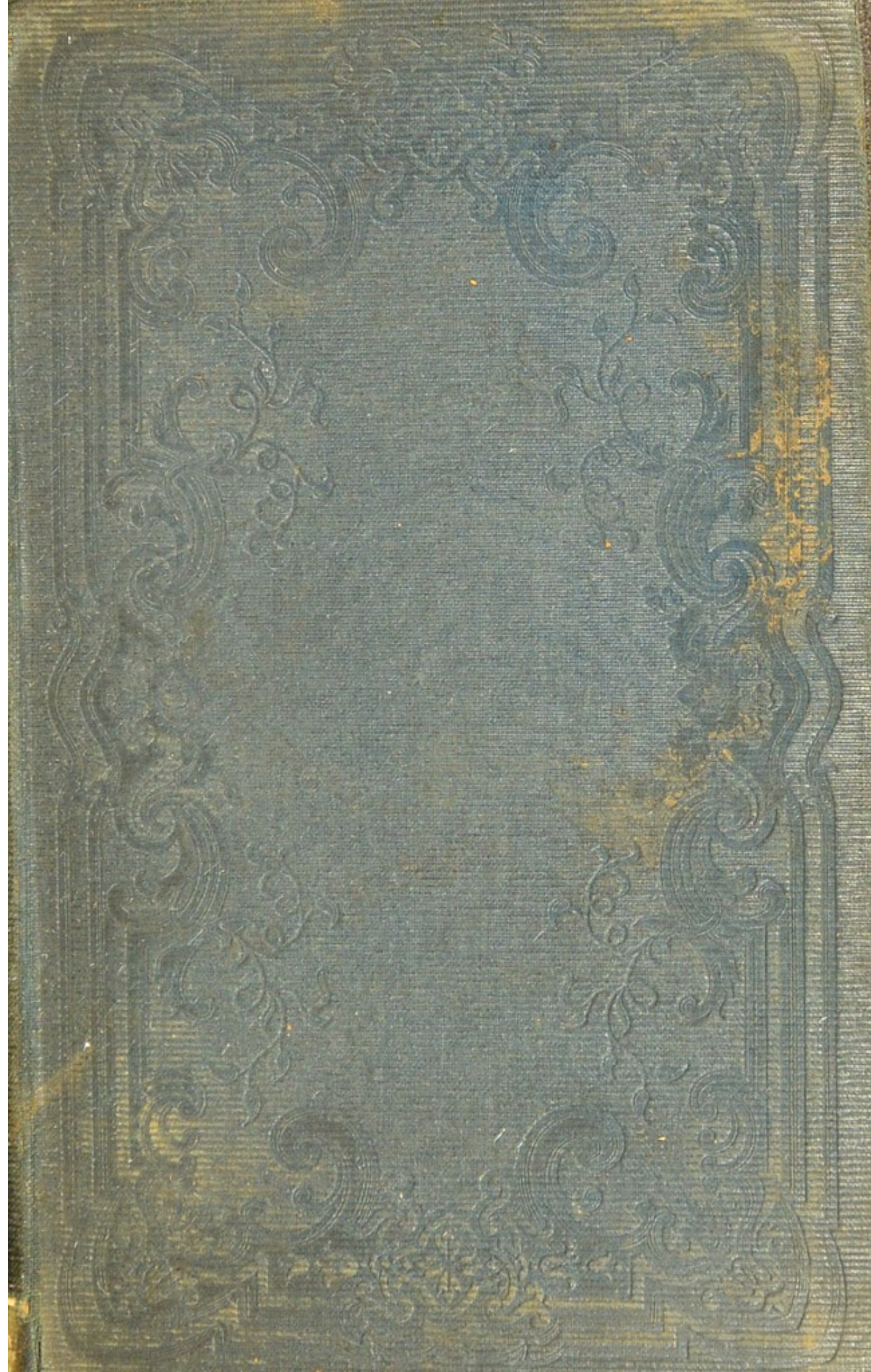
327° 24

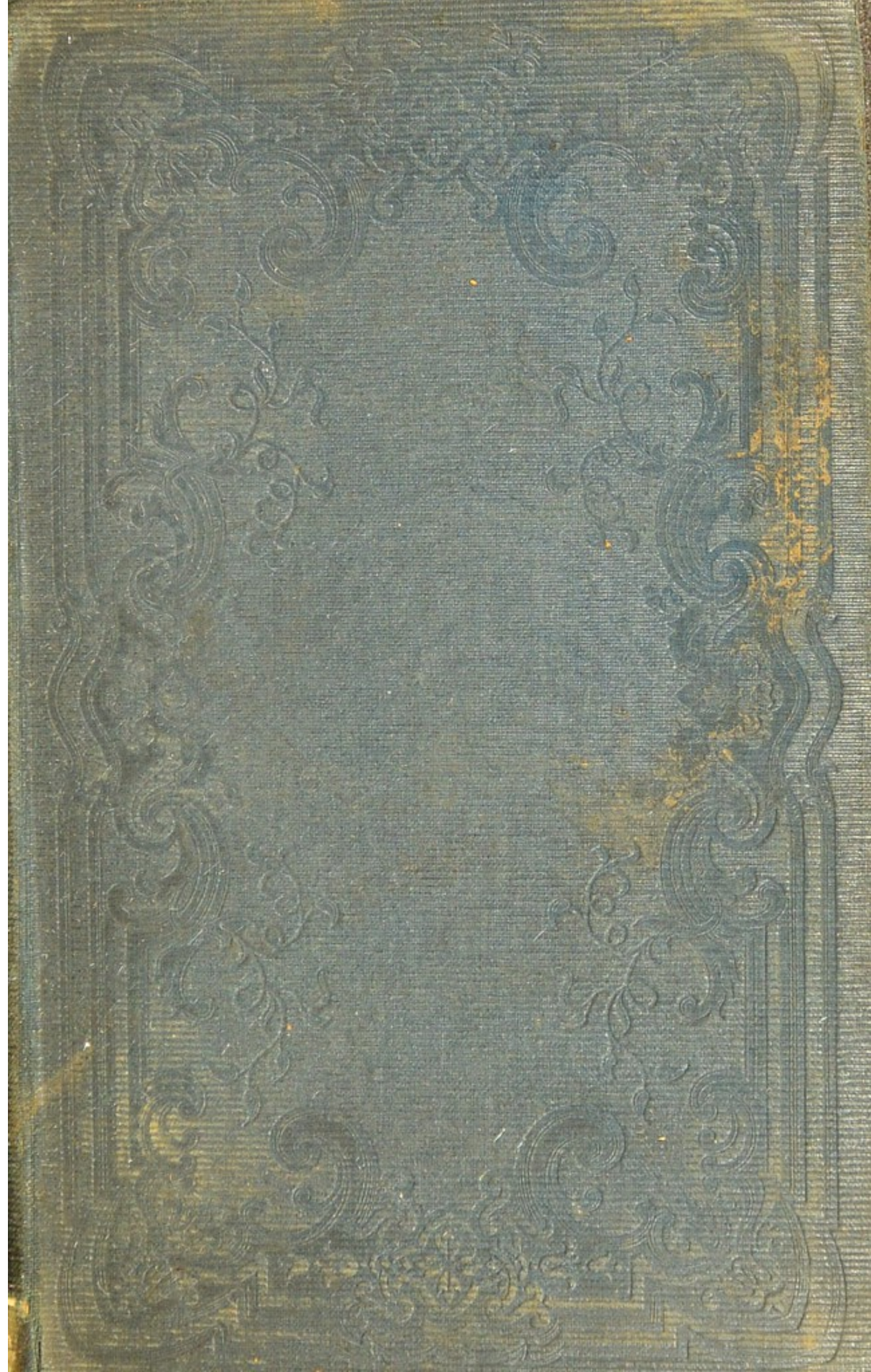
The predicted longitude 326 32

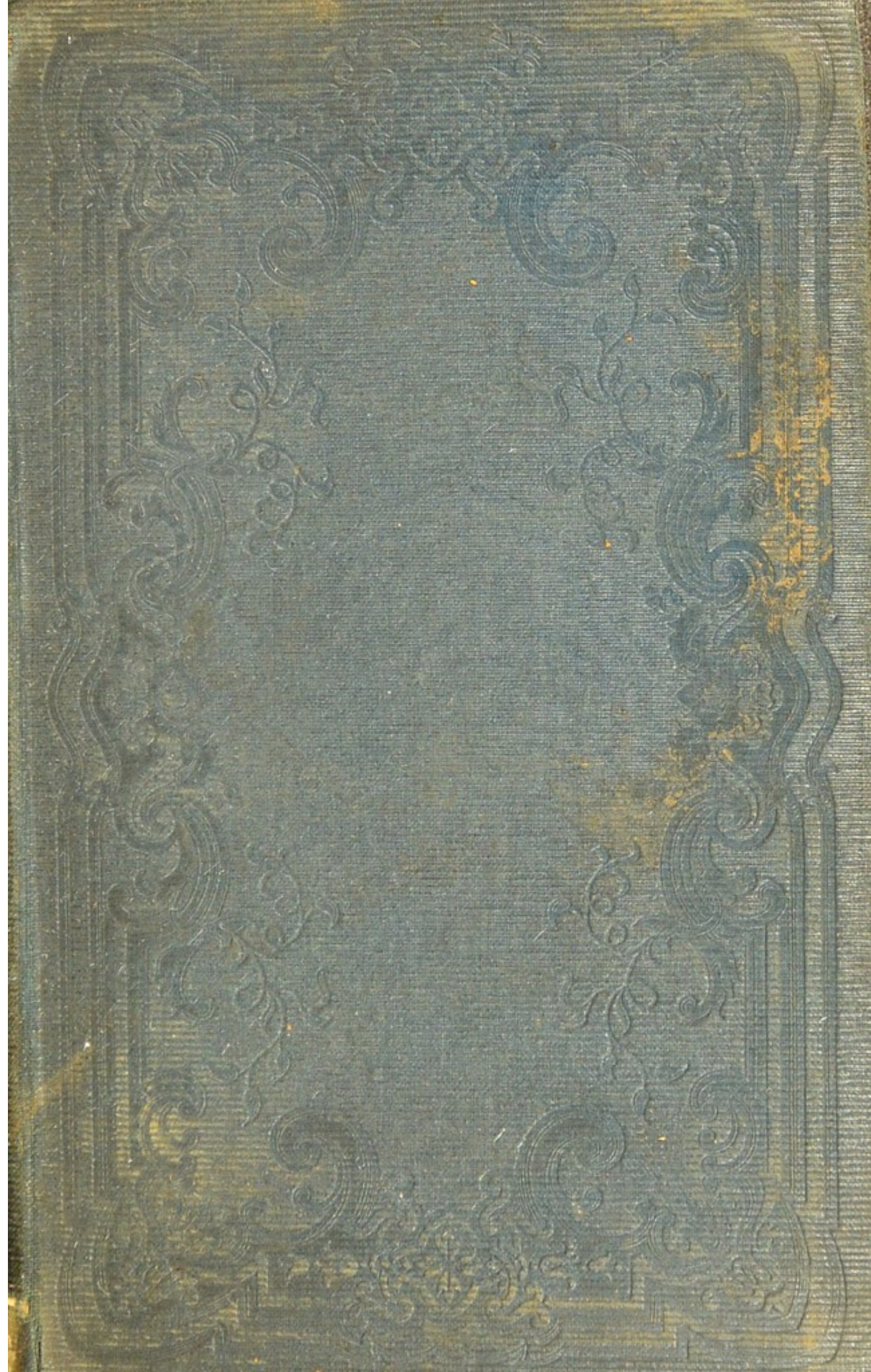
as before stated. The difference was, therefore, less than one degree or only fifty-two minutes!

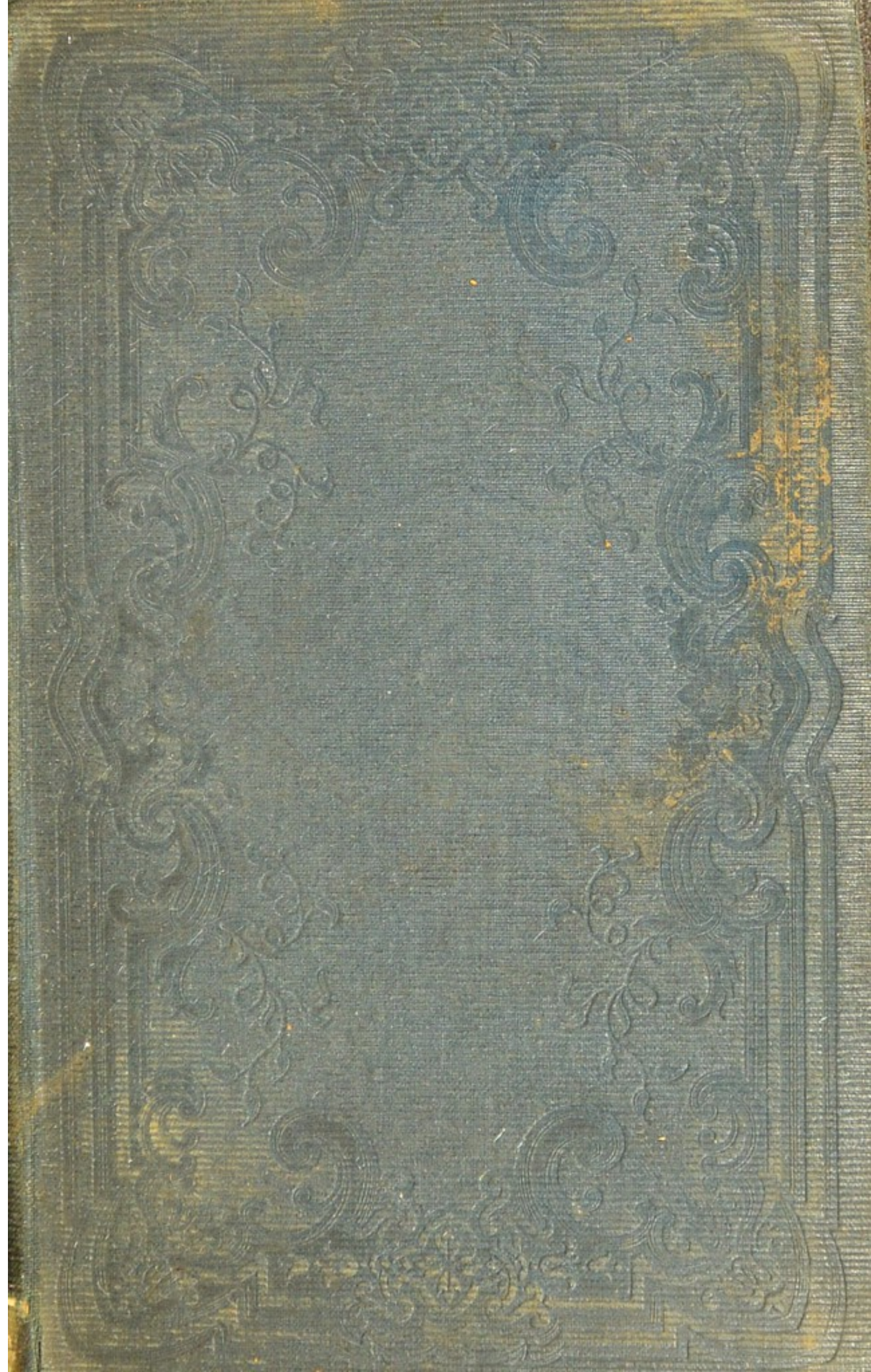
I am, indeed, aware that few grand discoveries have ever been achieved without some degree of previous disappointment on the part of the discoverer. More or less enveloped in shadow they loom for years before his anxious eye, but the entire annals of Observation probably do not elsewhere exhibit so extraordinary a verification of any theoretical conjecture adventured on by the human spirit! M. LEVERRIER received the cheering intelligence after he had concluded his last paper to the Institute on the subject; and his bearing was too striking and characteristic to allow me to omit reference to it. "This success," says he, "permits us to hope that after thirty or forty years of observation on the new Planet, we may employ it, in its turn, for the discovery of the one following it in its order of distances from the Sun. Thus, at least, we should unhappily soon fall among bodies invisible by reason of their immense distance, but whose orbits might yet be traced in a succession of ages, with the greatest exactness, by the theory of Secular Inequalities." Verily, what a man is this! On hearing that he had done a deed unparalleled in scientific history—that to his thought of unexampled daring, even God's Starry Universe had responded, and in its own splendid and imperishable language pronounced its verification—not one reflex glance on himself, not a complacent smile on the isolated ME, which amid these infinitudes had been privileged to do a work, and therefore claimed and panted for its special homage, but a firm—a rejoicing and withal a reverential hope as to the progress of that Humanity, from participation with which his own strength will come—for the progress of that Human Spirit whose earthly destiny will not cease until, after the evolution of ages, that grand material imagery lies in all its mysterious gorgeousness prostrate as spoils at its feet. (Great applause.)

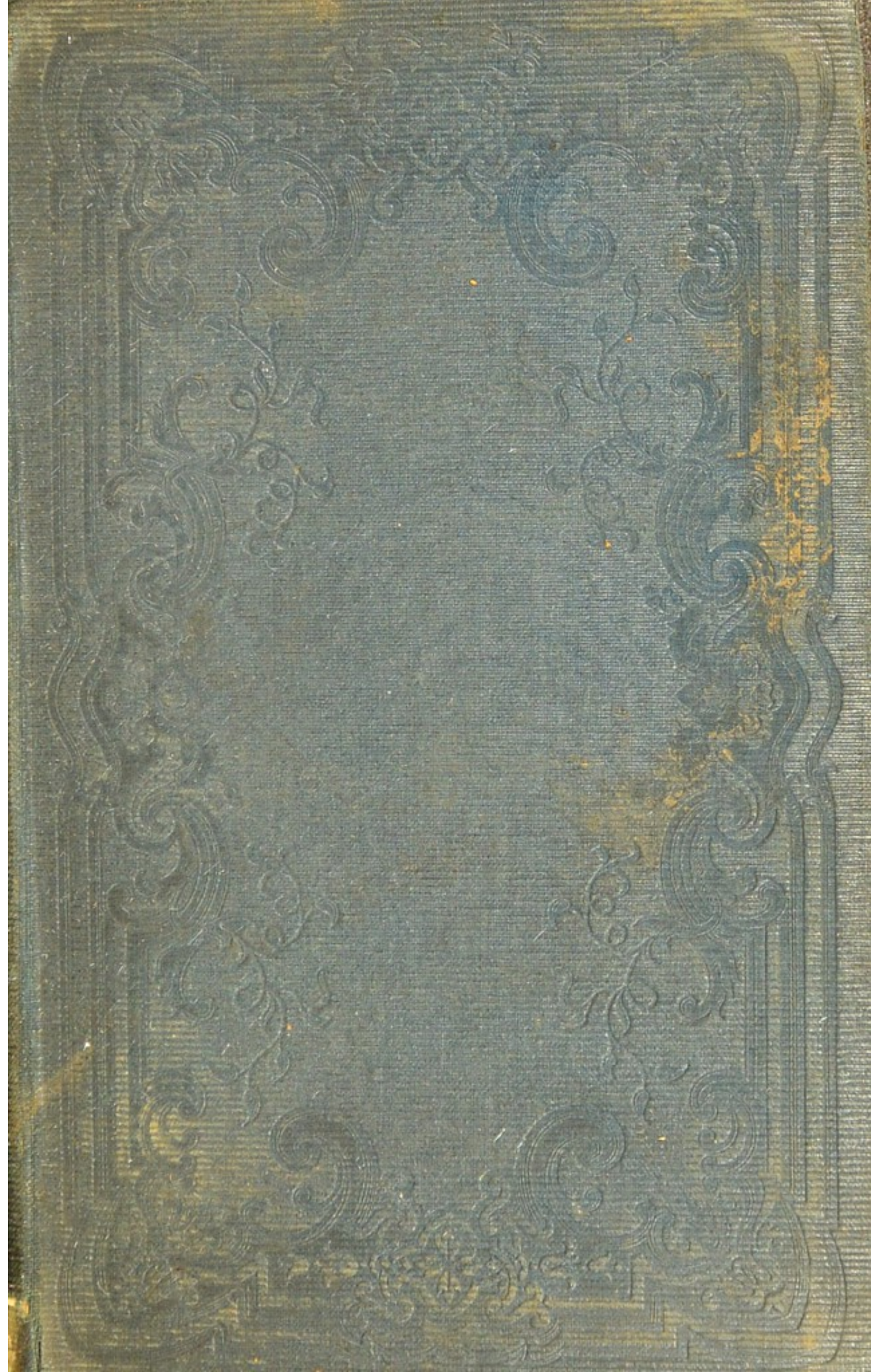
[Dr. NICHOL here closed his lecture, although he had to leave untouched several of the most interesting points relating to the discovery of the planet NEPTUNE.]

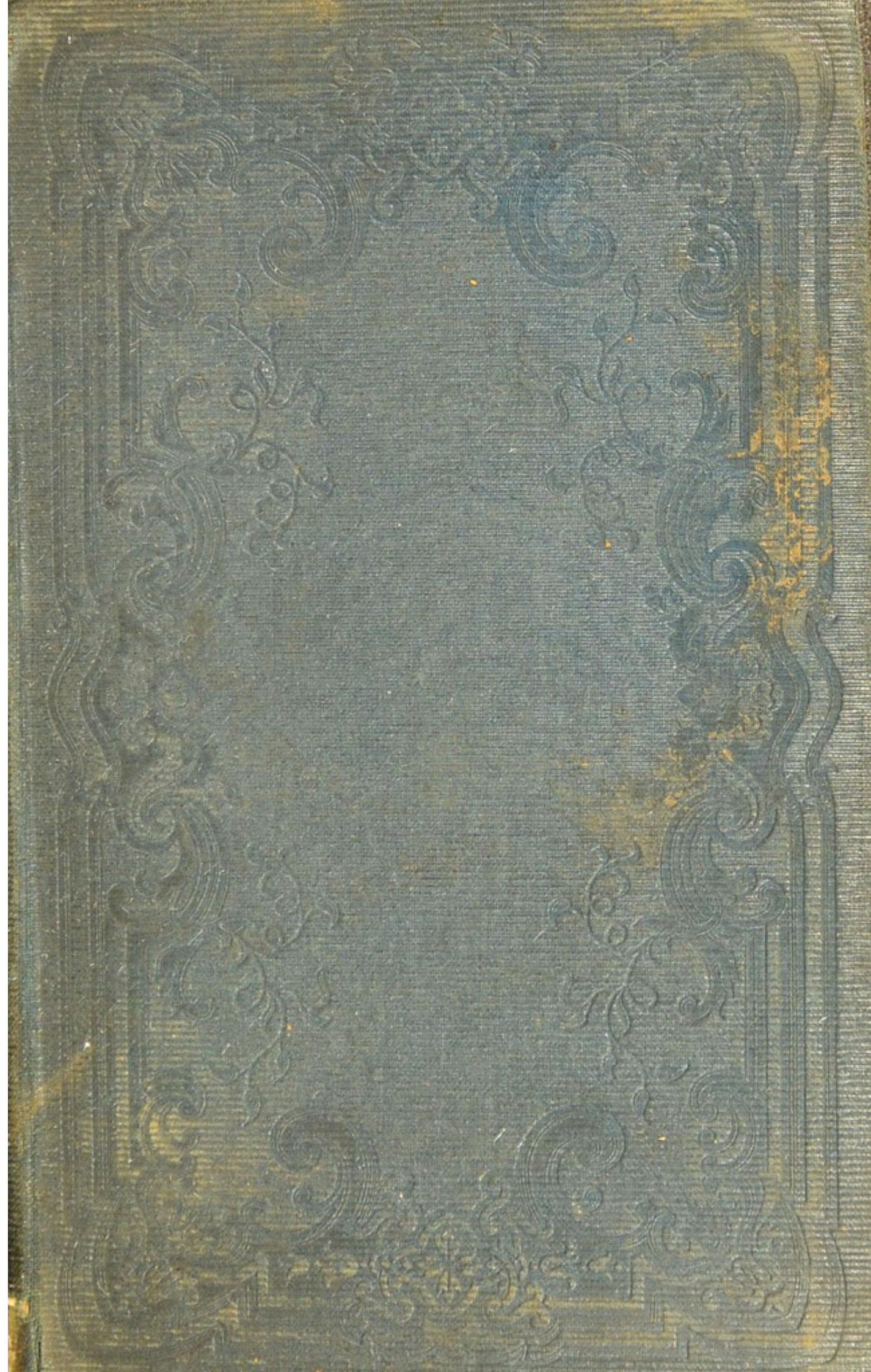












sarily inherent in our hypothesis, but does the hypothesis contain what seems far more difficult to conceive—the origin of these planets. So far we have spoken of nothing but this huge mass—no planets. Let us see if in accordance with a clear and distinct law, planets can arise from this mass. What gives the outer portion of this Nebula any connection with the center of the mass? Every particle on the outside of this Nebulous mass is acted on by two tendencies precisely similar to those which regulate the motions of the planets round the Sun; first, its tendency to fly away in consequence of its motion, and secondly, the attraction exerted over it by the whole mass which counteracts this center-flying tendency. Suppose however that one of these tendencies increases while the other does not. Suppose, for instance, that the tendency of the outer portion to fly away increases while the attractive power remains the same: what will take place? A separation of the mass, undoubtedly.—We know that the matter all around us upon the Earth is not homogeneous. There are varieties in it. We would naturally suppose therefore that the Nebulous mass out of which these orbs are passing would exhibit the same varieties of matter. If this were the case at intervals, the least condensive portions would gradually accumulate at the outer part of the Nebula. Suppose this to have been done then, so that at the outer portion of this Nebula there is a quantity of matter not so easily condensed as that occupying the inner portion. Now this inner portion would go on condensing more and more rapidly, and in consequence of this condensation the outer portion of the Nebula would be moving more swiftly, the equilibrium would be broken, the power drawing the outer part toward the center would not be so great as its tendency to fly away. There would then occur a separation between the outer portion of this mass—it would spread into a kind of ring standing by itself. This also may be illustrated by a common occurrence. For instance, sometimes when a grindstone is turned with too great velocity the outer part of it flies off. Now if this outer portion had not been solid stone it would not have broken. Had it been a band of caoutchouc for example, it would have stood out, a ring.—Now this would be precisely similar to the action of the mass to which I have referred. There would then occur, during the condensation of this Nebula, if it were not composed of homogeneous matters, ever and anon a throwing off of a ring which would lie out by itself in space. We here, therefore, have an idea how dependent matter would arise in the condensation. Indeed the ultimate state into which this condensation might bring this Nebula would be as follows:

We would have a large orb in the center, and at different distances in space apart from it, there would have been thrown off from it these dependent rings, turning round the central mass of course with the velocity with which the whole mass turned when they were thrown off. We thus have, as our first step, a great central orb and dependent rings lying out from it entirely in space. Now, before proceeding farther—before inquiring what forms of matter might probably spring from these rings, I would solicit my audience to observe what already we are able to deduce.

We can draw two inferences. Whatever the forms of these rings, they must be lying in the same plane. Then again observe another fact. The rings, as I have stated already, are found necessarily turning round the Sun with the velocity they had when thrown off, and they must all turn in the same direction. Then again, whatever is to come of these rings—whatever shape they assume, the great chance is that this kind of matter will

turn round the central mass almost in circles. Now, then, observe as far as we have yet gone, the most important of these constituent points have been explained:

First—That all the planets are lying in the same plane.

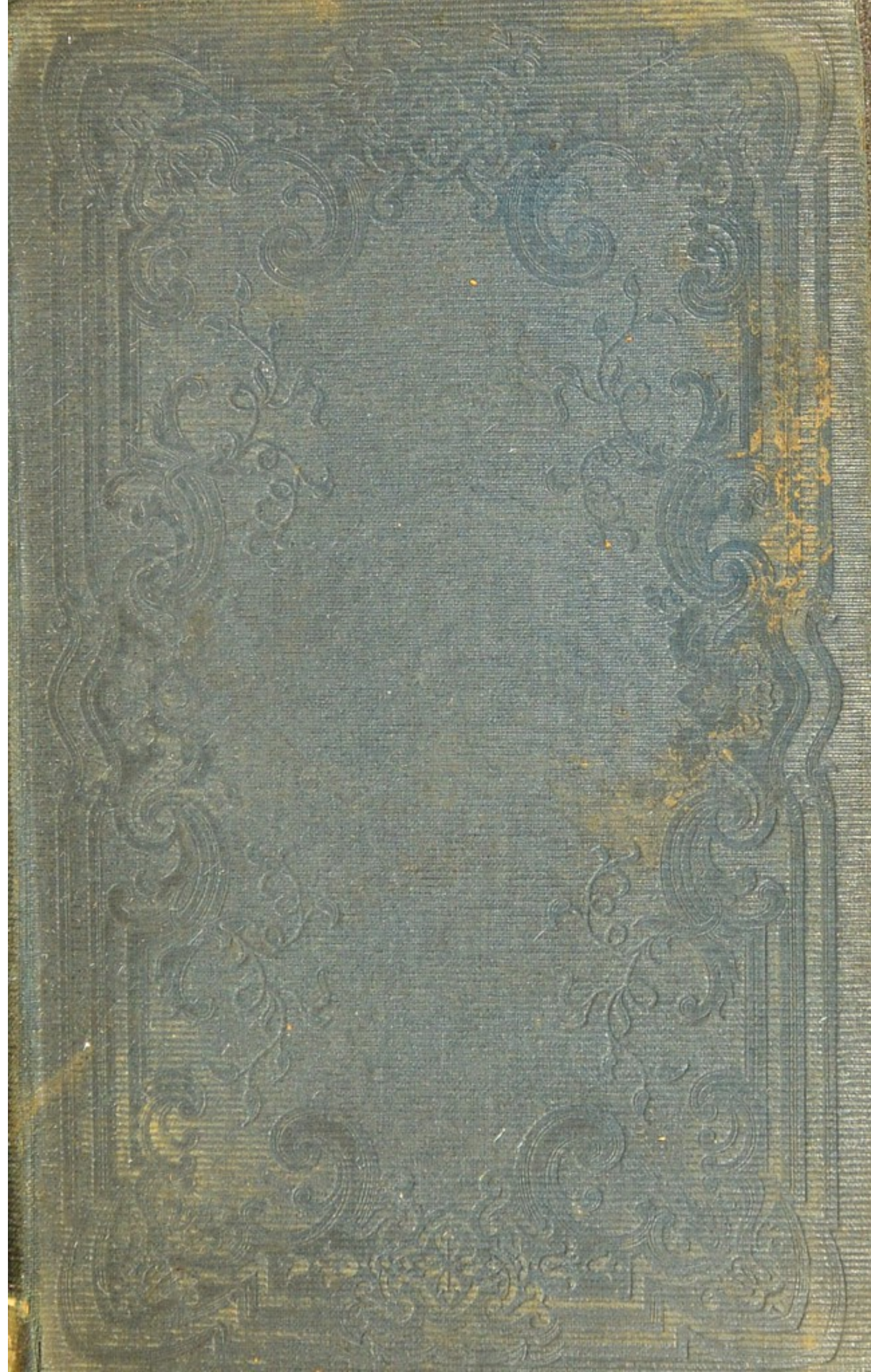
Secondly—They are all turning in the same direction.

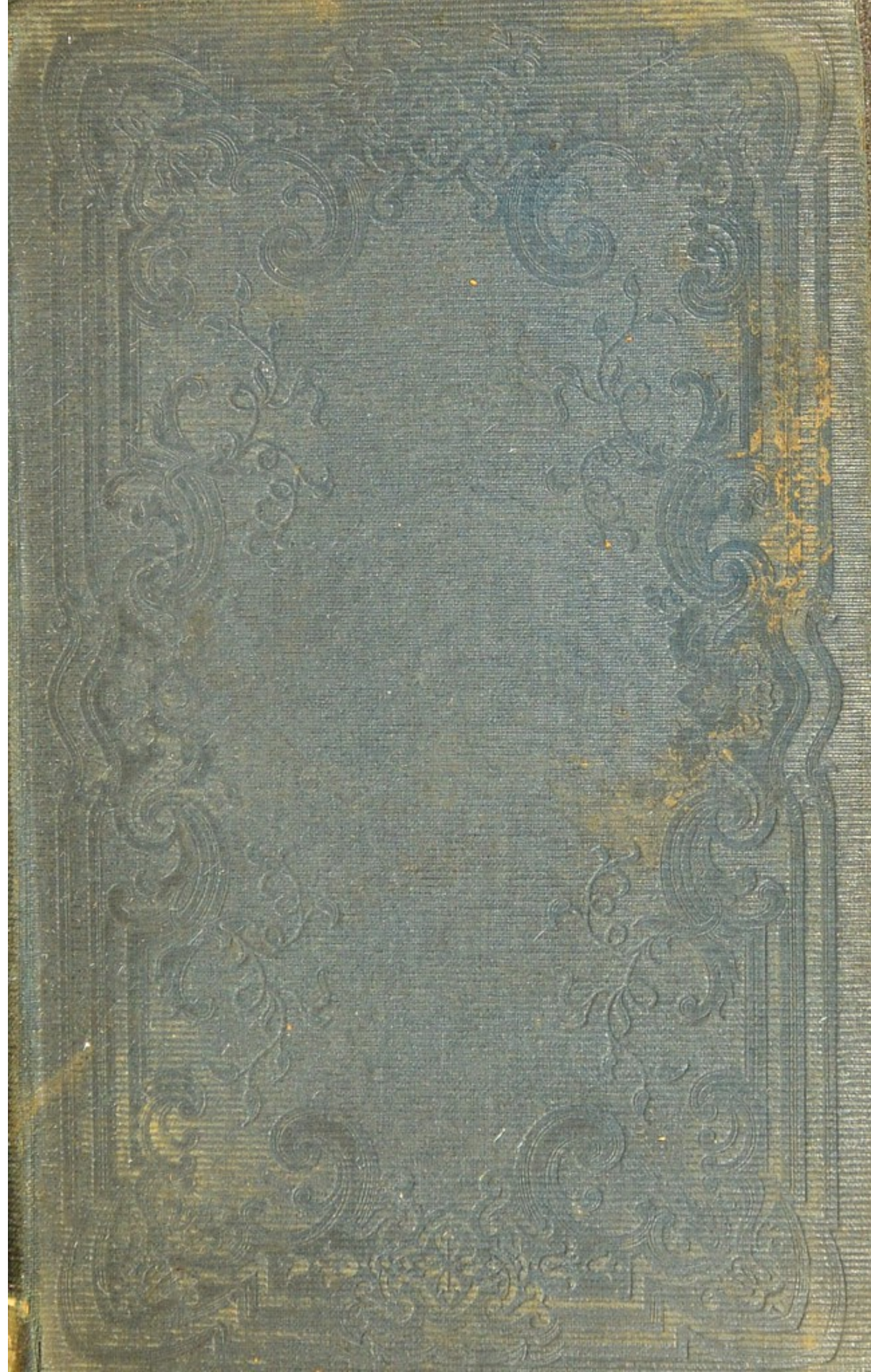
Thirdly—Their orbits are nearly circles.

As we proceed, the problem is manifestly becoming simplified—we are rapidly absorbing within one hypothesis all that seemed previously unintelligible. Let us advance with equal caution another step, and ask what is likely to become of those rings? In what manner will their particles ultimately arrange themselves? Now, first: if the ring, when it was thrown off, had been homogeneous and of the same thickness, or if during its subsequent changes, had been subjected to no foreign influence, the ring would *solidify and remain as a ring*; but if it were not homogeneous, and of the same thickness, or if it had been subjected to foreign influence, in consequence of its not being uniform the power of attraction prevailing in itself would break it up. Now, it is possible—although extremely improbable—that the ring would solidify and remain permanently as a ring in space. We might, therefore, considering the great number of bodies in our System, expect to find some one of them accompanied by such a formation, and sur enough we have one instance of the whole matter solidifying itself and remaining fixed in the heavens, a ring. Saturn furnishes us with this instance, which is the only one in our System. It has been said that Neptune has a ring, but I think a delusion has existed in this regard. It was formerly supposed that Uranus had rings, but it is now known that such is not the fact. In all probability, then, the ring upon Saturn is the only one in our System. I beg the audience to remember what I said concerning this matter. I said such a formation was possible but *highly uncertain*; and the bringing this ring into our System is a confirmation of our theory. When we are able to summon forth such formations to explain what is called an anomaly or a monster, we may be pretty sure that we are arriving at the truth. They stand out as finger posts to direct the attention to the investigation of the causes that produced them. (Applause.)

Secondly: Suppose the ring not to be uniform, as is by far the most likely to be the case. Suppose, for instance, that it had in different parts of it denser portions than in other parts, then the result would be this: Around these denser portions the whole matter would, ultimately, congregate.—It would cease to be a ring, and by the greater attraction of these denser parts the matter of the ring would be drawn around them. Now suppose these denser portions were scattered through the ring in such a way that their attractions would exactly balance each other. If the points acted so as to produce equilibrium, the ring would be broken up into a number of bodies, and they would appear as a number of small orbs revolving around the Sun at nearly the same distance. Accordingly, just as with the ring of Saturn, we have also one instance in our System of just such a result as this, viz: that group of small planets lying between Mars and Jupiter, all revolving in nearly the same orbit. We formerly supposed there were but four of these Asteroides; now, however, we know there are eight, and there may be more. Thus you perceive we have drawn into our System order out of disorder.

The third mode in which the ring might resolve itself is by far the most probable; it would condense and split up but the parts into which it would,





LECTURE VI.

Constitution of the PLANETS rapidly reviewed....Constitution of the MOON....Prevalence there of the cause which has upheaved our Earth's surface....Universality of this cause....Its nature, as indicated by the aspect of the Moon, not comprehended within current geological theories....Its tremendous craters or caverns....What gave existence to these?...Speculations as to this force....Two opposite views of it....Digression concerning meteoric stones....Progress of this grand cause of upheaval....Possibility of a relation between it and the apparition of the organic families on the surface of the Earth.

LADIES AND GENTLEMEN: I now proceed with you to the last portion of those contemplations which I desired to bring under your notice. We have spoken of the general structure and apparent destinies alike of the remote heavens and of our own Planetary Scheme; and I wish now to offer you a few thoughts on such details in regard of the constitution of our Companion Orbs, as more especially manifest their connection, as derived, probably, from a common origin.

Notwithstanding the memorable power of the Telescope, the information we have obtained in regard to the internal constitutions of the planets, is indeed singularly scant. I am not sure, indeed, that we can venture to state farther in regard of them than two very general propositions. The first is, that in so far as we know aught concerning the Primary Planets, matter exists there in the same three normal conditions as we find it existing on the Earth, viz: in the solid, the liquid and the æriform or gaseous states. These orbs have, as far as we know, atmospheres; and we discern floating about in these atmospheres clouds, clearly indicating that there is developed in them matter in a liquid state, so that the inference is that their physical constitution is in every respect similar to that of our own Earth. There is one important exception to this, however, which we are certain is manifested by one orb and which may characterize all the Secondary Planets. This exception occurs in the Moon. In the Moon we find matter in the form of air. The Moon has an atmosphere, though a small one. There are many doubts concerning an atmosphere in the Moon, but I think, however, that the phenomena which have been observed during Solar eclipses go to show that it has an atmosphere. Matter in the liquid form, however, does not exist on the Moon. There is no water in this Luminary and never has been any, a truth which we shall be able to establish in the course of the lecture. The mode in which we ascertain the absence of water in the Moon is very simple and accurate. It is as follows: As we can trace the Moon through all its phases, we may also trace the line of increasing or roaming light, which is the line of the beginning of morning or the close of evening, across every portion of its surface. Now if that light passed across an ocean or great lake or any collection of liquid, we would find, as is the case when our own ocean is the horizon, that it would be an even line unmarked by any ruggednesses, but on the contrary this line is rugged everywhere, arising from the shadows cast by irregularities in the ground across which it stretches. The Moon, indeed, has comparative flat places, such as those dark spots marked on the map, easily seen on the Moon's surface with a good telescope, but even there the ground is undulating and quite unlike any collection of water.

The second truth, however, is much more important and contains that to which, more especially this evening, I would solicit your attention.

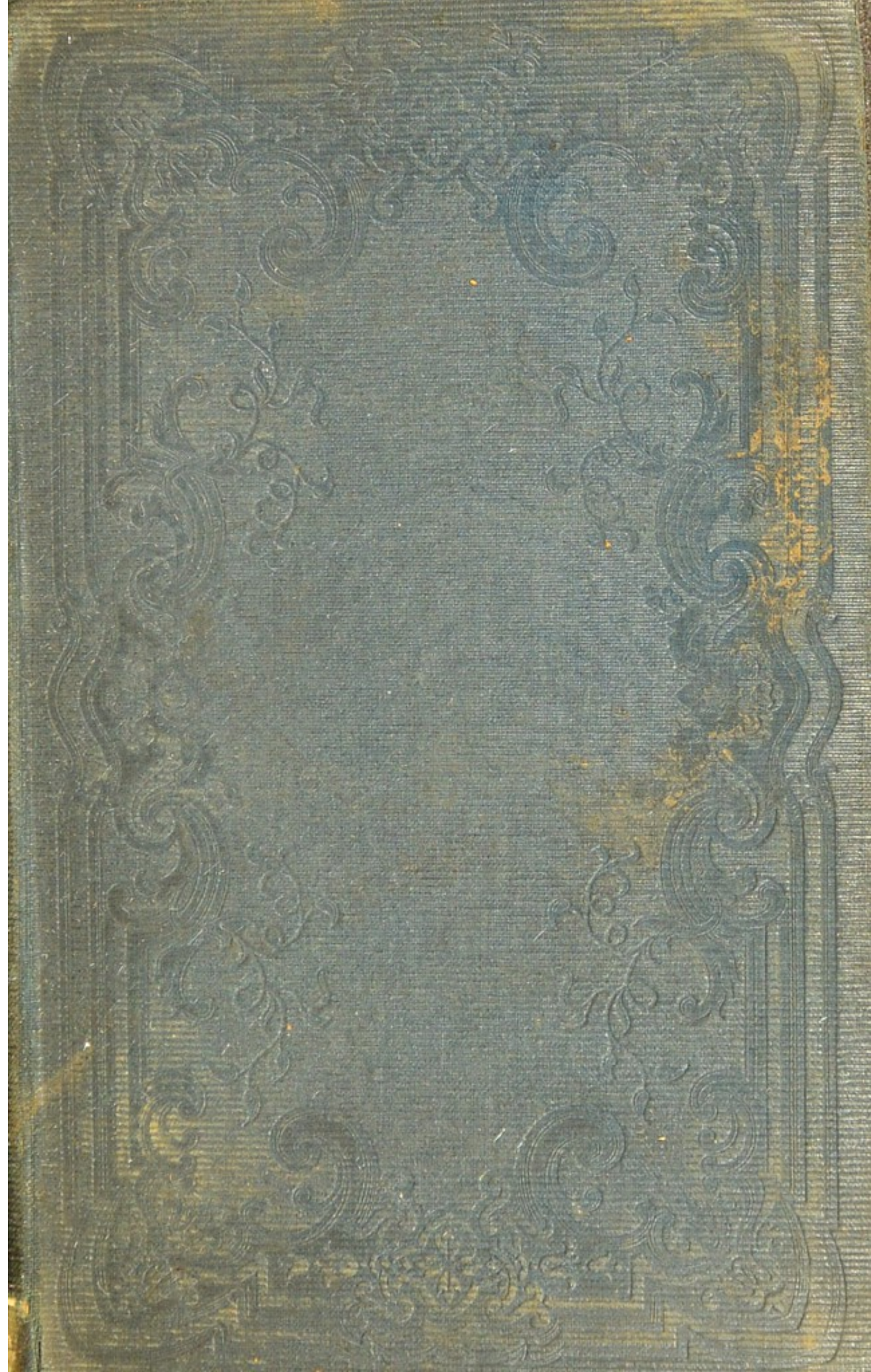
The following fact appears to be universal. We

discern it in all the planets which we have been able to examine. It is this: the surfaces of these orbs are broken and irregular, like the surface of the Earth. In other words we find there mountains, continents, oceans, great valleys and irregularities of every description which we find on the Earth. The Moon is an especial example of this. In most other planets mountains are discerned, and in some of them, such as Mars, we see even the division into continent and ocean. While acknowledging the importance of this fact, however, I do not deem that the simple discovery of what modes and disposition of land and water, of ocean and continent are manifested by the surface of any of these globes, is that which ought most to attract us during the examination; we propose, nay, we cannot regard these modifications aright, as we find them in Mars, Venus, and the Moon, unless the grand and singular fact be retained in the memory, that the phenomenon is a Cosmical and Universal one; and that whatever the cause which has upheaved the surface of these orbs, it has acted throughout all the domain of the Planetary System and left its mark on the face of every body yet explored by the Telescope.

Regarding the subject, then, in this its real generality, we cannot avoid the conclusion that if the Science of Geology shall ever succeed in discerning the source of the influence that has thus diffused its results so widely, we ought through this its grand generalization to explain satisfactorily not merely the form and phenomena of upheavals as they are developed on the Earth, but likewise all similar aspects recognizable among our Companion Planets; or if expectation so high is too ambitious for the present condition of Geological Science to account it hopeful, there is still in the truths revealed by these foreign bodies, much wherewithal we may correct premature or special conclusions, and by whose aid we may avoid the hazard of accepting as an universal law what is a simple result of circumstances that have no universality but belong rather to the constitution and specialty of the particular orb we examine.

The great value of our looking at the Moon and these other bodies in this point of view is that it will enable us to relieve our theories concerning the structure of the Earth from all mere specialty. It is with this view then, and not merely to gratify curiosity by an inspection of isolated wonders, that to night I solicit you to review the appearance of the Moon—a planet which of all others is most within our reach and connected with which we find almost every conceivable facility for clear and little-interrupted inspection.

The Moon, of all other bodies, is situated so that we can obtain the most favorable view of it with the Telescope. In the first place the entire absence of water causes the absence of clouds, hence the surface is never tinged with obscurity, or if tinged at all, only obscured in consequence of the mist floating in our own atmosphere. All the



efit which Astronomical observations might bestow upon Geology that the Moon negatives this explanation at once, for on this orb, as we have said, no liquid exists and has never been.

But the prevalent form of elevation belongs to neither class. At least two-fifths of the surface of our Luminary are studded with profound caverns penetrating its body, and generally engirt at the top by a great wall of rock which is surmounted or crowned by lofty peaks. These caverns, or, as they have been termed, *craters*, vary in diameter from fifty to sixty miles to the smallest space visible, probably one hundred and fifty feet; and the numbers increase as the distance diminishes, so that the multitude of the small ones passes enumeration.

In order to impress upon you what these objects are let us pay a visit to one of them, say the crater of Tycho. As we approach the crater we will find a very rough country. Our first glance would be arrested by a wall of solid rock appearing in the horizon stretching fifty miles away. As we approach we will find this wall sloping up to the height of about 3,000 feet. Suppose we ascend. What do we expect to see on the other side—a slope? On the contrary, when we arrive at the top, we find ourselves on the brink of a precipice that in one leap goes down 13,000 feet! Then we discover below that enormous depth some similar ranges of mountains, lying like terraces and stretching round the base of the wall, and a little onward beyond these lies the bottom of the chasm which is 17,000 feet from where we stand. The diameter of the cavern is about fifty-five miles. If a person were standing down in its center he would see on every side, at a distance of twenty-five miles, an appalling precipice rising up 17,000 feet—2,000 feet higher than Mont Blanc. If there are any inhabitants there they must have some means of locomotion with which we are unacquainted. (Laughter and applause.)

Such then is Tycho, and precisely of this kind are all the craters in the Moon. Many of them are not so deep, some of them are deeper. Some in the southern part of the Moon are said to be so deep that we can never see the bottom. Whether this be so or not there are several 3,000 feet in diameter and as deep as Tycho.

Now it is evident on the very first glance that even our *largest* volcanic craters are not to be compared with these caverns of the Moon. The largest we have any knowledge of is in the South Sea Islands, but that is comparatively small and is situated at the top of a mountain. In order to discern aught similar upon the Earth, then, we must look to larger displays of the disrupting energy.

[The Lecturer here drew a diagram of a group of mountains among the Alps, exhibiting the circular formation but differing from Lunar Craters in two points. In the first place the range is broken by gaps; and secondly, the interior is not a pit, but, on the contrary, rather higher than the external surface of the Earth. He showed then how these might be explained by the presence of the meteorological agents—rain, frost, wind, etc.—on the Earth, which are not present in the Moon: and interpreting them by this principle it seemed that the older of our terrestrial mountain formations rendered it likely that the crater form did, in the earlier epochs of the Earth's geological history, prevail likewise here.]

May it not then be that the Moon is simply in a comparatively early epoch of its development? That, as the Nebular hypothesis would seem to establish, the Lunar globe is younger than the Earth; and that with regard to it, also, a time may come when the upheaving cause will manifest itself principally,—as now in the Earth—by upheaving

ranges and groups of mountains instead of craters? This is probably all that we can derive from a view of this portion of the subject.

To proceed with our subject, can we form any idea regarding the nature of the power which could produce craters like Tycho? There is a feature connected with this crater which, in this respect, is of high importance. I mean those broad bands which issue from it and go across the surface of the Moon even to the distance, in one case at least, of 1,700 miles. [The Lecturer here went through a minute investigation of the characteristics of these bands, chiefly by means of diagrams on the black-board, and elaborate paintings, which we regret we cannot give. He seemed to render it probable that, like our own trap-dykes, these bands consist of matter which must have come up from the interior of the Moon's mass through cracks in its solid crust. Now as these cracks must have been formed by the convulsion which produced Tycho, this convulsion, then, must have been sudden as well as most violent, at once producing the cavern itself and cracking the Moon in the manner in which we see it. The phenomenon here indeed cannot be reconciled to any gradual operation or the action of any force long continued. It must have been as sharp as violent; instantaneous after the manner of an explosion. The imagination, habituated to the comparative quiet of our time, cannot easily reach the conception of a convulsion like this. Let my audience not discredit or doubt the speculation because of the fancied oddness or the gigantic character of the force whose action it presumes. So far from being impossible, the like of it, in part at least, has passed during the progress of time in almost every region of our globe. It is clear and perfectly indisputable, that when our own granitic ranges were pushed from the Earth's interior they bore up along with them many miles of rock of vast thickness that once lay quiet at the bottom of the ocean, and over which shell-fish crept, that are now entombed within their layers. Such convulsions were indeed often slow, and may have occupied ages in their progress of completion, for the rocks that were disturbed are frequently little confused, lying around the central granitic mass as a graceful robe; but go with me to the Alps, or even to our own English Cumberland, or North Wales, and I could show you masses above masses which, when they were formed, lay as flat and even as the surface of that floor, not only turned from their repose and tilted upward in the air, but, by the violence of the action that disturbed them, rolled over each other in confused heaps, presenting for miles together to the puzzled explorer the aspect of a crumpled and crushed sheet of paper. Yes! *there*, indeed, has been power, immeasurable, scarce even conceivable; but the giant Earthquake has an arm capable of all this work. (Great applause.)

I would now, ladies and gentlemen, for one moment digress from our course and inquire, if the force that formed Tycho was so great, what became of the rocks that it blew out of Tycho? A cavern of that kind, fifty-five miles in diameter, is not an infinitesimal thing which may be easily formed. What became of these rocks? The most ready answer is that they returned again to the surface of the Moon, just as matter thrown from the Craters of our Volcanoes returns again to the Earth. There are circumstances, however, I think, that will induce us to pause before we assert that this took place.

In the first place, the Moon being a small body does not exert much attractive power over a mass, therefore it would not take much force to drive away a body from the Moon altogether, and send it

flying about through space. If this matter did go back, where is it?—we certainly should see it if it was there. Therefore we may say it is probable that this matter did not go back to the Moon at all, but that the violence of the shock was sufficient to send it off to seek its own fortune through space. (Laughter and applause.) Then what became of it? It must be moving through space in strange orbits, in bodies of different magnitudes. The orbits of the planets are so regular that with them there is no chance for collision, but with these masses flying round through space there is no chance to escape collision, consequently it is to be expected that these masses would be continually coming in contact with the Earth. Thus may we account for the falling of Meteoric stones. This is not a strange phenomenon. At least two masses must fall to the Earth per day—taking into account all that have been observed to fall—a phenomenon sufficiently large to require some important cause.—Now, if this force had sent off this matter from the Moon, the Meteoric stones would not be difficult to explain.

There was a theory concerning this phenomenon called the "Chemical Theory," which, as far as I ever understood it, was this. "Suppose certain particles floating about in the atmosphere, then suppose particular forces should cause these particles to come in contact and unite, then particular stones would be the result." Now there are three difficulties attending this solution. First, it cannot be established "that such particles were floating about in the atmosphere." Secondly—It cannot be proved that "particular forces would cause them to unite;" and thirdly, it cannot be shown that "particular stones would result from their union." (Laughter and applause.)

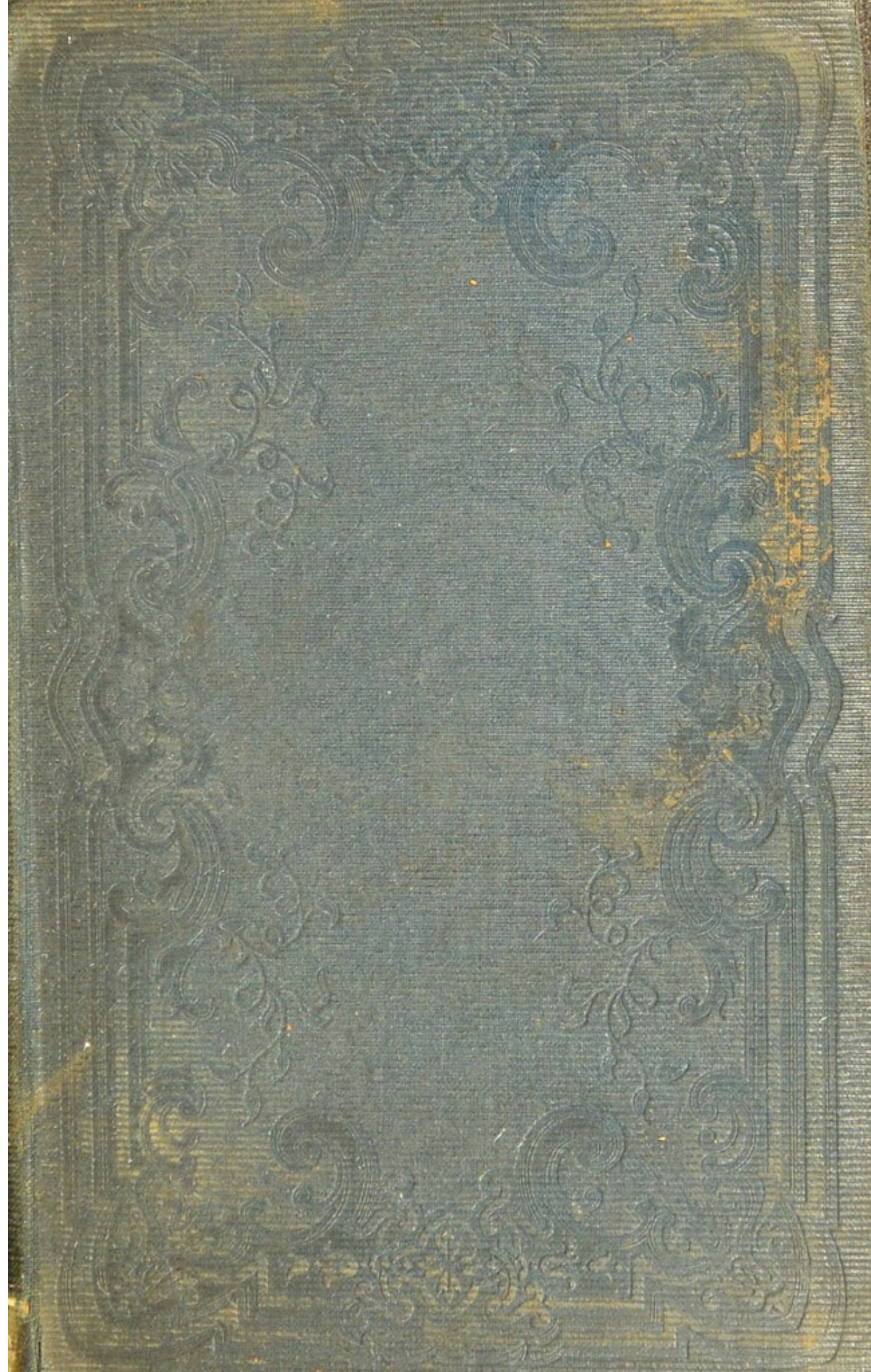
But let me return to our direct subject. We have now collected sufficient indications to entitle us to adventure some generalization regarding the seat of the force whose results we have been examining; but it may be well in the first instance to cast a rapid glance at other craters than Tycho. And I would as another instance of this description of formation claim your attention for one moment to the crater Copernicus. This is one of the most beautiful craters on the Moon's surface. It is best seen at the full of the Moon. It seems as if studded with pearls—a most beautiful object lying in the midst of a beautiful pearly light. When this light is analyzed we find that it, too, consists of a multitude of bands shining like those around Tycho; but, unlike those first bands, they wind along through the valleys of the undulating countries, and seem more like our superficial streams of lava. This, however, is the most remarkable circumstance about Copernicus. Notwithstanding the violent effort necessary to produce it, the plain in its immediate neighborhood has been scarcely at all disturbed. This very memorable feature we remarked as connected with the isolated peak, and it is eminently characteristic of the whole class of minor craters. From this truth of vast importance may be immediately inferred, viz: that the seat of the convulsion causing these craters cannot have been located deeply within the Moon's mass. A profound force, capable of producing such a crater, must, at the same time, have shattered a considerable portion of the Moon's surface. No theory, then, at all related to the prevailing conceptions of a *central force* can be applicable here. The aspects of the Moon are in this respect wholly contradictory of the idea of a central force; nay, a Geology formed upon the ground of the appearances in the Moon would not contain any notion of a central force. It seems to me, then, not unlikely that that department of existing Geolo-

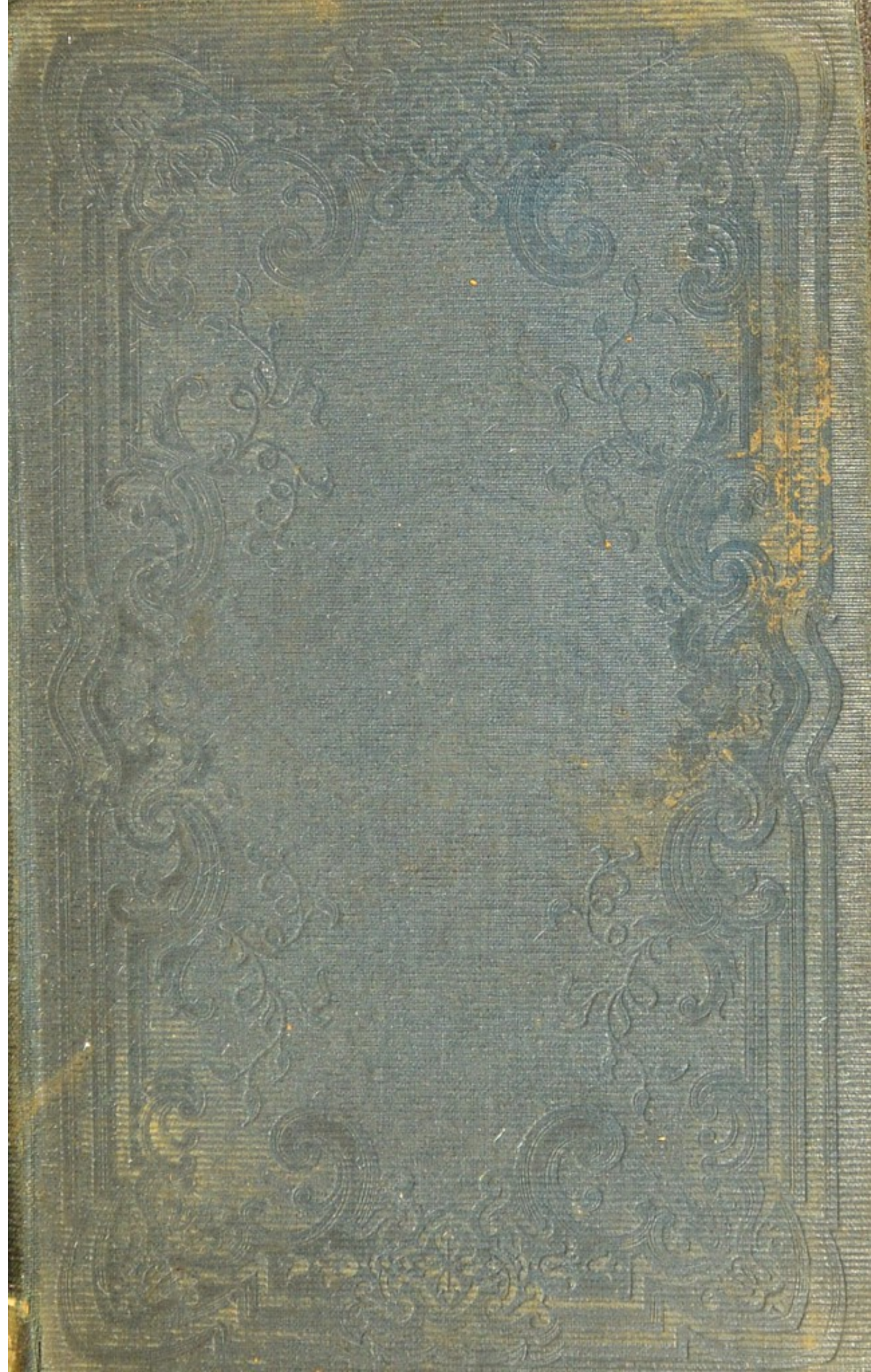
gical theory which is founded on the supposed action of central forces, or on supposed relationships between the crust of the planets and their so-called molten interiors, will ultimately undergo great modification.

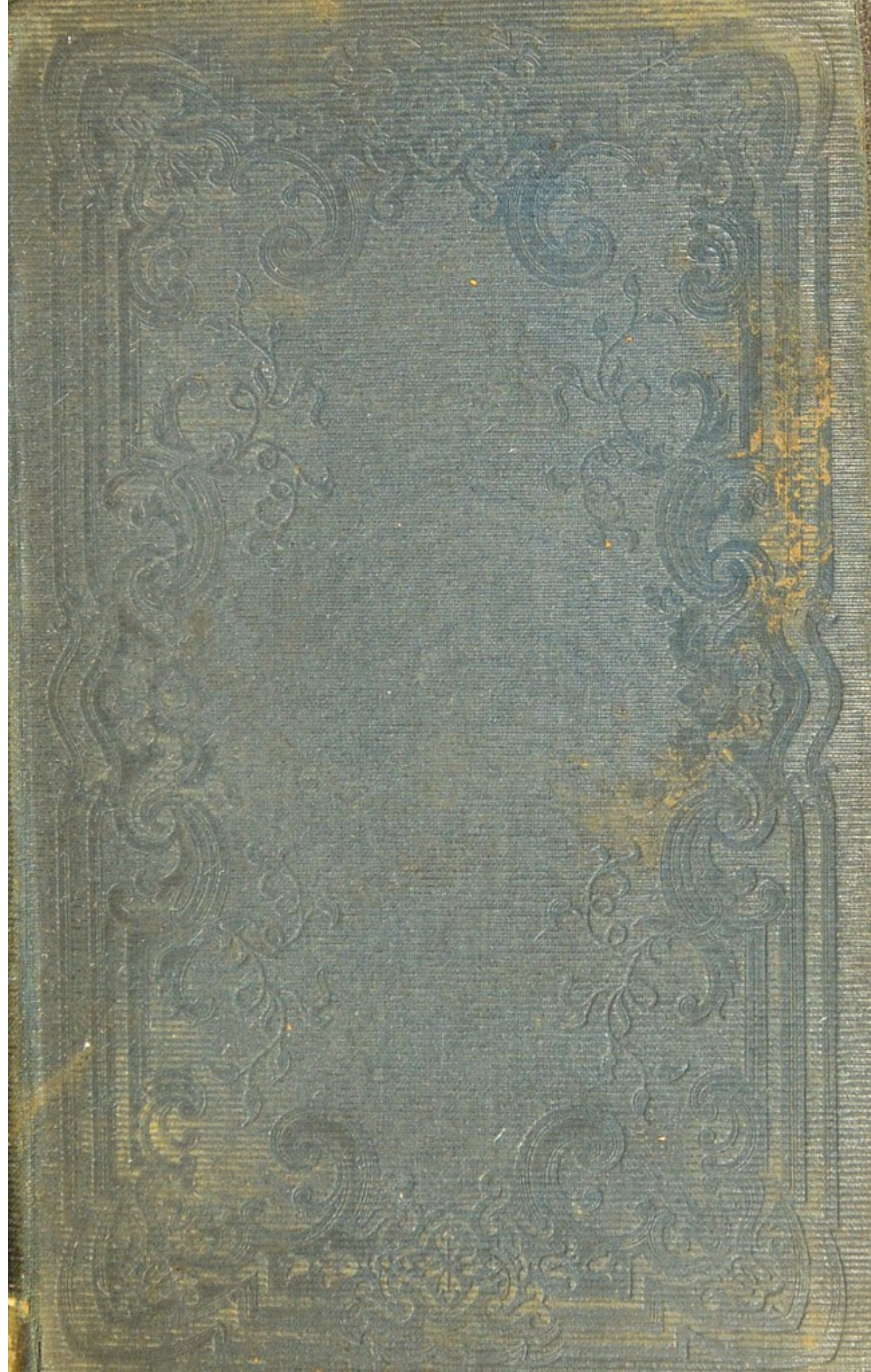
Another fact of great moment seems to be rendered probable by the Moon, namely, that in the course of time the upheaving energy has been becoming less convulsive, or that an epoch of comparative stability has been approaching that body. [The Lecturer showed, here, by aid of diagrams, how the relative ages of the different craters might be approximately ascertained. It seems that Tycho is the oldest formation, and that as the ages proceed, the craters appear to have originated in less and less violent actions. This great fact also seems established in the Earth.] He then continued:

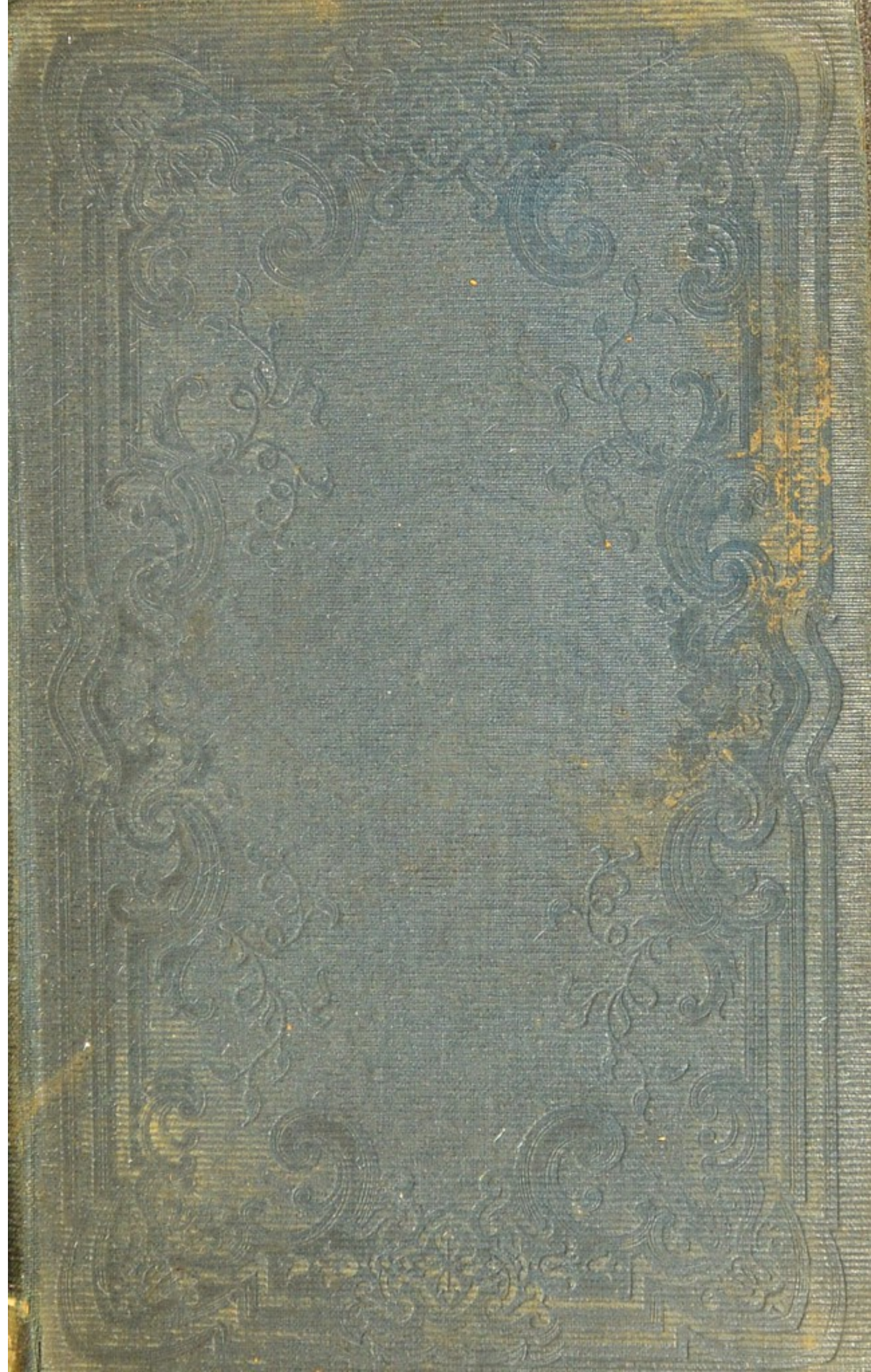
Connected with this curious subject there is a more general contemplation, on which notice should in conclusion be bestowed. What is termed the argument or consideration of *Final Causes*; that is an attempt to view any portion of the known Creation as an indication of the original purpose of the Divinity has ever seemed to me one which the human faculties cannot now undertake; for I cannot persuade myself that all the fitnesses that we see, multiplex as they are, go to constitute the entire of that scheme which the Almighty, from the innate necessities of his own perfections, determined from the beginning. It is thus, as I think, that every scheme observed by man has within it much of mystery, or, what is the same thing, points not accounted for, just because these touch on remoter forms of being and mightier plans. But though it is denied us to speak dogmatically in regard of anything that we can see of the ultimate or primary purposes of God; in no part of creation, great or small, when understood aright is want of harmony descried, or that adaptation which tells of the exquisiteness of the work of an Omniscient and Omnipotent Creator. In reference to the scenes over which to-night we have traveled, we have found the long existence of eras of unsettlement and commotion, and a promise of a period of repose. Sympathizing with inorganic Nature, and toiling along with her, the vital energies have accordingly all along accommodated their products to these vast transitions. Passing by the primal ages, it seems clear that only when Nature's actions became so ordered that in the main they could foresee by ordinary prudence, was the Earth a fitting habitation for a being gifted with pure reason and will, and thereby cut loose from the safeguard of pure instinct.

I think the audience will understand this idea.—We can imagine creatures of instinct fitted to live in any state in the world. We know that the instincts of animals forewarn them of dangers which man with all his boasted reason cannot foresee. These beings of instinct can in many cases foresee some of the great calamities of Nature, such as earthquakes, volcanic eruptions, etc. The beings of reason could not understand the approach of these dangers. A world may be adapted to the abode of beings under the control of instinct which would not be at all adapted to the abode of those compelled to trust for safety to their reason alone. We know that there are some portions of the Earth unfitted at the present time for the habitation of Man—regions where the erections of civilization for years are overthrown in an hour; consequently, in those portions of the Earth the inhabitants are, for the most part, semi-barbarous. This may account for the comparatively recent appearance of Man in the world. Long before his appearance, we find the Globe teeming with races of beings, but all of them of an









could not be, unless the Moon were sending out light herself.

From all these circumstances, there seems no tenable conclusion save this; that the matter both of Sun and planets is capable in certain circumstances, whose exact conditions are not known, of evolving the energy we term Light; and that the atmosphere of the Sun is at present under influences favorable to the high manifestations of a power which from the other orbs has not wholly departed. And thus forever is broken down that supposed distinction, which seemed to place our central luminary apart in space to an immeasurable extent from the humble worlds that roll around him.

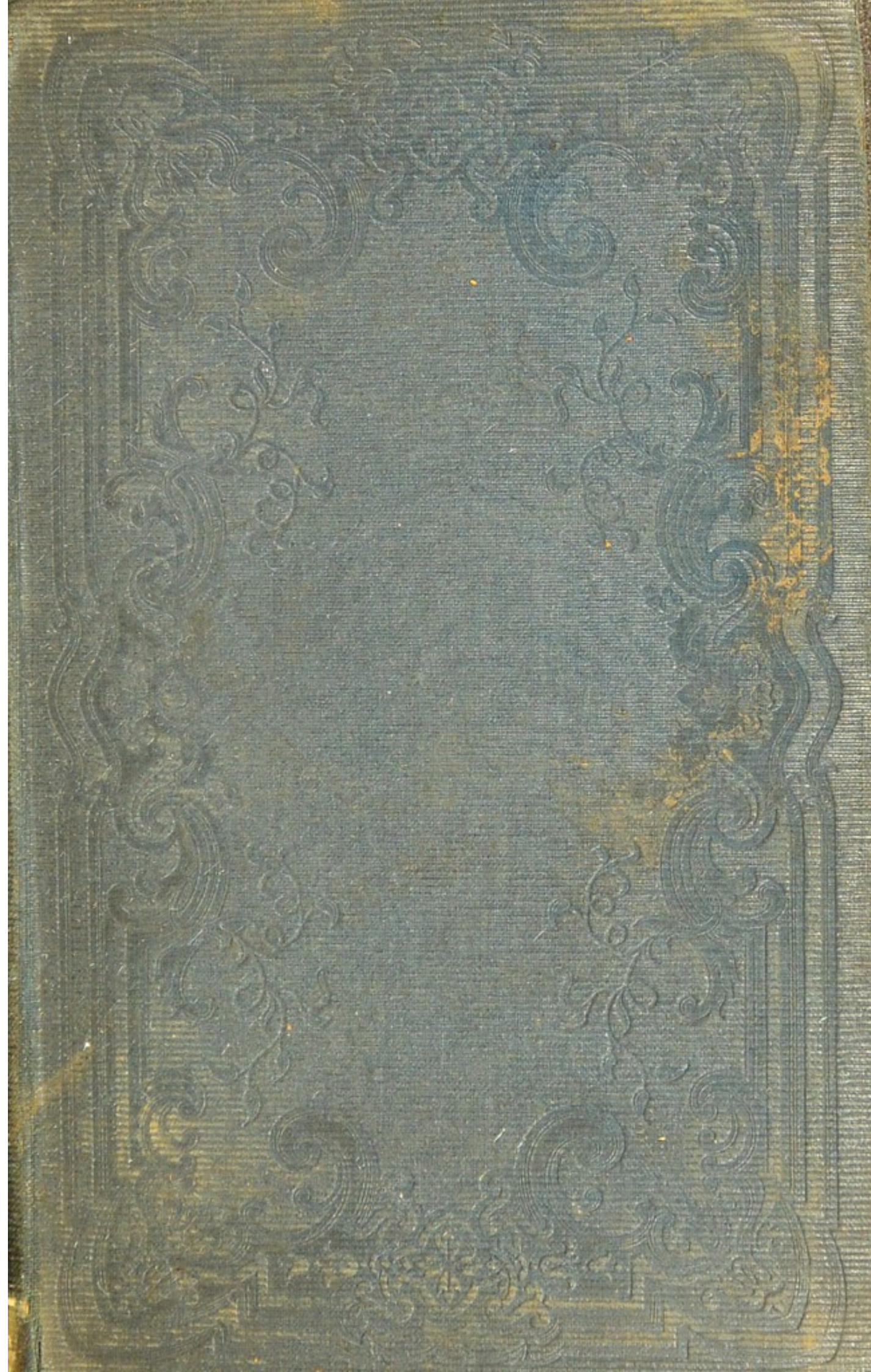
It will naturally be expected, that if our theory be true, if the power to evolve light be subject to change, it may have left its impress on that farthest field of its energy—the wilderness of the Fixed Stars. Now, startling though it at first sight must appear, on all sides, there are here marks of change and of the modifications of light-giving power. The Stars have changed their colors. They have been described by their colors. Poets used to call Sirius the "Red Dog-Star." Now it is the whitest star in the Heavens. The stars have also altered their quantities—they have diminished their magnitude without changing their place. Tycho, a Danish astronomer saw one night in the constellation Cassiopea, a most brilliant star which he had not previously noticed. He watched it for a year. It grew brighter and brighter until it became as light as Venus. After a year, it began to wane, and continued waning and waning, exhibiting the appearance of a dying conflagration. This is but a rapid instance of that change which is constantly going on among the stars.

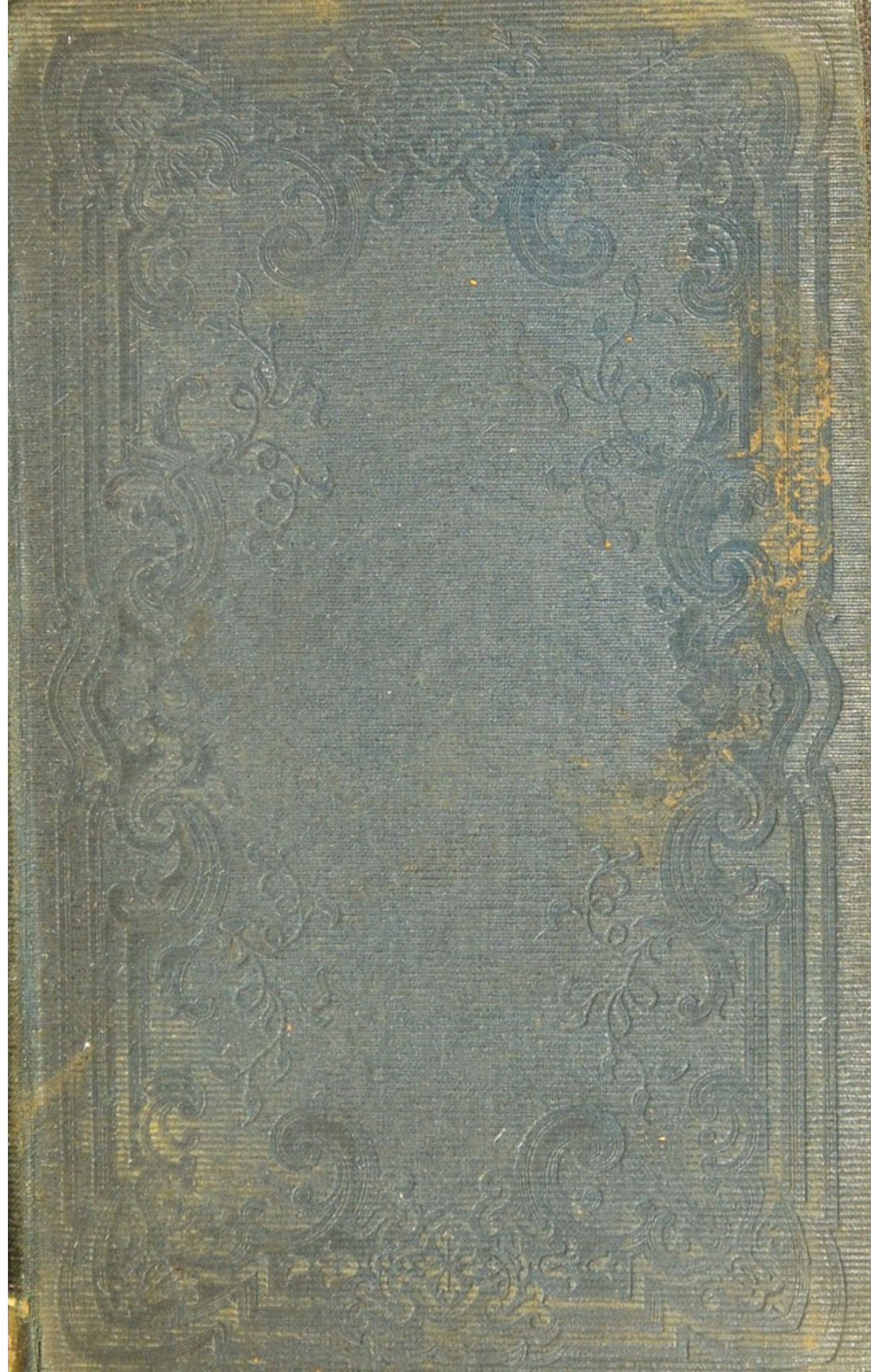
Sir John Herschel, at the Cape of Good Hope, witnessed a similar phenomenon. He saw, on looking at the Star η Argus, it was brighter than laid down in the catalogues. It was originally a star between the second and third magnitudes. It went on increasing till it became not only a star of the first magnitude, but the third star in brightness in the whole skies, after which it began to wane. Herschel's theory was, that there are what might be called cosmical clouds floating about in space—that these clouds intervene between us and the stars, thus darkening them. This theory, however, is not generally received. Why, it is asked, do not these clouds dim other stars? Especially, with respect to this Star of Tycho, how could a cloud have rested before it, from the be-

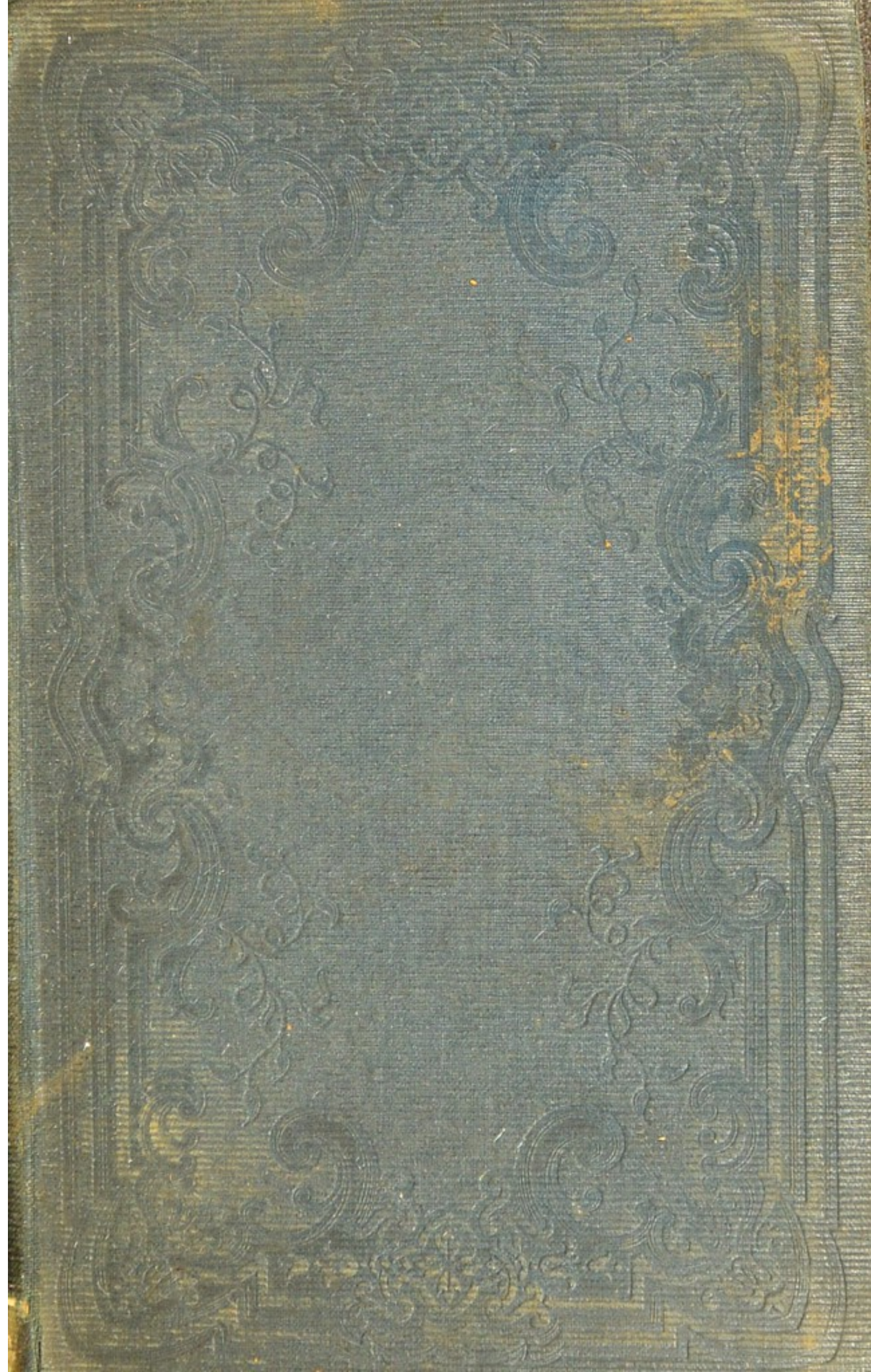
ginning of time, and just went away for a year and then returned again? I think we are bound to reject this explanation.

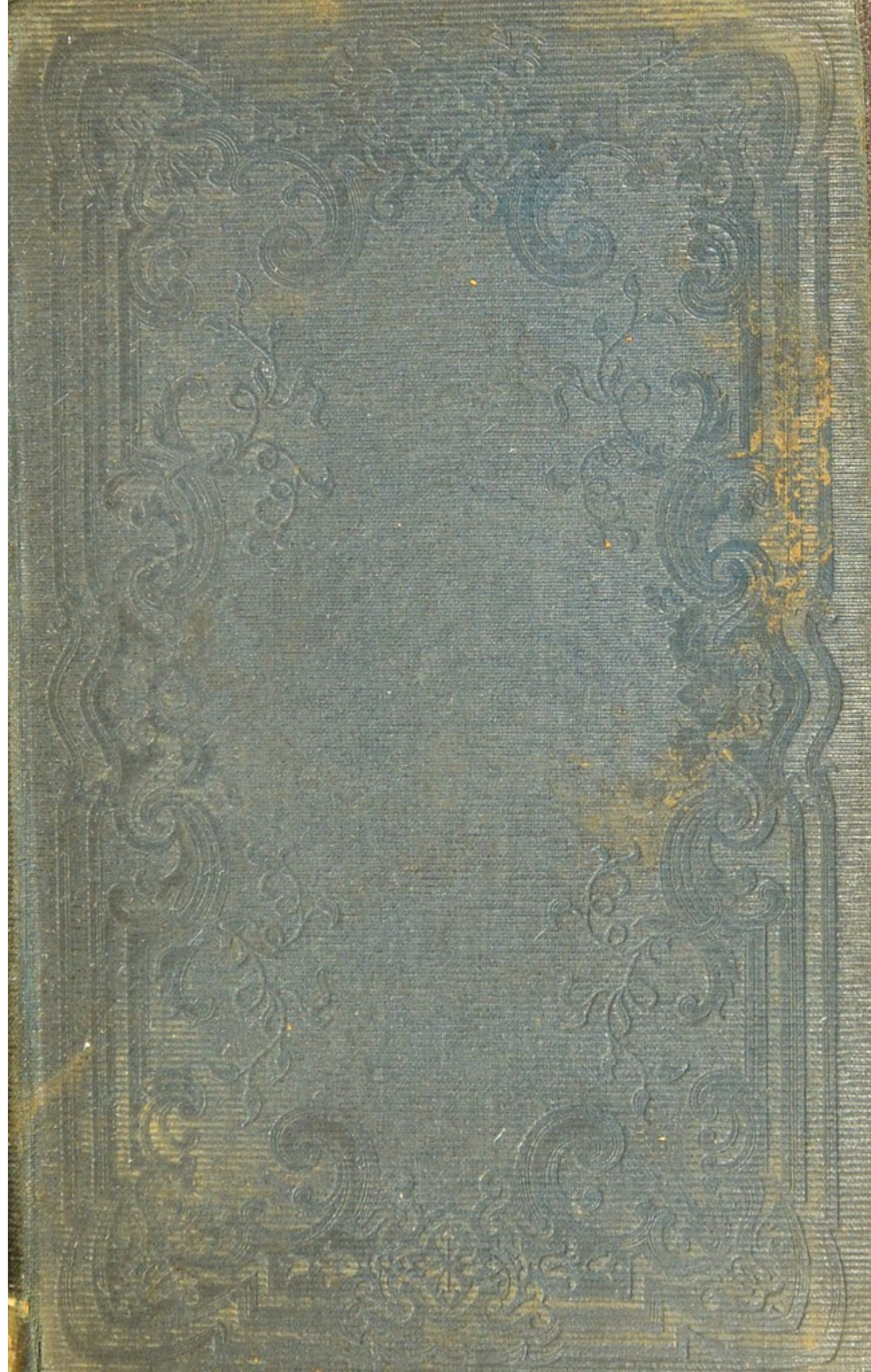
Deeper, far deeper among Nature's potencies must be the origin of these astonishing displays.—Doubtless they result from varied comminglings of the energies that produce light, and which, as we have seen, act far and near. And here as Time rolls on, these, like others, are ever weaving a devious web, their product, Light, must, as ages course, sparkle variously in every portion of their vast domain. And thus one other fanciful tradition disappears! No more is Light inherent in the Sun than in Tycho's vanished Star; and as with it and other orbs, a time may come when through the concert of all the powers of Nature, he may cease to be required to shine. And if even now he is only in one stage of this majestic mutation—if, as the Planets have rolled on and worked out their fates under his beams, he, the Vivifier, has been changing and yet must farther change—once more are we in presence of revolutions that seem illimitable—of progressions whose vista reaches to the very infinite—and we are but as points amid accumulating, superimposed immensities—flashes from the wheel of the Burning Car—creatures we know not what!

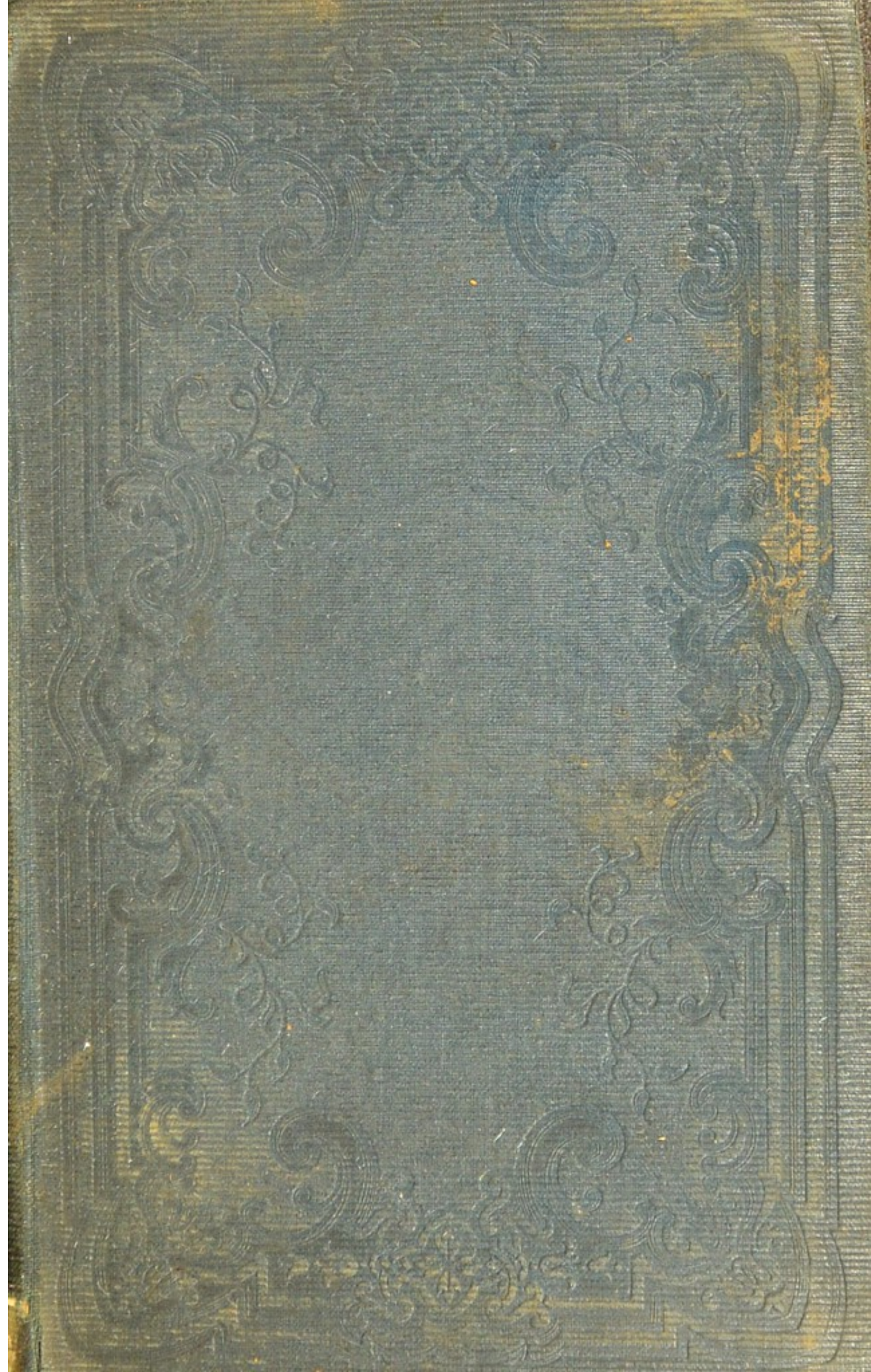
Oh what a world is this! Change rising above change, cycle growing out of cycle in majestic progression, each new one ever widening—like the circles that wreath from a spark of flame, elongating as they ascend, finally to become lost in the empyrean! And if all that we see—if from Earth to Sun and from Sun to the Universal Star work—that wherein we the best behold images of Eternity, Immortality and God—if that is only a state or phase of a course of Being rolling onward evermore—what must be the Creator, the Preserver, the Guide of all. He at whose bidding these phantasms come from nothingness and again disappear, whose Name—amid all things—alone is EXISTENCE—I AM IN THAT I AM! The All-Encompasser: the All-Sustainer! He enwraps, He upholds all those gorgeous Heavens! Yea, unassisted, uncounseled, sustains he not unchanged and unchangeably forevermore, even the fabric of His own Awful Being! Reverentially before him—humbly grateful that in the course of this beneficent arrangement He has permitted such intimations of his glory to reach us—let us conclude in the rapt language of the Psalmist: How manifold, oh God, are thy works, by wisdom Thou hast made them all!

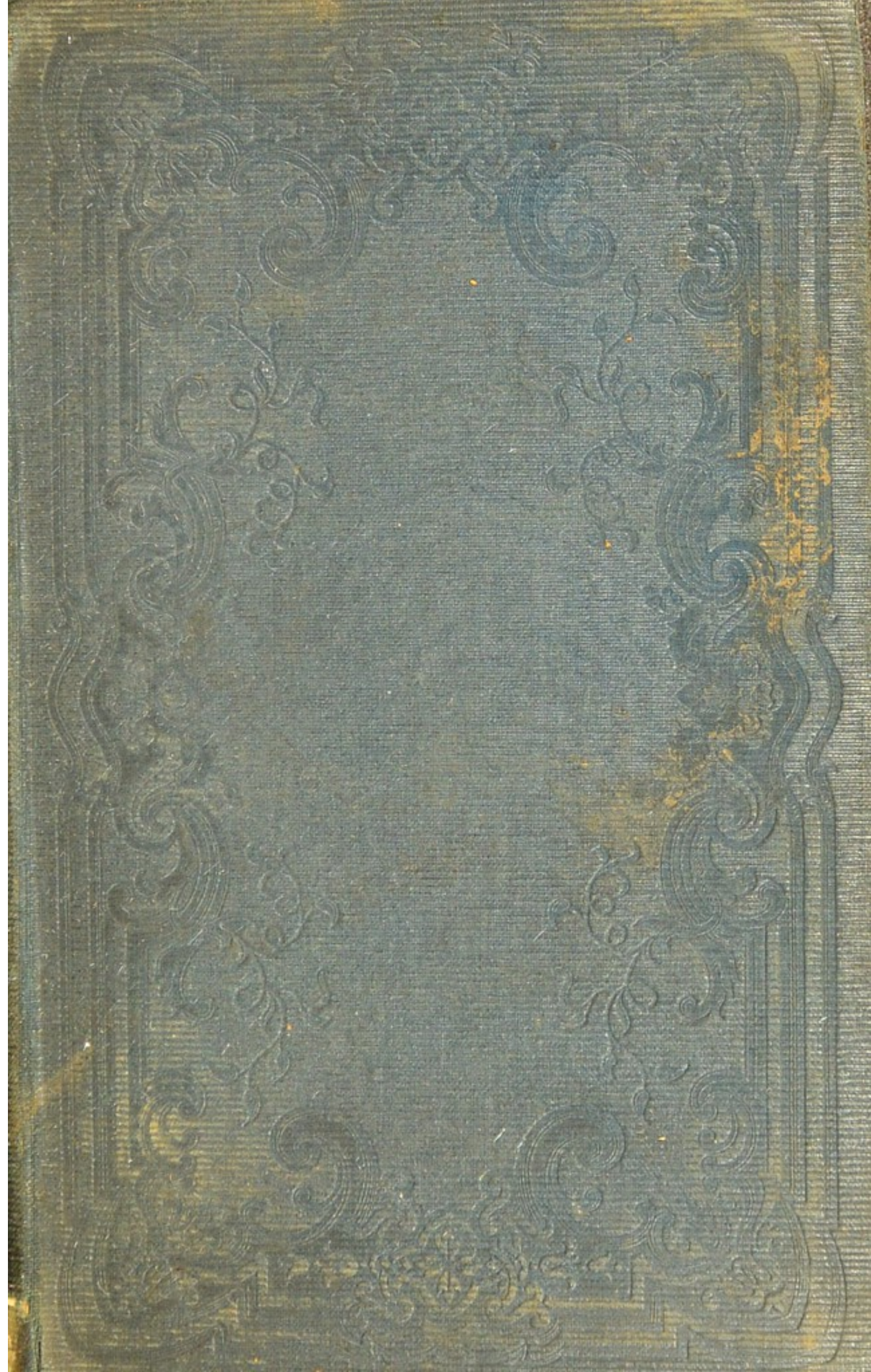












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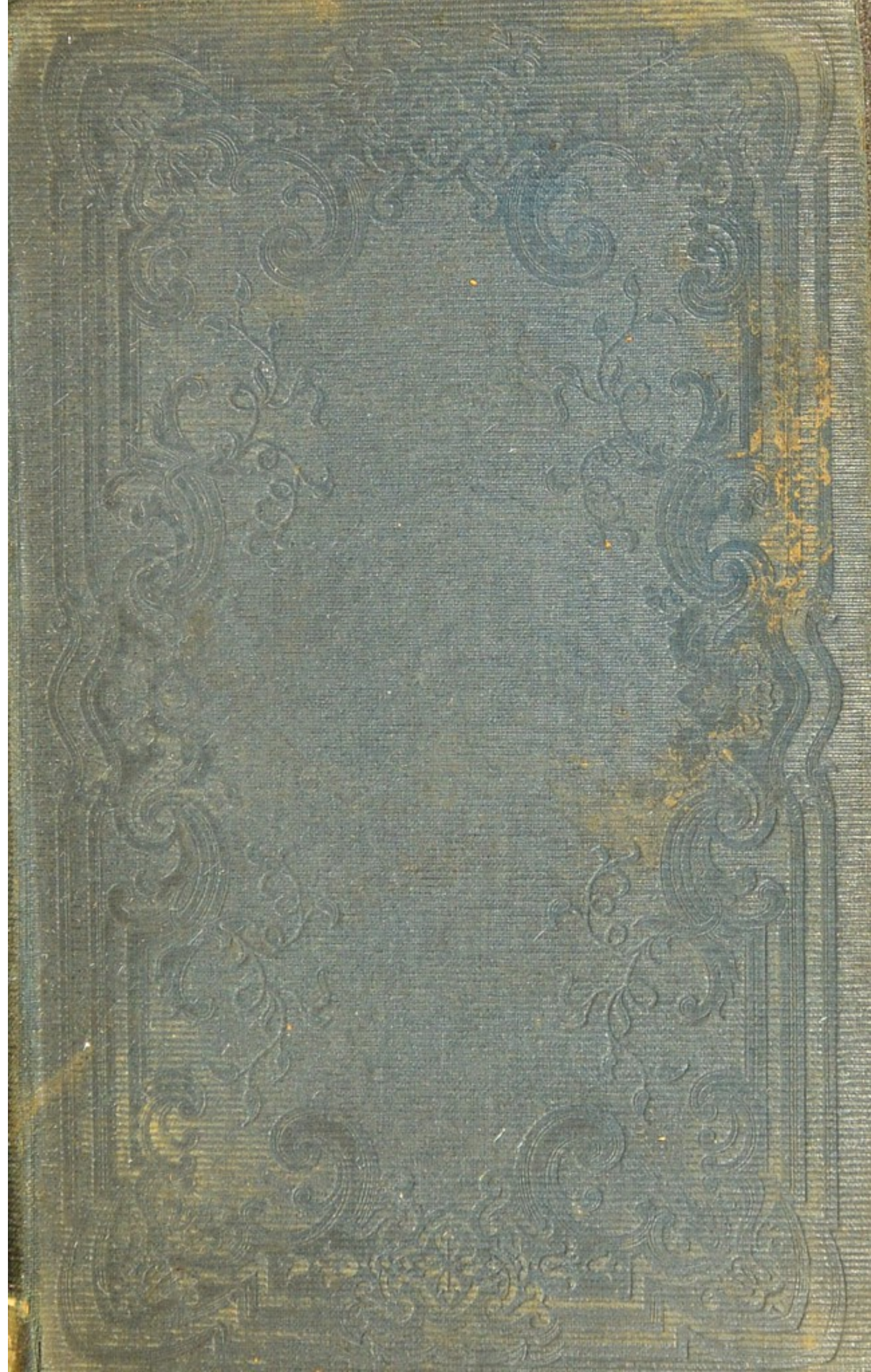
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