

Gilbert of Colchester, father of electrical science : a reprint of the chapter on electrics from De magnete, lib. 2 / with notes by Silvanus P. Thompson.

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GILBERT TERCENTENARY CELEBRATION

DECEMBER 10TH, 1903



GILBERT OF COLCHESTER

FATHER OF ELECTRICAL SCIENCE

Born May 24th, 1544

Died Dec. 10th, 1603

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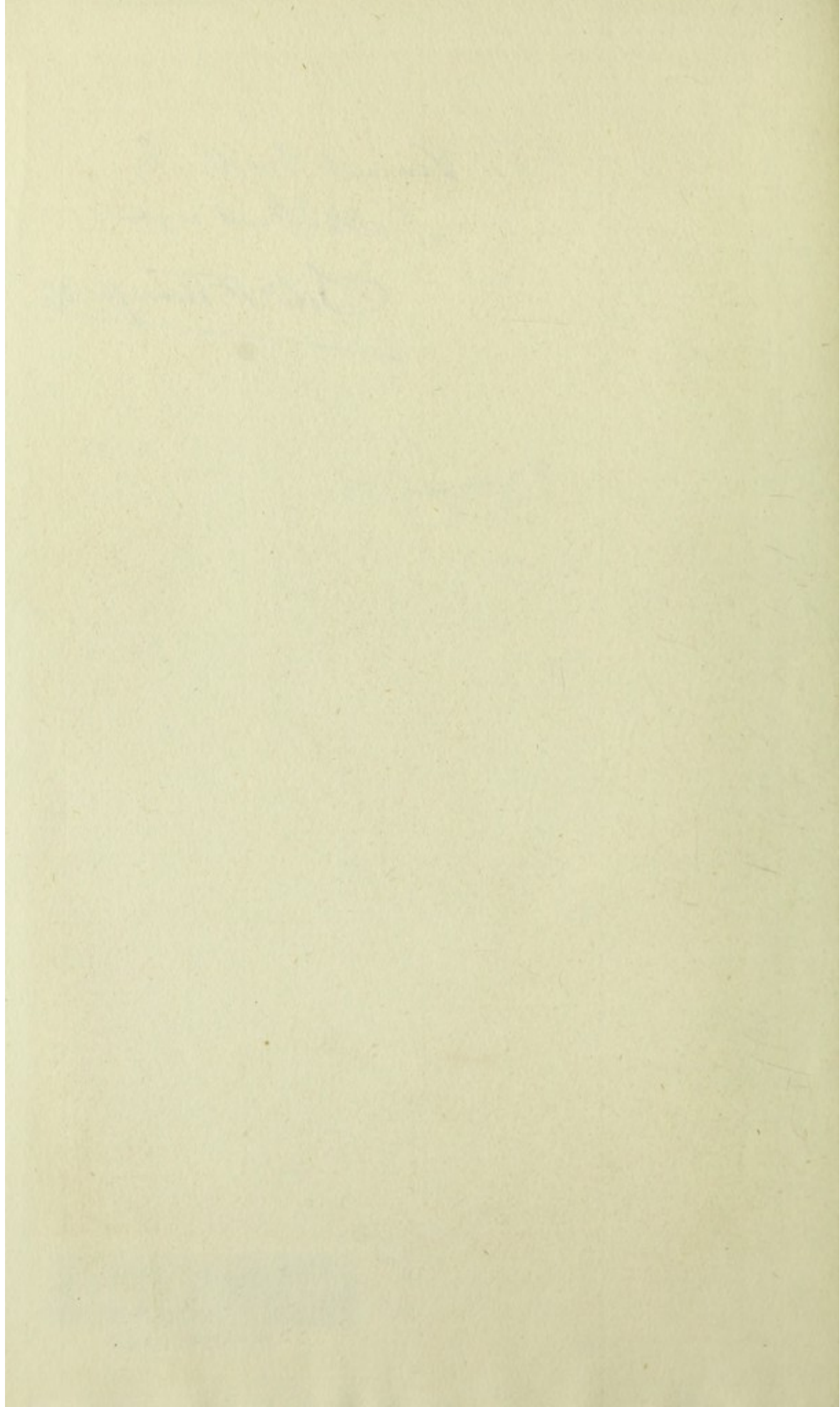


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T. Vincent Smith Esq.
with kind regards

Geo. P. Thompson

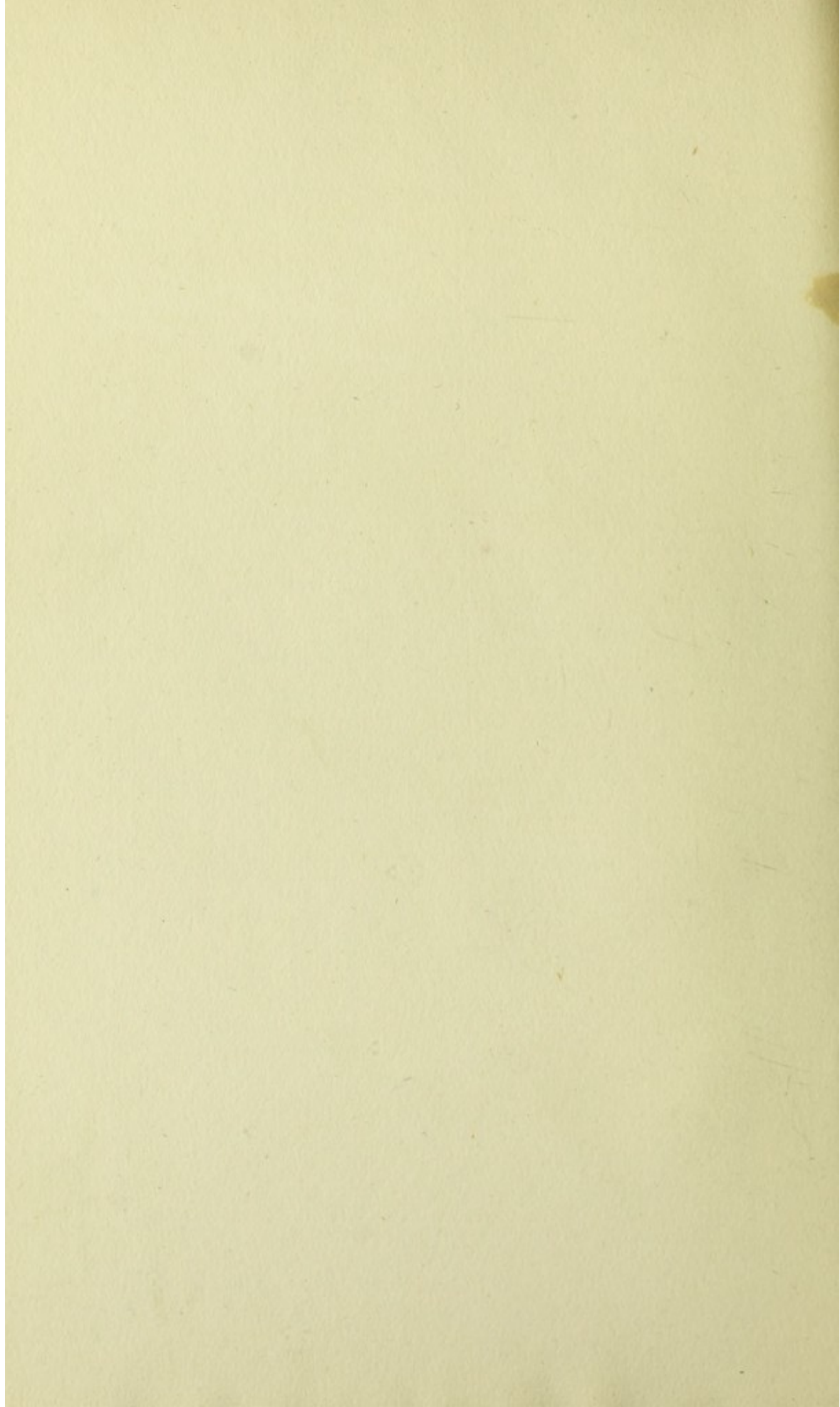
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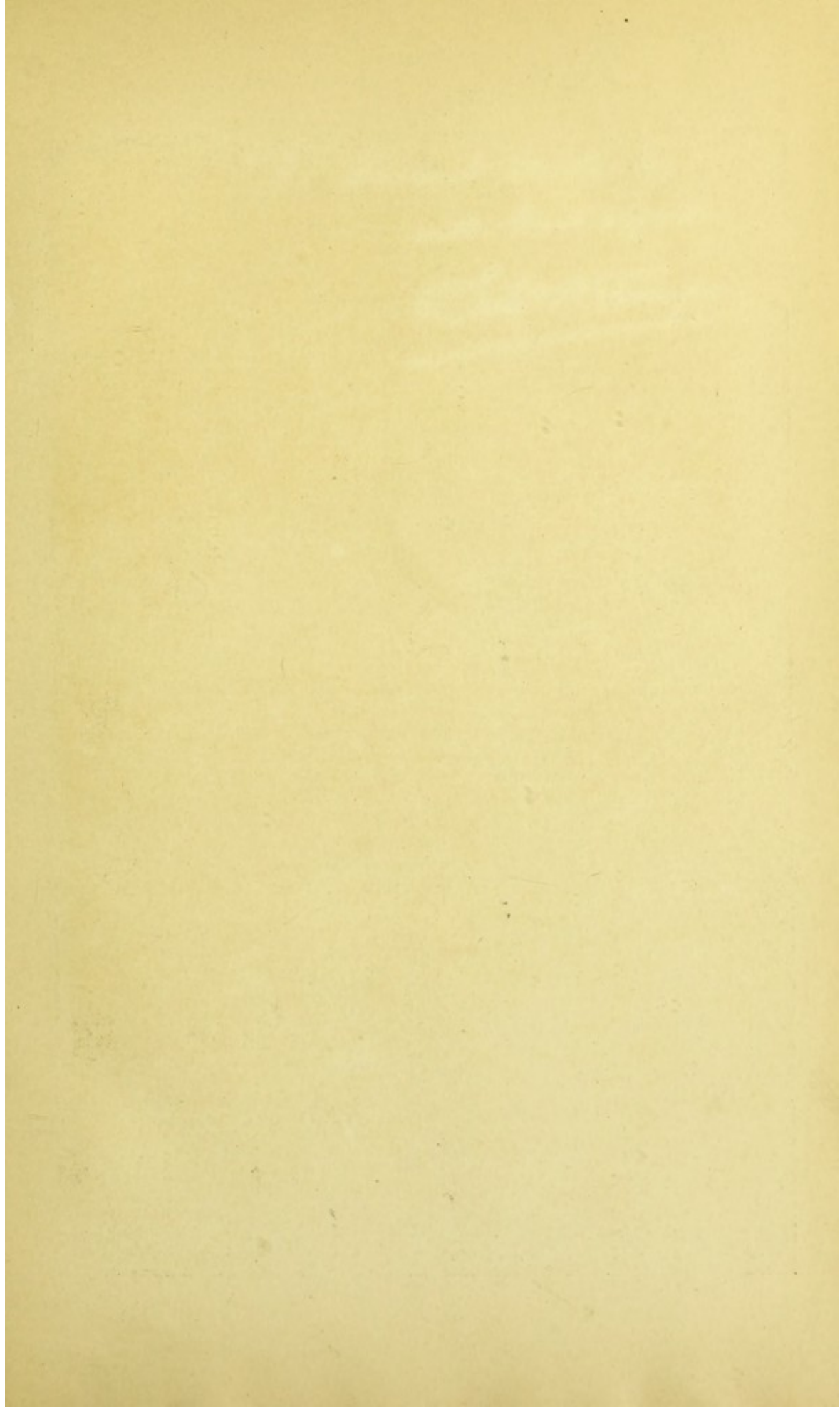




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A. Ackland Hunt, pinxit.

GILBERT SHEWING HIS EXPERIMENTS ON ELECTRICITY TO QUEEN ELIZABETH AND HER COURT.

Gilbert Tercentenary Commemoration, December 10, 1903

Gilbert of Colchester

FATHER OF ELECTRICAL SCIENCE

A REPRINT OF THE CHAPTER ON ELECTRICS FROM
DE MAGNETE, LIB. 2

WITH NOTES BY

SILVANUS P. THOMPSON, F.R.S.

LONDON

PRINTED AT THE CHISWICK PRESS

1903

AFO, AAS (2)

Gilbert shall live till loadstones cease to draw,
Or British fleets the boundless Ocean awe.

DRYDEN.

21440



GILBERT OF COLCHESTER

Father of Electrical Science.



BY the publication in 1600 of the *De Magnete* of Dr. William Gilbert the science of electricity was founded. Today, December 10th, 1903, is the three-hundredth anniversary of his death.

Born in Colchester on May 24th, 1544, William Gilbert was educated at Colchester School, and at St. John's College, Cambridge, where he became mathematical examiner and senior bursar. He graduated M.D. in 1569, and after three years of travel and study in Italy and elsewhere, settled down in London as a physician in 1573. He rose rapidly to eminence in his profession, and for twenty years took an active part in the administration of the Royal College of Physicians, of which in 1599 he became President. He was also in favour at Court, and was appointed in February, 1600-1, Physician to Queen Elizabeth, who conferred upon him various marks of distinction; and after her death he was continued as Chief Physician by James I. He died during a visitation of the plague, December 10th, 1603, and was buried in the Church of Holy Trinity, Colchester, where there is a monumental tablet to his memory.

Gilbert's renown rests not on his eminence as a physician, but on his achievements in the foundation of the twin sciences of electricity and magnetism. He is beyond question rightfully regarded as the Father of Electric Science. He founded the entire subject of

Terrestrial Magnetism. He also made notable contributions to Astronomy, being the earliest English expounder of Copernicus. In an age given over to metaphysical obscurities and dogmatic sophistry, he cultivated the method of experiment and of reasoning from observation, with an insight and success which entitles him to be regarded as the father of the inductive method. That method, so often accredited to Bacon, Gilbert was practising years before him.

It seems therefore fitting upon the occurrence of the Tercentenary of his death to recall Gilbert's achievements as the Father of Electric Science.

GILBERT'S MAGNETIC DISCOVERIES.



GILBERT'S magnetic work has been so often described that a brief summary will here suffice. Trying the properties of loadstones in innumerable experiments lasting over many years, he was led to several notable discoveries, and to one generalization of immense importance. He discovered the augmentation of the power of a loadstone by arming or capping it with soft iron cheeks. Gilbert called such a cap an *armatura*, the first occurrence of the term. This invention brought him much fame. In the *Dialogues of Galileo* (p. 369 of Salusbury's *Mathematical Collections*, Dialogue iii.), Sagredus and Salviatus discuss the arming of the loadstone, and the increased lifting power conferred by adding an iron cap. Salviatus mentions a loadstone in the Florentine Academy which, unarmed, weighed six ounces, lifting only two ounces, but which when armed took up 160 ounces. Whereupon Galileo makes Salviatus say: "I extremely praise, admire, and envy this Authour, for that a conceit so stupendious should come into his minde. . . . I think him [*i.e.*, Gilbert] moreover worthy of extraordinary applause for the many new and true Observations that he made, to the disgrace of so many fabulous Authours, that write not only what they do not know, but whatever they hear spoken by the foolish vulgar, never seeking to assure themselves of the same

by experience, perhaps, because they are unwilling to diminish the bulk of their Books."

Gilbert also discovered the screening effect of a sheet of iron; the method of magnetizing iron by hammering it while it lies North and South; the destruction of magnetism by heat; and the existence around the magnet of an "orbe of virtue," that is to say, a magnetic field. He perfected the dipping-needle of Norman, and other instruments of observation. He collected data as to the declination and inclination of the compass in different regions. Using loadstones of many different shapes he observed their actions on one another and on compass-needles. In particular he studied the magnetic properties of a globular loadstone or *terrella*, and found that compass-needles were directed toward its poles, and dipped at various angles over its surface, just as compass-needles do at various regions of the earth's surface.

Generalizing from small to large he advanced the entirely novel idea that the globe of the earth is itself a great magnet; thus laying the foundations of the science of terrestrial magnetism. He was particularly keen in disproving the many absurd fables that had grown up about the magnet, such as that the magnet refuses to act in the presence of a diamond, or if touched with garlic. The former he tested by surrounding a loadstone with seventy diamonds. Gilbert denounced the quackery of using loadstone medicinally or in plasters for the cure of wounds. He ridiculed the idea that the variation of the compass was due to imaginary loadstone-mountains like those described in the Arabian Nights. He sought to explain it by the local irregularities of the earth's crust, and exemplified his theory by experiments on round loadstones of irregular outline as models. His book, over which he spent eighteen years, was published in 1600, and for the next hundred years became the standard work on magnetism. Though denounced by the Church, the theory of terrestrial magnetism was by Gilbert thus firmly established on an enduring basis of fact, and remained a permanent acquisition in science. The publication of the book marked an epoch in scientific development. It was praised by Sarpi, by Galileo, by Kepler. Sir Christopher Wren proposed to erect a statue to its author, while Dryden sang of his enduring fame.

THE ELECTRICAL KNOWLEDGE OF THE ANCIENTS.



RIOR to Gilbert's time the only electrical phenomenon known generally was the simple fact that the minerals amber and jet, when rubbed, will attract light bodies. This property of amber was indeed known to the ancients, and is mentioned by Theophrastus. The following quotations from early writers include practically all that was known.

"Hee [*Niceas*] writeth also, that in Aegypt it [amber] is engendered . . . Semblably in Syria, the women (saith hee) make wherves of it for their spindles, where they use to call it Harpax, because it will catch up leaves, straws, and fringes hanging to cloaths. . . . To come to the properties that Amber hath, If it bee well rubbed and chaufed betwene the fingers, the potentiall facultie that lieth within, is set on work, and brought into actual operation, whereby you shall see it to drawe chaffe strawes, drie leaves, yea, and thin rinds of the Linden or Tillet tree, after the same sort as loadstone draweth yron" (Pliny, *Natural History*, book xxxvii., chap. ii., p. 606 of the English version of 1601).

"Moreover to the intent to passe the large abundance of sundry mettals (whereof Britaine hath many rich mynes on all sides), Here is store of the stone called Geate, and y^e best kind of it. If ye demaund y^e beautie of it, it is a black Jewell: if the qualitie, it is of no weight: if the nature, it burneth in water, and goeth out in Oyle; if the power, rubbe it till it be warme, and it holdeth such things as are laide to it; as Amber doth. The Realme is partlie inhabited of barbarous people, who even frõ theyr childhoode haue shapes of divers beastes cunninglye impressed and incorporate in theyr bodyes, so that beeing engraued as it were in theyr bowels, as the man groweth, so growe the marks painted vpon him" (Julius Solinus, *The Secretes and Providence of Nature*, chap. xxiv., *Of Britaine*; English version by A. Golding, 1587).

GILBERT'S CHAPTER ON ELECTRICS.

The contribution made by Gilbert to electrical knowledge is contained in the second chapter of the second book of his *De Magnete*, and constitutes a digression interpolated into the discussion of magnetic motions. Later portions of the same book make slight references also to the subject: but all that is essential in Gilbert's work is in this single chapter, here reprinted from the English Edition of 1900, the version prepared by the Gilbert Club.

BOOK II., CHAPTER II.

On the Attraction of Amber, or more truly, on the
Attaching of Bodies to Amber.

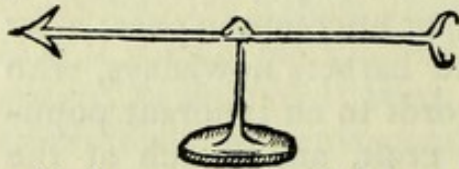


CELEBRATED has the fame of the loadstone and of amber ever been in the memoirs of the learned. Loadstone and also amber do some philosophers invoke when in explaining many secrets their senses become dim and reasoning cannot go further. Inquisitive theologians also would throw light on the divine mysteries set beyond the range of human sense, by means of loadstone and amber; just as idle Metaphysicians, when they are setting up and teaching useless phantasms, have recourse to the loadstone as if it were a Delphick sword, an illustration always applicable to everything. But physicians even (with the authority of Galen), desiring to confirm the belief in the attraction of purgative medicines by means of the likeness of substance and the familiarities of the juices—truly a vain and useless error—bring in the loadstone as witness as being a nature of great authority and of conspicuous efficacy and a remarkable body. So in very many cases there are some who, when they are pleading a cause and cannot give a reason for it, bring in loadstone and amber as though they were personified witnesses. But these men (apart from that common error) being ignorant that the causes of magnetical motions are widely different from the forces of amber, easily fall into error, and are themselves the more deceived by their own cogitations. For in other bodies a conspicuous force of attraction manifests itself otherwise than in loadstone; like as in amber, concerning which some things must first be said, as to what is that attaching of bodies to it, and how different from and foreign to the magnetical actions; those mortals being still ignorant, who think

that inclination to be an attraction, and compare it with the magnetick coitions. The Greeks call it ἤλεκτρον, because it attracts straws to itself, when it is warmed by rubbing; then it is called ἄρπαξ; and χρυσοφόρον, from its golden colour. But the Moors call it Carabe, because they are accustomed to offer the same in sacrifices and in the worship of the Gods. For Carab signifies to offer in Arabic; so Carabe, an offering: or seizing chaff, as Scaliger quotes from Abohalis, out of the Arabic or Persian language. Some also call it Amber, especially the Indian and Ethiopian amber, called in Latin *Succinum*, as if it were a juice. The Sudavienses or Sudini call it *geniter*, as though it were generated terrestrially. The errors of the ancients concerning its nature and origin having been exploded, it is certain that amber comes for the most part from the sea, and the rustics collect it on the coast after the more violent storms, with nets and other tackle; as among the Sudini of Prussia; and it is also found sometimes on the coast of our own Britain. It seems, however, to be produced also in the soil and at spots of some depth, like other bitumens; to be washed out by the waves of the sea; and to become concreted more firmly from the nature and saltness of the sea-water. For it was at first a soft and viscous material; wherefore also it contains enclosed and entombed in pieces of it, shining in eternal sepulchres, flies, grubs, gnats, ants; which have all flown or crept or fallen into it when it first flowed forth in a liquid state. The ancients and also more recent writers recall (experience proving the same thing), that amber attracts straws and chaff. The same is also done by jet, which is dug out of the earth in Britain, in Germany, and in very many lands, and is a rather hard concretion from black bitumen, and as it were a transformation into stone. There are many modern authors who have written and copied from others about amber and jet attracting chaff, and about other substances generally unknown; with whose labours the shops of booksellers are crammed. Our own age has produced many books about hidden, abstruse, and occult causes and wonders, in all of which amber and jet are set forth

as enticing chaff; but they treat the subject in words alone, without finding any reasons or proofs from experiments, their very statements obscuring the thing in a greater fog, forsooth in a cryptic, marvellous, abstruse, secret, occult, way. Wherefore also such philosophy produces no fruit, because very many philosophers, making no investigation themselves, unsupported by any practical experience, idle and inert, make no progress by their records, and do not see what light they can bring to their theories; but their philosophy rests simply on the use of certain Greek words, or uncommon ones; after the manner of our gossips and barbers nowadays, who make show of certain Latin words to an ignorant populace as the insignia of their craft, and snatch at the popular favour. For it is not only amber and jet (as they suppose) which entice small bodies; but Diamond, * Sapphire, Carbuncle, Iris gem, Opal, Amethyst, Vincentina, and Bristolla (an English gem or spar), Beryl, and Crystal do the same. Similar powers of attraction are seen also to be possessed by glass (especially when clear and lucid), as also by false gems made of glass or Crystal, by glass of antimony, and by many kinds of spars from the mines, and by Belemnites. Sulphur also attracts, and mastick, and hard sealing-wax compounded of lac tinctured of various colours. Rather hard resin entices, as does orpiment, but less strongly; with difficulty also and indistinctly under a suitable dry sky, Rock salt, muscovy stone, and rock alum. This one may see when the air is sharp and clear and rare in mid-winter, when the emanations from the earth hinder electricks less, and the electrick bodies become more firmly indurated; about which hereafter. These substances draw every- * thing, not straws and chaff only, but all metals, woods, leaves, stones, earths, even water and oil, and everything which is subject to our senses, or is solid; although there are who write that amber does not attract anything but chaff and certain twigs; (wherefore Alexander Aphrodisseus falsely declares the question of amber to be inexplicable, because it attracts dry chaff only, and not basil leaves). But these are the utterly false and disgrace-

ful tales of the writers. But in order that you may be able clearly to test how such attraction occurs, and what those materials are which thus entice other bodies (for even if bodies incline towards some of these, yet on account of weakness they seem not to be raised by them, but are more easily turned), make yourself a versorium of any metal you like, three or four digits in length, resting rather lightly on its point of support after the manner of a magnetick needle, to one end of which bring up a



piece of amber or a smooth and polished gem which has been gently rubbed; for the versorium turns forthwith. Many things are thereby seen to attract, both those

which are formed by nature alone, and those which are by art prepared, fused, and mixed; nor is this so much a singular property of one or two things (as is commonly supposed), but the manifest nature of very many, both of simple substances, remaining merely in their own form, and of compositions, as of hard sealing-wax, and of certain other mixtures besides, made of unctuous stuffs. We must, however, investigate more fully whence that tendency, and what those forces, concerning which a few men have brought forward very little, the crowd of philosophizers nothing at all. By Galen three kinds of attractives in general were recognized in nature: a First class of those substances which attract by their elemental quality, namely, heat; the Second is the class of those which attract by the succession of a vacuum; the Third is the class of those which attract by a property of their whole substance, which are also quoted by Avicenna and others. These classes, however, cannot in any way satisfy us; they neither embrace the causes of amber, jet, and diamond, and of other similar substances (which derive their forces on account of the same virtue); nor of the loadstone, and of all magnetick substances, which obtain their virtue by a very dissimilar and alien influence derived from other sources. Wherefore also it is fitting that we find other causes of the motions, or else we must wander (as in the shades), with these men, and in no way

reach the goal. Amber truly does not allure by heat, *
since if warmed by fire and brought near straws, it does
not attract them, whether it be tepid, or hot, or glowing,
or even when forced into the flame. Cardan (as also
Pictorio) reckons that this happens in no different way
than with the cupping-glass, by the force of fire. Yet
the attracting force of the cupping-glass does not really
come from the force of fire. But he had previously said
that the dry substance wished to imbibe fatty humour,
and therefore it was borne towards it. But these state-
ments are at variance with one another, and also foreign
to reason. For if amber had moved towards its food, or
if other bodies had inclined towards amber as towards
provender, there would have been a diminution of the
one which was devoured, just as there would have been a
growth of the other which was fated. Then why should
an attractive force of fire be looked for in amber? If the
attraction existed from heat, why should not very many
other bodies also attract, if warmed by fire, by the sun,
or by friction? Neither can the attraction be on account
of the dissipating of the air, when it takes place in open
air (yet Lucretius the poet adduces this as the reason for
magnetical motions). Nor in the cupping-glass can heat
or fire attract by feeding on air: in the cupping-glass
air, having been exhausted into flame, when it condenses
again and is forced into a narrow space, makes the skin
and flesh rise in avoiding a vacuum. In the open air
warm things cannot attract, not metals even or stones,
if they should be strongly incandescent by fire. For a *
rod of glowing iron, or a flame, or a candle, or a blazing
torch, or a live coal, when they are brought near to
straws, or to a verforium, do not attract; yet at the same
time they manifestly call in the air in succession; because
they consume it, as lamps do oil. But concerning heat,
how it is reckoned by the crowd of philosophizers, in
natural philosophy and in *materia medica* to exert an
attraction otherwise than nature allows, to which true
attractions are falsely imputed, we will discuss more at
length elsewhere, when we shall determine what are the
properties of heat and cold. They are very general

qualities or kinships of a substance, and yet are not to be assigned as true causes, and, if I may say so, those philosophizers utter some resounding words; but about the thing itself prove nothing in particular. Nor does this attraction accredited to amber arise from any singular quality of the substance or kinship, since by more thorough research we find the same effect in very many other bodies; and all bodies, moreover, of whatever quality, are allured by all those bodies. Similarity also is not the cause; because all things around us placed on this globe of the earth, similar and dissimilar, are allured by amber and bodies of this kind; and on that account no cogent analogy is to be drawn either from similarity or identity of substance. But neither do similars mutually attract one another, as stone stone, flesh flesh, nor aught else outside the class of magneticks and electricks. Fracastorio would have it that “things which mutually attract one another
“are similars, as being of the same species, either in action
“or in right subjection. Right subjection is that from
“which is emitted the emanation which attracts and which
“in mixtures often lies hidden on account of their lack
“of form, by reason of which they are often different in
“act from what they are in potency. Hence it may be
“that hairs and twigs move towards amber and towards
“diamonds, not because they are hairs, but because either
“there is shut up in them air or some other principle,
“which is attracted in the first place, and which bears
“some relation and analogy to that which attracts of itself;
“in which diamond and amber agree through a principle
“common to each.” Thus far Fracastorio. Who if he had observed by a large number of experiments that all bodies are drawn to electricks except those which are aglow and aflame, and highly rarefied, would never have given a thought to such things. It is easy for men of acute intellect, apart from experiments and practice, to slip and err. In greater error do they remain sunk who maintain these same substances to be not similar, but to be substances near akin; and hold that on that account a thing moves towards another, its like, by which it is brought to more perfection. But these are ill-considered views; for

towards all electricks all things move except such as are aflame or are too highly rarefied, as air, which is the universal effluvium of this globe and of the world. Vegetable substances draw moisture by which their shoots are rejoiced and grow; from analogy with that, however, Hippocrates, in his *De Natura Hominis*, Book I., wrongly concluded that the purging of morbid humour took place by the specifick force of the drug. Concerning the action and potency of purgatives we shall speak elsewhere. Wrongly also is attraction inferred in other effects; as in the case of a flagon full of water, when buried in a heap of wheat, although well stoppered, the moisture is drawn out; since this moisture is rather resolved into vapour by the emanation of the fermenting wheat, and the wheat imbibes the freed vapour. Nor do elephant's tusks attract moisture, but drive it into vapour or absorb it. Thus then very many things are said to attract, the reasons for whose energy must be sought from other causes. Amber in a fairly large mass * allures, if it is polished; in a smaller mass or less pure it seems not to attract without friction. But very many electricks (as precious stones and some other substances) do not attract at all unless rubbed. On the other hand many gems, as well as other bodies, are polished, yet do not allure, and by no amount of friction are they aroused; thus the emerald, agate, carnelian, pearls, jasper, chalcidony, alabaster, porphyry, coral, the marbles, touchstone, flint, bloodstone, emery, do not acquire any power; nor do bones, or ivory, or the hardest woods, as ebony, nor do cedar, juniper, or cypress; nor do metals, silver, gold, brass, iron, nor any loadstone, though many of them are finely polished and shine. But on the other hand there are some other polished substances of which we have spoken before, toward which, when they have been rubbed, bodies incline. This we shall understand only when we have more closely looked into the prime origin of bodies. It is plain to all, and all admit, that the mass of the earth, or rather the structure and crust of the earth, consists of a twofold material, namely, of fluid and humid matter, and of material of more con-

fiftency and dry. From this twofold nature or the more simple compacting of one, various substances take their rise among us, which originate in greater proportion now from the earthy, now from the aqueous nature. Those substances which have received their chief growth from moisture, whether aqueous or fatty, or have taken on their form by a simpler compacting from them, or have been compacted from these same materials in long ages, if they have a sufficiently firm hardness, if rubbed after they have been polished and when they remain bright with the friction—towards those substances everything, if presented to them in the air, turns, if its too heavy weight does not prevent it. For amber has been compacted of moisture, and jet also. Lucid gems are made of water; just as Crystal, which has been concreted from clear water, not always by a very great cold, as some used to judge, and by very hard frost, but sometimes by a less severe one, the nature of the soil fashioning it, the humour or juices being shut up in definite cavities, in the way in which spars are produced in mines. So clear glass is fused out of sand, and from other substances, which have their origin in humid juices. But the dross of metals, as also metals, stones, * rocks, woods, contain earth rather, or are mixed with a good deal of earth; and therefore they do not attract. Crystal, mica, glass, and all electricks do not attract if they are burnt or roasted; for their primordial supplies of moisture perish by heat, and are changed and exhaled. All things therefore which have sprung from a predominant moisture and are firmly concreted, and retain the appearance of spar and its resplendent nature in a firm and compact body, allure all bodies, whether humid or dry. Those, however, which partake of the true earth-substance or are very little different from it, are seen to attract also, but from a far different reason, and (so to say) magnetically; concerning these we intend to speak afterwards. But those substances which are more mixed of water and earth, and are produced by the equal degradation of each element (in which the magnetick force of the earth is deformed and remains

buried; while the watery humour, being fouled by joining with a more plentiful supply of earth, has not concreted in itself but is mingled with earthy matter), can in no way of themselves attract or move from its place anything which they do not touch. On this account metals, marbles, flints, woods, herbs, flesh, and very many other things can neither allure nor solicit any body either magnetically or electrically. (For it pleases us to call that an electric force, which hath its origin from the humour). But substances consisting mostly of humour, and which are not very firmly compacted * by nature (whereby also they do not bear rubbing, but either melt down and become soft, or are not levigable, such as pitch, the softer kinds of resin, camphor, galbanum, ammoniack, storax, asafœtida, benzoin, asphaltum, especially in rather warm weather) towards them small bodies are not borne; for without rubbing most * electricks do not emit their peculiar and native exhalation and effluvium. The resin turpentine when liquid does not attract; for it cannot be rubbed; but if it has hardened into a mastick it does attract. But now at length we must understand why small bodies turn towards those substances which have drawn their origin from water; by what force and with what hands (so to speak) electricks seize upon kindred natures. In all bodies in the world two causes or principles have been laid down, from which the bodies themselves were produced, matter and form. Electrical motions become strong from matter, but magnetick from form chiefly; and they differ widely from one another and turn out unlike, since the one is ennobled by numerous virtues and is prepotent; the other is ignoble and of less potency, and mostly restrained, as it were, within certain barriers; and therefore that force must at times be aroused by attrition or friction, until it is at a dull heat and gives off an effluvium and a polish is induced on the body. For spent air, either blown out of the mouth or given * off from moister air, chokes the virtue. If indeed either a sheet of paper or a piece of linen be interposed, there will be no movement. But a loadstone, on the other

hand, without friction or heat, whether dry or suffused with moisture, as well in air as in water, invites magneticks, and attracts them even with the most solid bodies interposed, even planks of wood or pretty thick
* slabs of stone or sheets of metal. A loadstone appeals to magneticks only; towards electricks all things move. A loadstone raises great weights; so that if there is a loadstone weighing two ounces and strong, it attracts half an ounce or a whole ounce. An electrical substance only attracts very small weights; as, for instance, a piece of amber of three ounces weight, when rubbed, scarce raises a fourth part of a grain of barley. But this attraction of amber and of electrical substances must be further investigated; and since there is this particular affection of matter, it may be asked why is amber rubbed, and what affection is produced by the rubbing, and what causes arise which make it lay hold on everything? As a result of friction it grows slightly warm and becomes smooth; two results which must often occur together. A large polished fragment of amber or jet attracts indeed, even without friction, but less strongly; but if it be brought gently near a flame or a live coal, so that it equally becomes warm, it does not
* attract small bodies because it is enveloped in a cloud from the body of the flaming substance, which emits a hot breath, and then impinges upon it vapour from a foreign body which for the most part is at variance with the nature of amber. Moreover the spirit of the amber which is called forth is enfeebled by alien heat; wherefore it ought not to have heat excepting that produced by motion only and friction, and, as it were, its own, not sent into it by other bodies. For as the igneous heat emitted from any burning substance cannot be so used that electricks may acquire their force from
* it; so also heat from the solar rays does not fit an electrick by the loosening of its right material, because it dissipates rather and consumes it (albeit a body which has been rubbed retains its virtue longer exposed to the rays of the sun than in the shade; because in the shade the effluvia are condensed to a greater degree and more

quickly). Then again the fervour from the light of the Sun aroused by means of a burning mirror confers no vigour on the heated amber; indeed it dissipates and corrupts all the electrick effluvia. Again, burning sulphur and hard wax, made from shell-lac, when aflame do not allure; for heat from friction resolves bodies into effluvia, which flame consumes away. For it is impossible for solid electricks to be resolved into their own true effluvia otherwise than by attrition, save in the case of certain substances which by reason of innate vigour emit effluvia constantly. They are rubbed with bodies which do not befoul their surface, and which produce a polish, as pretty stiff silk or a rough wool rag which is as little soiled as possible, or the dry palm. Amber also is rubbed with amber, with diamond, and with glass, and numerous other substances. Thus are electricks manipulated. These things being so, what is it which moves? Is it the body itself, inclosed within its own circumference? Or is it something imperceptible to us, which flows out from the substance into the ambient air? Somewhat as Plutarch opines, saying in his *Quæstiones Platonicae*: That there is in amber something flammable or something having the nature of breath, and this by the attrition of the surface, being emitted from its relaxed pores, attracts bodies. And if it be an effusion does it seize upon the air whose motion the bodies follow, or upon the bodies themselves? But if amber allured the body itself, then what need were there of friction, if it is bare and smooth? Nor does the force arise from the light which is reflected from a smooth and polished body; for the Gem of Vincent's rocks, Diamond, and clear glass, attract when they are rough; but not so powerfully and quickly, because they are not so readily cleansed from extraneous moisture on the surface, and are not rubbed equally so as to be copiously resolved at that part. Nor does the sun by its own beams of light and its rays, which are of capital importance in nature, attract bodies in this way; and yet the herd of philosophizers considers that humours are attracted by the sun, when it is only denser humours

that are being turned into thinner, into spirit and air; and so by the motion of effusion they ascend into the upper regions, or the attenuated exhalations are raised up from the denser air. Nor does it seem to take place from the effluvia attenuating the air, so that bodies impelled by the denser air penetrate towards the source of the rarefaction; in this case both hot and flaming bodies would also allure other bodies; but not even the lightest chaff, or any verforium moves towards a flame. If there is a flow and rush of air towards the body, how can a small diamond of the size of a pea summon towards itself so much air, that it seizes hold of a biggish long body placed in equilibrio (the air about one or other very small part of an end being attracted)? It ought also to have stopped or moved more slowly, before it came into contact with the body, especially if the piece of amber was rather broad and flat, from the accumulation of air on the surface of the amber and its flowing back again. If it is because the effluvia are thinner, and denser vapours come in return, as in breathing, then the body would rather have had a motion toward the electrick a little while after the beginning of the application; but when electricks which have been rubbed are applied quickly to a verforium then especially

* at once they act on the verforium, and it is attracted more when near them. But if it is because the rarefied effluvia make a more rarefied medium, and on that account bodies are more prone to slip down from a denser to a more attenuated medium; they might have been carried from the side in this way or downwards, but not to bodies above them; or the attraction and apprehension of contiguous bodies would have been momentary only. But with a single friction jet and amber draw and attract bodies to them strongly and for a long time, sometimes for the twelfth part of an hour, especially in clear weather. But if the mass of amber be rather large, and the surface polished, it attracts without friction. Flint is rubbed and emits by attrition an inflammable matter that turns into sparks and heat. Therefore the denser effluvia of flint producing fire are very far different from electrical

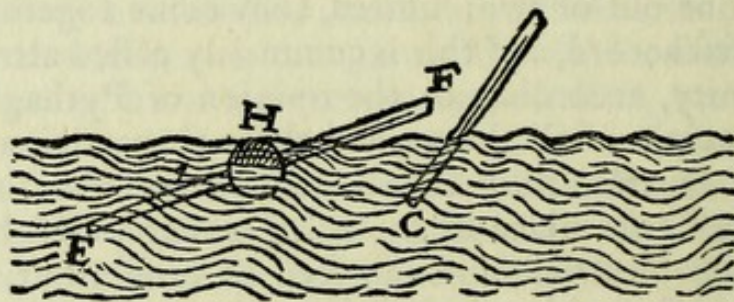
effluvia, which on account of their extreme attenuation do not take fire, nor are fit material for flame. Those effluvia are not of the nature of breath, for when emitted they do not propel anything, but are exhaled without sensible resistance and touch bodies. They are highly attenuated humours much more subtile than the ambient air; and in order that they may occur, bodies are required produced from humour and concreted with a considerable degree of hardness. Non-electrick bodies are not resolved into humid effluvia, and those effluvia mix with the common and general effluvia of the earth, and are not peculiar. Also besides the attraction of bodies, they retain them longer. It is probable therefore that amber * does exhale something peculiar to itself, which allures bodies themselves, not the intermediate air. Indeed it plainly does draw the body itself in the case of a spherical drop of water standing on a dry surface; for a piece of amber applied to it at a suitable distance pulls the nearest parts out of their position and draws it up into a cone; otherwise, if it were drawn by means of the air * rushing along, the whole drop would be moved. That it does not attract the air is thus demonstrated: take a very thin wax candle, which makes a very small and clear flame; bring up to this, within two digits or any convenient distance, a piece of amber or jet, a broad flat * piece, well prepared and skilfully rubbed, such a piece of amber as would attract bodies far and wide, yet it does not disturb the flame; which of necessity would have occurred, if the air was disturbed, for the flame would have followed the current of air. As far as the effluvia are sent out, so far it allures; but as a body approaches, its motion is accelerated, stronger forces drawing it; as also in the case of magneticks and in all natural motion; not by attenuating or by expelling the air, so that the body moves down into the place of the air which has gone out; for thus it would have allured only and would not have retained; since it would at first also have repelled approaching bodies just as it drives the air itself; but indeed a particle, be it ever so small, does not avoid the first application made very quickly after rubbing.

An effluvium exhales from amber and is emitted by rubbing: pearls, carnelian, agate, jasper, chalcedony, coral, metals, and other substances of that kind, when they are rubbed, produce no effect. Is there not also something which is exhaled from them by heat and attrition? Most truly; but from grosser bodies more blended with the earthy nature, that which is exhaled is gross and spent; for even towards very many electricks, if they are rubbed too hard, there is produced but a weak attraction of bodies, or none at all; the attraction is best when the rubbing has been gentle and very quick; for so the finest effluvia are evoked. The effluvia arise from the subtile diffusion of humour, not from excessive and turbulent violence; especially in the case of those substances which have been compacted from unctuous matter, which when the atmosphere is very thin, when the North winds, and amongst us (English) the East winds, are blowing, have a surer and firmer effect, but during South winds and in damp weather, only a weak one; so that those substances which attract with difficulty in clear weather, in thick weather produce no motion at all; both because in grosser air lighter substances move with greater difficulty; and especially because the effluvia are stifled, and the surface of the body that has been rubbed is affected by the spent humour of the air, and the effluvia are stopped at their very starting. On that account in the case of amber, jet, and sulphur, because they do not so easily take up moist air on their surface and are much more plenteously set free, that force is not so quickly suppressed as in gems, crystal, glass, and substances of that kind which collect on their surface the moister breath which has grown heavy. But it may be asked why does amber allure water, when water placed on its surface removes its action? Evidently because it is one thing to suppress it at its very start, and quite another to extinguish it when it has been emitted. So also thin and very fine silk, in common language *Sarce-*

* *net*, placed quickly on the amber, after it has been rubbed, hinders the attraction of the body; but if it is interposed in the intervening space, it does not entirely

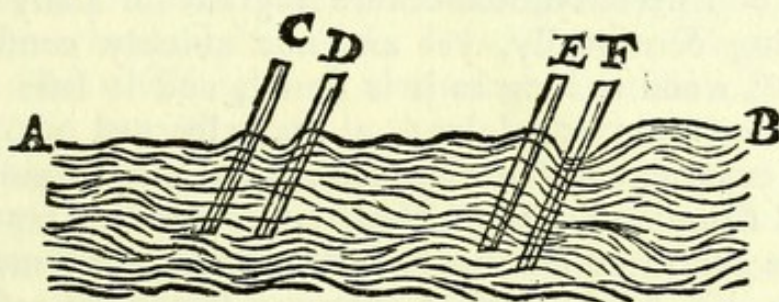
obstruct it. Moisture also from spent air, and any breath blown from the mouth, as well as water put on the amber, immediately extinguishes its force. But oil, * which is light and pure, does not hinder it; for although *
amber be rubbed with a warm finger dipped in oil, still it attracts. But if that amber, after the rubbing, is moistened with *aqua vitæ* or spirits of wine, it does not attract; for it is heavier than oil, denser, and when added to oil sinks beneath it. For oil is light and rare, and does not resist the most delicate effluvia. A breath therefore, proceeding from a body which had been compacted from humour or from a watery liquid, reaches the body to be attracted; the body that is reached is united with the attracting body, and the one body lying near the other within the peculiar radius of its effluvia makes one out of two; united, they come together into the closest accord, and this is commonly called attraction. This unity, according to the opinion of Pythagoras, is the principle of all things, and through participation in it each several thing is said to be one. For since no action can take place by means of matter unless by contact, these electricks are not seen to touch, but, as was necessary, something is sent from the one to the other, something which may touch closely and be the beginning of that incitement. All bodies are united and, as it were, cemented together in some way by moisture; so that a wet body, when it touches another body, attracts it, if it is small. So wet bodies on the surface of water attract wet bodies. But the peculiar electrical effluvia, which are the most subtile material of diffuse humour, entice corpuscles. Air (the common effluvium of the earth) not only unites the disjointed parts, but the earth calls bodies back to itself by means of the intervening air; otherwise bodies which are in higher places would not so eagerly make for the earth. Electrical effluvia differ greatly from air; and as air is the effluvium of the earth, so electricks have their own effluvia and properties, each of them having by reason of its peculiar effluvia a singular tendency toward unity, a motion toward its origin and fount, and toward the body emitting the

effluvia. But those substances which by attrition emit a gross or vapourous or aeriform effluvia produce no effect: for either such effluvia are alien to the humour (the uniter of all things), or being very like common air are blended with the air and intermingle with the air, wherefore they produce no effect in the air, and do not cause motions different from those so universal and common in nature. In like manner bodies strive to be united and move on the surface of water, just as the rod C, which is put a little way under water. It is plain that the rod E F, which floats on the water by reason of the cork H, and only has its wet end F above the surface of the water, is attracted by the rod C, if the rod C is wet a little above the surface of the water; they are suddenly united, just as a drop adjoining a drop is at-



tracted. So a wet thing on the surface of water seeks union with a wet thing, since the surface of the water is raised on both; and they immediately flow together, just like drops or bubbles. But they are in much greater proximity than electricks, and are united by their clammy natures. If, however, the whole rod be dry above the water, it no longer attracts, but drives away the stick E F. The same is seen in those bubbles also which are made on water. For we see one drive towards another, and the quicker the nearer they are. Solids are impelled towards solids by the medium of liquid: for example, touch the end of a versorium with the end of a rod on which a drop of water is projecting; as soon as the versorium touches the top of the droplet, immediately it is joined strongly by a swift motion to the body of the rod. So concreted humid things attract when a little resolved into air (the effluvia in the intermediate

space tending to produce unity); for water has on wet bodies, or on bodies wet with abundant moisture on the top of water, the force of an effluvium. Clear air is a convenient medium for an electrical effluvium excited from concremented humour. Wet bodies projecting above the surface of water (if they are near) run together so that they may unite; for the surface of the water is raised around wet substances. But a dry thing is not impelled to a wet one, nor a wet to a dry, but seems to run away. For if all is dry above the water, the surface of the water close to it does not rise, but shuns it, the wave sinking around a dry thing. So neither does a wet thing move towards the dry rim of a vessel; but it seeks a wet rim. A B is the surface of the water; C D two rods, which stand up wet above the water; it is manifest that



the surface of the water is raised at C and D along with the rods; and therefore the rod C, by reason of the water standing up (which seeks its level and unity), moves with the water to D. On E, on the other hand, a wet rod, the water also rises; but on the dry rod F the surface is depressed; and as it strives to depress also the wave rising on E in its neighbourhood, the higher wave at E turns away from F; for it does not suffer itself to be depressed. All electrical attraction exists through an intervening humour; so it is by reason of humour that all things mutually come together; fluids indeed and aqueous bodies on the surface of water, but concremented things, if they have been resolved into vapour, in air;—in air indeed, the effluvium of electrics being very rare, that it may the better permeate the medium and not impel it by its motion; for if that effluvium had been thick, as that of air, or of the winds, or of saltpetre burnt by fire, as

the thick and foul effluvia given out with very great force, from other great bodies, or air set free from humour by heat rushing out through a pipe (in the instrument of Hero of Alexandria, described in his book *Spiritualia*), then the effluvia would drive everything away, not allure it. But those rarer effluvia take hold of bodies and embrace them as if with arms extended, with the electricks to which they are united; and they are drawn to the source, the effluvia increasing in strength with the proximity. But what is that effluvia from crystal, glass, and diamond, since these are bodies of considerable hardness and firmly concreated? In order that such an effluvia should be produced, there is no need of any marked or perceptible flux of the substance; nor is it necessary that the electrick should be abraded, or worn away, or deformed. Some odoriferous substances are fragrant for many years, exhaling continually, yet are not quickly consumed. Cypress wood as long as it is found, and it lasts also a very long time, is redolent; as many learned men attest from experience. Such an electrick only for a moment, when stimulated by friction, emits powers far more subtile and more fine beyond all odours; yet sometimes amber, jet, sulphur, when they are somewhat easily set free into vapour, also pour out at the same time an odour; and on this account they allure with the very gentlest rubbing, often even without rubbing; they also excite more strongly, and retain hold for a longer time, because they have stronger effluvia and last longer. But diamond,

* glass, rock-crystal, and numerous others of the harder and firmly concreated gems first grow warm: therefore at first they are rubbed longer, and then they also attract strongly; nor are they otherwise set free into vapour. Everything rushes towards electricks excepting flame, and flaming bodies, and the thinnest air. Just as they do not draw flame, in like manner they do not affect a ver-

* forium, if on any side it is very near to a flame, either the flame of a lamp or of any burning matter. It is manifest indeed that the effluvia are destroyed by flame and igneous heat; and therefore they attract neither flame nor bodies very near a flame. For electrical effluvia

have the virtue of, and are analogous with, extenuated humour; but they will produce their effect, union and continuity, not by the external impulse of vapours, not by heat and attenuation of heated bodies, but by their humidity itself attenuated into its own peculiar effluvia. *
 Yet they entice smoke sent out by an extinguished light; and the more that smoke is attenuated in seeking the upper regions, the less strongly is it turned aside; for things that are too rarefied are not drawn to them; and at length, when it has now almost vanished, it does not incline towards them at all, which is easily seen against *
 the light. When in fact the smoke has passed into air, it is not moved, as has been demonstrated before. For air itself, if somewhat thin, is not attracted in any way, unless on account of succeeding that which has vacated its place, as in furnaces and such-like, where the air is fed in by mechanical devices for drawing it in. Therefore an effluvia resulting from a non-fouling friction, and one which is not changed by heat, but which is its own, causes union and coherency, a prehension and a congruence towards its source, if only the body to be attracted is not unfitted for motion, either by the surroundings of the bodies or by its own weight. To the bodies therefore of the electricks themselves small bodies are borne. The effluvia extend out their virtue—effluvia which are proper and peculiar to them, and *sui generis*, differing from common air, being produced from humour, excited by a calorifick motion from attrition and attenuation. And as if they were material rays, they hold and take up chaff, straws, and twigs, until they become extinct or vanish away: and then they (the corpuscles) being loosed again, attracted by the earth itself, fall down to the earth. The difference between Magneticks and Electricks is that all magneticks run together with mutual forces; electricks only allure; that which is allured is not changed by an implanted force, but that which has moved up to them voluntarily rests upon them by the law of matter. *
 Bodies are borne towards electricks in a straight line towards the centre of the electrick; a loadstone draws a loadstone directly at the poles only, in other parts ob-

liquely and transversely, and in this way also they adhere and hang to one another. Electrical motion is a motion of aggregation of matter; magnetical motion is one of disposition and conformation. The globe of the earth is aggregated and coheres by itself electrically. The globe of the earth is directed and turned magnetically; at the same time also it both coheres, and in order that it may be solid, is in its inmost parts cemented together.

A SUMMARY OF GILBERT'S ELECTRICAL WORK.



O distinguish his original discoveries from things already known, Gilbert set in the margin of his book asterisks, large or small, in proportion to the importance of the matter. These have been preserved in the foregoing reprint; and it will be seen that he marked with large asterisks the discovery of the generality of electrifiable bodies, for which he coined the name *electrics*, and the observation that electrified bodies attract not straws and chaff only, but equally attract metals, woods, earths, and even oil and water. The logical outcome of this discovery was the invention of the versorium or *electroscope*. The method of trying everything, instead of accepting statements on authority is characteristic of the man: he must bring all to the touchstone of experiment. The authors who raised Gilbert's wrath by ignorantly copying out all the old tales about amber, jet, and loadstone, instead of investigating the facts, were, as he says at the beginning of the chapter, some theologians, and some physicians. He seems to have taken a special dislike to Albertus Magnus, to Puteanus, to Paracelsus, and to Levinus Lemnius.

Gilbert mentions amber and jet as known to become electrical by friction: but the list was not quite so restricted as would appear from this passage. Five, if not six, other minerals had been mentioned in addition to amber and jet.

(1.) *Lyncurium*. This stone, about which there has been more obscurity and confusion than about any other gem, is supposed by some writers to be the tourmaline, by others a jacinth, and by others a belemnite. The following is the account of Theophrastus, *Theophrastus's History of Stones. With an English Version . . .*, by "Sir" John Hill,

London, 1774, p. 123, ch. xlix.-1. "The *Lapis Lyncurius*, which is likewise used for engraving Seals on, and is of a very solid Texture, as Stones are; it has also an attractive Power, like that of Amber, and is said to attract not only Straws and small pieces of Sticks, but even Copper and Iron, if they are beaten to thin pieces. . . . The *Lapis Lyncurius* is pellucid, and of a fire Colour." See also W. Watson in *Philos. Trans.*, 1759, L. i., p. 394, *Observations concerning the Lyncurium of the ancients*.

(2.) *Ruby*.

(3.) *Garnet*. The authority for both these is Pliny, *Natural History*, book xxxvii., chap. vii. (p. 617 of English edition of 1601).

"Over and besides, I find other sorts of Rubies different from those above-named; . . . which being chaufed in the Sun, or otherwise set in a heat by rubbing with the fingers, will draw unto them chaffe, strawes, shreads, and leaves of paper. The common Grenat also of Carhedon or Carthage, is said to doe as much, although it be inferiour in price to the former."

(4.) *Jasper*. Affaytatus is the authority, in a book called *Physicæ & Astronomicæ cōsiderationes* (Venet., 1549), p. 20.

(5.) *Lychnis*. Pliny and St. Isidore speak of a certain stone *lychnis*, of a scarlet or flame colour, which, when warmed by the sun or between the fingers, attracts straws or leaves of papyrus. Pliny puts this stone amongst carbuncles, but it is much more probably *rubellite*, that is to say, red tourmaline.

(6.) *Diamond*. In spite of a confusion between loadstone and diamond, both of which were called *adamant* by some writers, there seems to be one distinct account of an attractive effect having been observed with a rubbed diamond. This was recorded by Fracastorio, *De sympathiis*, Venice, MDLXXIII, chap. v., p. 60. An incontestable case of the electrification of the diamond occurs in Gartias ab Horto, in his *Historia dei Semplici Aromati*, published at Goa in India in 1563.

In Gilbert's list of bodies newly discovered to become electric are several names not now common. The name *iris* was given, there can be little doubt, to clear six-sided prisms of rock-crystal (quartz), which, when held in the sun's beams, cast a crude spectrum of the colours of the rainbow. The following is the account of it given in Pliny, book xxxvii., chap. vii. (p. 623 of the English version of 1601):

" . . . there is a stone in name called Iris: digged out of the ground it is in a certaine Island of the red sea, distant from the city Berenice three score miles. For the most part it resembleth Crystall: which is the reason that some hath tearmed it the root of Crystall. But the cause why they call it Iris, is, That if the beames of the Sunne strike upon it directly within house, it doth send from it against the walls that bee neare, the very resemblance both in forme and also in colour of a rainebow; and eftsoones it will change the same in much varietie, to the great admiration of them that behold it. For certain it is knowne, that six angles it hath in manner of the Crystall: but they say that some of them have their sides rugged, and the same unequally angled: which

if they be laid abroad against the Sunne in the open aire, do scatter the beames of the Sunne, which light upon them too and fro: also that others doe yeeld a brightnes from themselves, and thereby illuminat all that is about them. As for the diverse colours which they cast forth, it never happeneth but in a darke or shaddowie place: whereby a man may know, that the varietie of colours is not in the stone Iris, but cometh by the reverberation of the wals. But the best Iris is that which representeth the greatest circles upon the wall, and those which be likest unto rainebowes indeed."

Iris is also mentioned by Lomatus (*Artes of curious Painting*, Haydocke's translation, Lond., 1598, p. 157), who says, ". . . the Sunne, which casting his beames vpon the *stone Iris*, causeth the *raine-bowe* to appeare therein."

The *Vincentina*, or *Bristolla*, or gem of St. Vincent's rock, is nothing else than the so-called "Bristol diamond," a variety of quartz crystallized in small brilliant crystals upon a basis of hæmatite. To the work by Dr. Thomas Venner (Lond., 1650), entitled *Via ReĒta* or the *Bathes of Bathe*, there is added an appendix, *A Censure concerning the water of Saint Vincents Rocks neer Bristol*, in which, at p. 376, occurs this passage: "This Water of Saint *Vincents* Rock is of a very pure, cleare, crystalline substance, answering to those crystalline Diamonds and transparent stones that are plentifully found in those Clifts." The name *Vincentina* is not known as occurring in any mineralogical book.

Electrical attraction by natural products other than amber, after they have been rubbed, must have been observed by the primitive races of mankind. Indeed Humboldt in his *Cosmos* (Lond., 1860, vol. i., p. 182) records a striking instance:

"I observed with astonishment, on the woody banks of the Orinoco, in the sports of the natives, that the excitement of electricity by friction was known to these savage races, who occupy the very lowest place in the scale of humanity. Children may be seen to rub the dry, flat and shining seeds or husks of a trailing plant (probably a *Negretia*) until they are able to attract threads of cotton and pieces of bamboo cane."

The passage on p. 16 very clearly sets forth the differences to be observed between magnetic and electric effects. Though Gilbert was the first systematically to explore the differences that exist between the magnetic attraction of iron and the electric attraction of all light substances, the point had not passed unheeded, for we find St. Augustine, in the *De Civitate Dei*, liber xxi., cap. 6, raising the question why the loadstone which attracts iron should refuse to move straws. The many analogies between electric and magnetic phenomena had led

many experimenters to speculate on the possibility of some connexion between electricity and magnetism. See, for example, Tiberius Cavallo, *A Treatise on Magnetism*, London, 1787, p. 126. Aepinus wrote a treatise on the subject, entitled *De Similitudine vis electricæ et magneticæ* (Petropolis, 1758). This was, of course, long prior to the discovery, by Oersted, in 1820, of the real connexion between magnetism and the electric current. It is interesting to note on p. 25 a suggestion of material *rays*, as the operation of electric forces seems to foreshadow the notion of electric lines of force.

Gilbert had imbibed the schoolmen's ideas as to the relations of matter and form. He had discovered and noted that in the magnetic attractions there was always a verticity, and that in the electrical attractions the rubbed electrical body had no verticity. To account for these differences he drew the inference that since (as he had satisfied himself) the magnetic actions were due to *form*, that is to say to something immaterial—to an "imponderable" as in the subsequent age it was called—the electrical actions must necessarily be due to *matter*. He therefore put forward his idea that a substance to be an electric must necessarily consist of a concremented humour which is partially resolved into an effluvium by attrition. His discoveries that electric actions would not pass through flame, whilst magnetic actions would, and that electric actions could be screened off by interposing the thinnest layer of fabric such as sarcenet, whilst magnetic actions would penetrate thick slabs of every material except iron only, doubtless confirmed him in attributing the electric forces to the presence of these effluvia. There arose a fashion, which lasted for over a century, for ascribing to "humours," or "fluids," or "effluvia," physical effects which could not otherwise be accounted for.

In spite of his care to test everything by experiment, Gilbert fell into several errors. He denied the existence of electric repulsion, and whilst he strenuously affirmed that the magnetic forces were mutual between the magnet and the iron, each being urged toward the other, he also affirmed that, in the case of the action of the electric on the object which moved toward it, the action was not mutual but was a one-sided force—an impossibility in physics.

Gilbert's experimental discoveries in electricity may be summed up as follows:

1. The generalization of the class of *Electrics*.
2. The observation that damp weather hinders electrification.
3. The generalization that electrified bodies attract everything, including even metals, water, and oil.

4. The invention of the non-magnetic *versorium* or electroscope.
5. The observation that merely warming amber does not electrify it.
6. The recognition of a definite class of *non-electrics*.
7. The observation that certain electrics do not attract if roasted or burnt.
8. That certain electrics when softened by heat lose their power.
9. That the electric effluvia are stopped by the interposition of a sheet of paper or a piece of linen, or by moist air blown from the mouth.
10. That glowing bodies, such as a live coal, brought near excited amber discharge its power.
11. That the heat of the sun, even when concentrated by a burning mirror, confers no vigour on the amber, but dissipates the effluvia.
12. That sulphur and shell-lac when aflame are not electric.
13. That polish is not essential for an electric.
14. That the electric attracts bodies themselves, not the intervening air.
15. That flame is not attracted.
16. That flame destroys the electrical effluvia.
17. That during south winds and in damp weather, glass and crystal, which collect moisture on their surface, are electrically more interfered with than amber, jet and sulphur, which do not so easily take up moisture on their surfaces.
18. That pure oil does not hinder production of electrification or exercise of attraction.
19. That smoke is electrically attracted, unless too rare.
20. That the attraction by an electric is in a straight line toward it.

Gilbert's list of electrics should be compared with those given subsequently by Cabeus (1629), by Sir Thomas Browne (1646), and by Bacon. The last-named copied out Gilbert's list almost without change. Sir Thomas Browne's list is given in the following passage, which is interesting as using for the first time in the English language the noun *Electricities*:

"Many stones also both precious and vulgar, although terse and smooth, have not this power attractive; as Emeralds, Pearle, Jaspis, Corneleans, Agathe, Heliotropes, Marble, Alablaster, Touchstone, Flint and Bezoar. Glasse attracts but weakly though cleere, some slick stones and thick glasses indifferently: Arsenic but weakly, so likewise glasse of Antimony, but Crocus Metallorum not at all. Saltes generally but weakly, as Sal Gemma, Alum, and also Talke; nor very discoverably by any frication: but if gently warmed at the fire, and wiped with a dry cloth, they will better discover their Electricities" (*Pseudodoxia Epidemica*, p. 79).

If, as shown above, the electric powers of diamond and ruby had already been observed, yet Gilbert was the first beyond question to extend the list of *electrics* beyond the class of precious stones, and his discovery that *glass, sulphur, and sealing-wax* acted, when rubbed, like amber, was of capital importance. So was also his observation that electrical experiments succeed better in dry or frosty weather. Though he did not pursue the discovery into mechanical contrivances, he left the

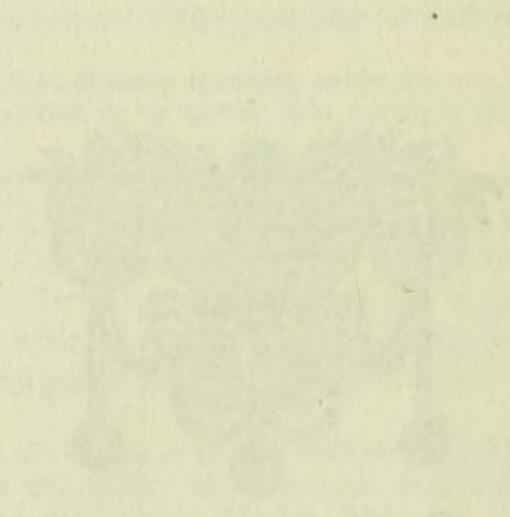
means of that extension to his followers. To Otto von Guericke we owe the application of *sulphur* to make the first electrical machine out of a revolving globe; to Sir Isaac Newton and to Hauksbee the suggestion of *glass* as affording a more mechanical construction. And both materials were discovered by Gilbert to be electric.

“Such,” said Priestley in 1767, “were the discoveries of our countryman Gilbert, who may justly be called the father of modern electricity, though it be true that he left his child in its very infancy.” To Priestley’s quaint remark we may add that as electricity is no longer in its infancy, we who claim Gilbert as our countryman are all the more proud to acknowledge his just claims to its paternity.



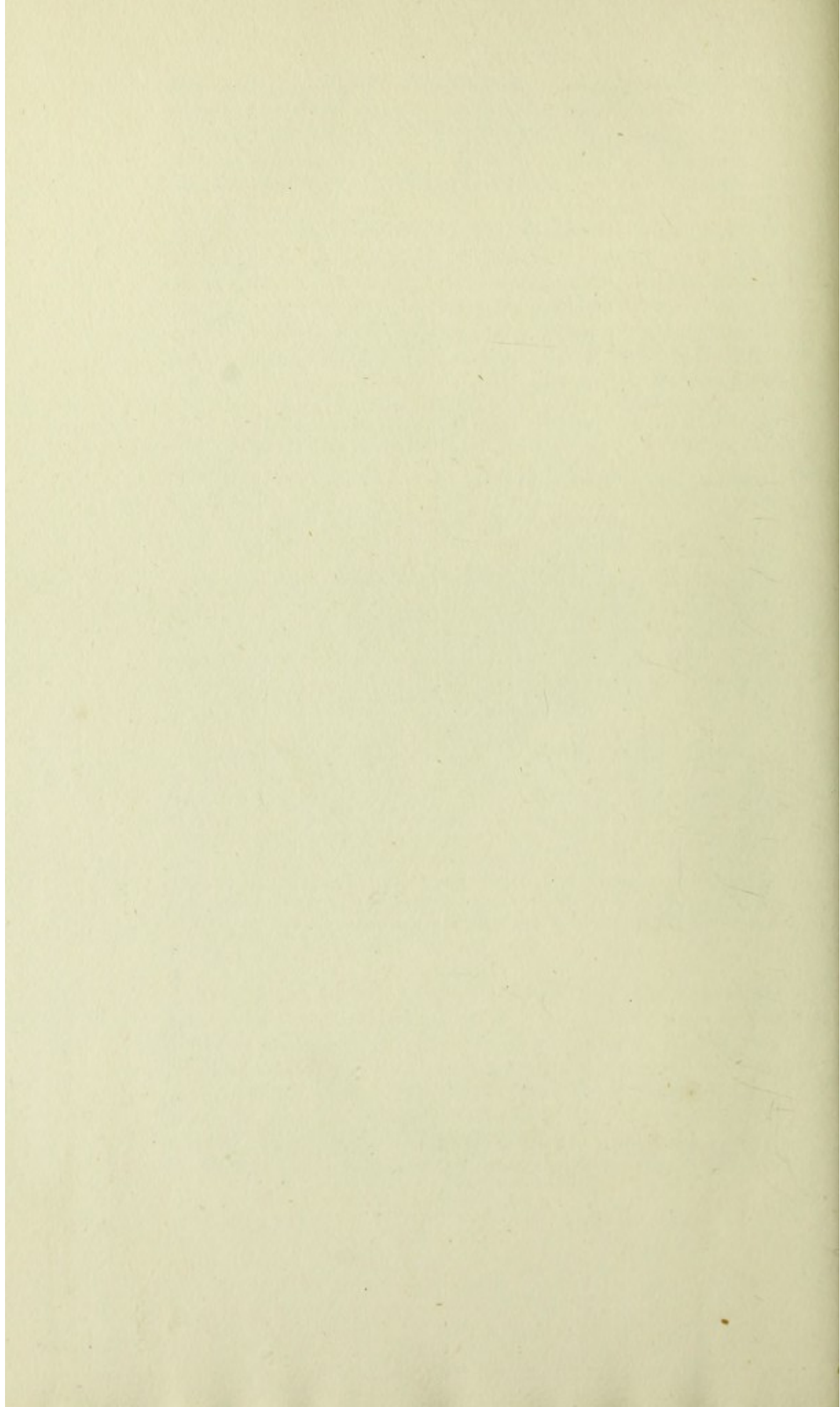
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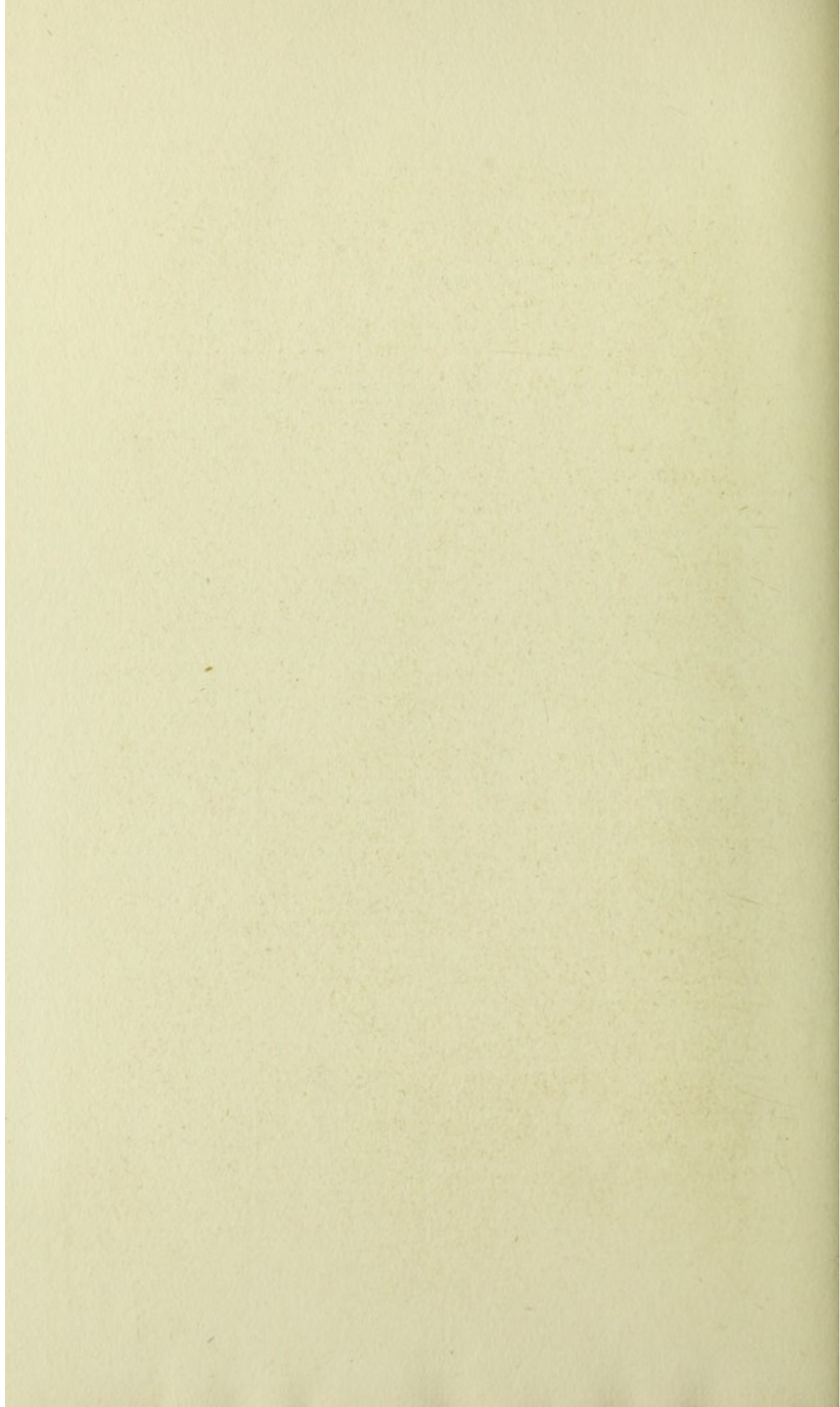
THE YOUNG MEN'S CHRISTIAN ASSOCIATION OF AMERICA
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 AND TO DEVELOP THE CHARACTER AND ABILITIES OF THE YOUNG MEN OF THE WORLD
 TO THE END THAT THEY MAY BE BETTER CITIZENS AND BETTER MEN

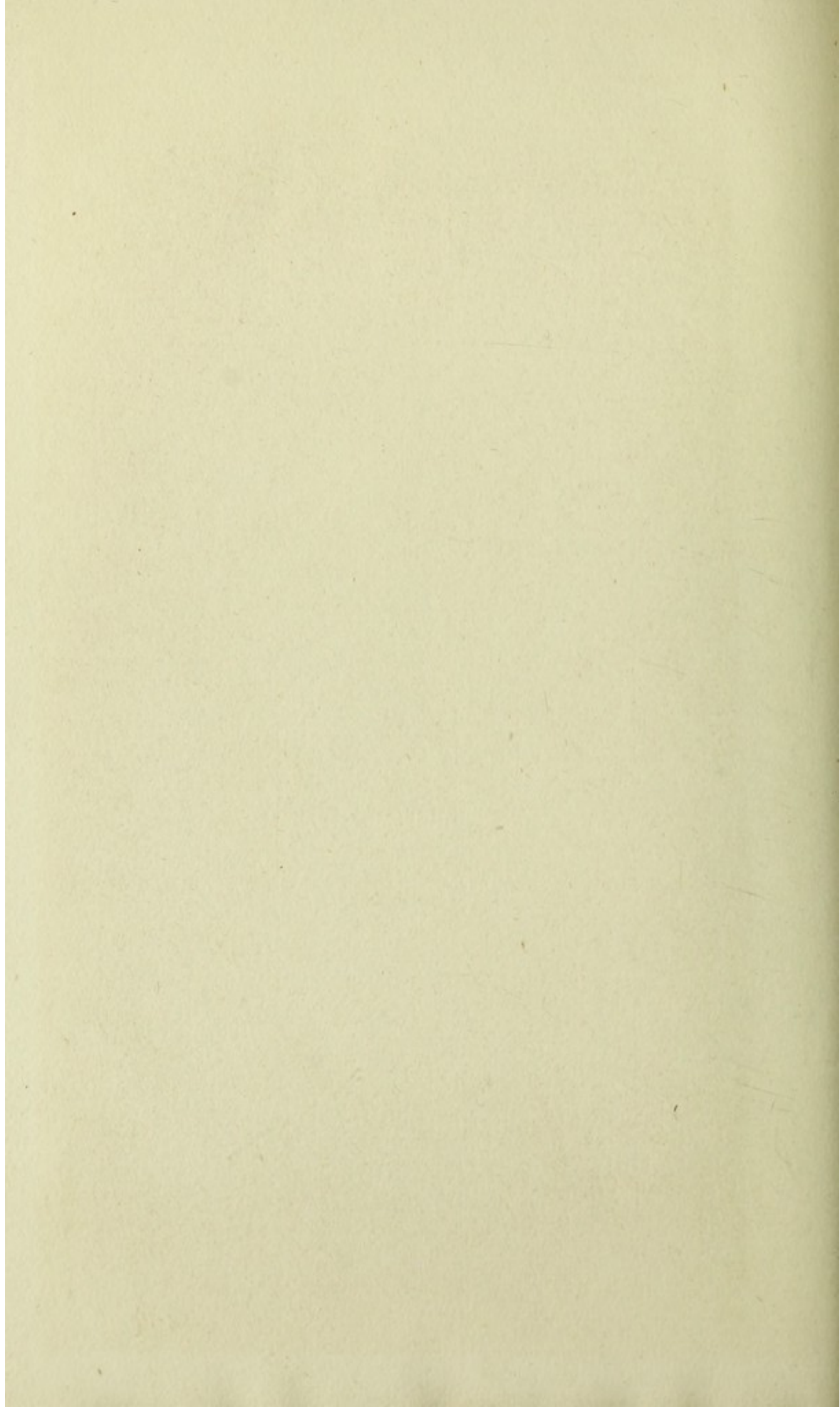


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