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A TEXT-BOOK ON SOUND:

The Substantial Theory of Acoustics,

ADAPTED TO

The Use of Schools, Colleges, etc.,

BY REV. J. I. SWANDER, A. M. D. D.

(Being the 10th Chapter of His Book, entitled, "The Substantial Philosophy.")

CAREFULLY REVISED BY

A. WILFORD HALL, Ph. D., LL. D.,

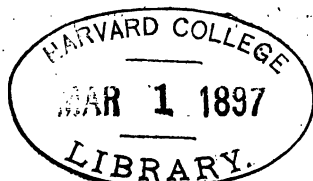
FOUNDER OF SUBSTANTIALISM.

1887:

HALL & CO., PUBLISHERS,
23 PARK ROW, N. Y.

~~V. 5731~~

Phys 353.4



Dr. S. A. Green

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3-1-97

W. C. DUNN, Printer and Electrotyper, 24 and 26 Vandewater St., N. Y.

PREFACE.

IN presenting this Text-Book on Sound to the student of physical science it is requisite that it should be prefaced by a brief explanation. Some ten years or more ago we became convinced that the views of scientists concerning the nature and character of the physical forces were essentially weak and erroneous, and after considering the matter seriously for a year or two, accompanied by numerous experimental investigations, we resolved that every form of natural force, or, in other words, that every phenomena-producing or sensation-producing cause in Nature must of necessity be a real objective existence, or an actual substantial entity, as much so as are the grossest material objects with which our sensuous observation brings us into contact.

This new departure from the generally received mode-of-motion theories of the text-books involved so much reconstruction in physical philosophy that we were at first appalled at the magnitude of the task we had assumed, provided we should decide to persist in our revolutionary crusade against modern scientific theories. Suffice it to say that, after the most careful consideration of the various questions involved in the premises, we were forced to the decision that either

all the forces of Nature, or phenomena-producing causes, were modes of molecular motion, or else that they were all but different forms of substance variously graduated in the scale of physical existence, commencing at the highest plane of the material substances as observed around us. As all our reasoning and experimenting had forced us to the belief that no mechanical or sensuous effect could be produced in Nature without the intervention of a substantial cause of some kind, we were driven irresistibly to the latter general conclusion as stated above, namely, that the forces were all substantial entities, which led at once to the general classification of all the phenomena-producing causes in the universe into material and immaterial substances.

At this point in our analysis of the problems involved, we struck the key-note to the whole subject in the single question of the nature and phenomena of sound. Either *sound* must be included in the category of the substantial forces or phenomena-producing causes, or else there would be a spanless chasm in this new Substantial Philosophy which would break up its continuity, and totally vitiate the symmetry of our proposed revolutionary work in physical science. Hence our attention was instantly concentrated upon this single paramount phase of the discussion as the key to the situation.

It was not a very startling position to assume that light, heat, electricity, gravity, magnetism, cohesion, life, mind, soul and spirit, might be considered real entities or objective existences in some form or character, since different philosophers at different ages of the world had variously questioned the non-entitative nature

of many of these phenomena-producing causes. But not so with *sound*. The whole scientific world without one exception were united, and had been for centuries, in regarding this form of physical force as an indisputable mode of motion and nothing else. Hence, should we succeed in showing all the other forms of natural force to be real entities or substantial existences, and should we leave *sound* out of the category, a mere novice in the discussion of science would at a glance see that our whole grand attempt at a new and harmonious system of natural philosophy must be set down as a logical abortion.

This, then, explains why so much space and critical labor were given up to the sound discussion in the "Problem of Human Life," in which our new departures in physical science were first given to the public.

Of course, in that first attempt to show the fallacy of the wave-theory of sound as universally taught, and to outline the substantial theory of acoustics, we are free to admit that many minor errors in expression, and some in calculations, found their way into the generally correct arguments and positions of that monograph. Dr. Henry A. Mott, Ph. D., LL. D., of New York, one of the brightest and best posted scientific investigators in the United States, and who has, after the most careful consideration of the entire matter, unqualifiedly indorsed the Substantial Philosophy, including the substantial theory of sound, expresses his astonishment that the whole question of acoustics was so thoroughly and correctly presented in that early treatise in the "Problem of Human Life," with so few errors to take back, considering the

fact that the author had not one line of previous discussion *pro* or *con* in that direction with which to guide his pen or aid him in steering clear of mistakes. How noble and magnanimous is this view of the case in a great scientific investigator, rather than stopping to carp at some trivial error in language or mistake in calculation, thereby ignoring all the great truths and arguments of the monograph, as has been the case with so many previous reviewers of that work since its first publication!

This brings us to the present formulation of the sound-theory, as presented in the following concise questions and answers, covering, as they do, the whole subject of acoustics from beginning to end. When Dr. Swander wrote us, some four months ago, that he was at work on a volume to be entitled the "Substantial Philosophy," in which he purposed to formulate every branch of that subject in different chapters, and that *sound* would occupy the tenth chapter of the book, he requested us to assist him in the way of suggesting and correcting matter for the various questions and answers of that special chapter on acoustics. We gladly consented to do so, and we have to say, for the credit of Dr. Swander's generous estimate of our original labors on this branch of physics, that he did not demur to a single suggestion we made involving the scientific aspects of the discussion as presented in his eighty-nine questions and answers.

In consideration for such assistance on our part Dr. Swander voluntarily gave us this tenth chapter of his book as our own personal property, to be published and sold as a *text-book on sound* for the use of schools and colleges. As such we now offer it to teachers and

students, believing as we do that in the midst of all the prejudice which is naturally called forth against scientific innovations by the routine work of a professorship in setting forth the accepted theories of science, there still remain, with a vast majority of professors and students, an abiding willingness and even anxiety to receive new truth in science and philosophy how much soever it may cross the paths of previous investigators.

We request, therefore, that teachers, into whose hands this little work shall chance to fall, shall not lay it aside till they have critically examined and considered every question, answer, and foot-reading it contains. If after carefully comparing the various solutions of sound-problems as set forth in the substantial theory with those of the current doctrine of acoustics, the reader shall candidly and without prejudice decide that the wave-theory presents the more reasonable view of acoustical science, we cheerfully submit, believing that the truth upon the subject, in whatever direction it may lie, will ultimately prevail.

A. WILFORD HALL.

NEW YORK, 23 Park Row, Jan. 1, 1887.

As a further and concise embodiment of the substantial theory of sound, preparatory to an intelligible understanding of the succeeding pages, we add the following brief statement of its cardinal features as furnished to the Cleveland (Ohio) *Plain Dealer* at the request of its editor, and as copied into the *Scientific Arena*, Vol. 1, page 45:

THE SUBSTANTIAL THEORY OF SOUND—BY ITS FOUNDER.

This theory is the exact opposite of the undulatory theory, or the wave-theory as it is commonly termed. The substantial theory of sound is based on the general position, as maintained in the Substantial Philosophy, that every force of Nature, or phenomenon-producing cause in Nature, whether physical, vital, mental or spiritual, must be a substantial entity. That philosophy insists that the substances of the universe are by no means limited to material bodies, however gross or attenuated they may be. Hence, that substances may be immaterial as well as materialial entities. The leading principle of Substantialism is that motion, *per se*, is absolutely nothing, being the mere position of a body in space changing from one place to another, while that which causes motion or change of position, namely, force or energy, is of necessity a veritable substantial entity or objective thing.

It follows from this that sound, light, heat, gravitation, electricity, magnetism, etc., cannot in the nature of things be the mere motions of some material substance or substances, but must themselves, as natural forces, or as phenomena-producing causes, be different forms of immaterial substance.

By immaterial substances are meant such entities as are not limited or confined by material conditions, as best illustrated by magnetism or gravitation, which totally defies a material body to impede its progress. Other immaterial substances, as, for example, heat, sound, and electricity, seem to be limited by matter in their progress to a greater or less degree, since they travel with greater freedom and velocity through some material bodies than through others. This, however, is only in appearance, as the different facility with which electricity, for example, travels through different bodies, is alone caused by the action of the governing force of cohesion among the particles of different material bodies, and not by the material particles themselves.

For example, electricity, though an immaterial substance, will not travel perceptibly through glass, while silver is its best

known conductor. Why is this? Science as now taught offers no attempt at explanation, while Substantialism has a ready and rational answer to all such questions. The force of cohesion, another immaterial substance, has so arranged and combined the material particles of the glass, and so presides over that arrangement, as to interfere with the passage of electricity, while in silver the arrangement is such as to favor and co-operate with the electric current.

So with the passage of substantial light rays through bodies which are transparent. This property of transparency, as also its opposite property, opacity, is due to the action of cohesion among the particles of a material body. By different cohesive arrangements the very same material substance will be transparent or opaque, as the case may be. In one case, the same as with electricity, the substantial force of cohesion co-operates with light, and in the other case opposes it.

But I must not argue the case. I merely, by request, make a brief statement of what constitutes the principles of Substantialism, or of the substantial theory of sound. Sound being universally regarded as but the motion of air-particles, outside of our sensations, it was necessary for the founder of the Substantial Philosophy especially to attack that theory, and by setting it aside, thereby to corroborate his general position that sound, as well as gravitation, heat, light, magnetism, electricity, etc., must be an immaterial but substantial force. A score or more of proofs in favor of the correctness of this new departure in modern science have been presented by its originator in his various publications, beginning with the "Problem of Human Life." In reply to this new philosophy no arguments worth mentioning have yet been offered, while on the other hand it appears so consistent, when understood, with everything positively known in science, that many professors of physics have already abandoned the wave-theory of sound, and have publicly announced their adherence to the Substantial Philosophy.

EXTRACTS FROM THE INTRODUCTION.

[THE following is a specimen of Dr. Swander's generous acknowledgment of his indebtedness to the founder of Substantialism, for the scientific features of his work.]

"It is not the primary object of this book to teach in detail the many positive truths of science and religion which enter into a complete academic course of study or college curriculum; but to suggest some general outlines thereof, as well as some new departures therefrom, and to assist the honest student in 'learning to unlearn' whatever he may have learned amiss. That the highway of the scientific architect is strewn with the rubbish of worthless theories is an assumption whose justification may be looked for in the following pages. In presenting these pages to the public, the author disclaims any sympathy with that pessimistic school of philosophers known as the screech-owls of humanity. And yet he is just as unwilling to be classed with those credulous optimists who not only see that everything in nature is ordered for the best, but who also seem to act upon the supposition that the most popular interpretation of Nature's forces and phenomena is for that reason the most reliable.

"It is also due to all parties interested that we announce candidly and publicly that this work lays no claim to originality on the part of the author. With the exception of the last four chapters, for which he is willing to be held individually responsible, this volume is

an attempted formulation of some of the fundamental truths of the Substantial Philosophy, founded by Dr. A. Wilford Hall, and set forth in his 'Problem of Human Life,' which made its first appearance before a startled public in 1878, and since that date more fully explained and advocated by himself, and to some extent by his coadjutors, in the *Microcosm*, until very recently, when the challenge which the discussion of the questions involved was tossed into the *Scientific Arena*, the leading monthly journal of this country devoted to a bold investigation of current philosophical teaching and its bearing upon the religious thought of the age.

"Whatever, therefore, this volume contains of original freshness in scientific investigation and discovery, and whatever is startling in its stalwart character and claims of revolutionary truth, are credited to others, but especially to that earnest investigator, logical reasoner, indefatigable worker, Christian scientist, and scientific revolutionist—Dr. A. Wilford Hall, at whose apostolic feet we are proud to place this little book as the most appropriate expression of our esteem for one whom we have never seen, as well as our best token of gratitude to him for the great benefits which we are constantly deriving from his rich discoveries of laws and facts in Nature never previously even dreamed of by those whose greatest fidelity to truth consisted mainly in feeling the popular scientific pulse, and in following the beaten paths of ancient and modern scholasticism. And while we thus make our obeisance to our venerable and beloved teacher, we are fully convinced, through what we know by correspondence and otherwise of the warm pulsations of his Christian heart, that he will readily join us in our further pilgrimage to the foot of the throne of that great "Teacher sent from God," to acknowledge Him as the personal embodiment of all truth, as well as the fountain of all redeeming life and love.

“ Candor compels us to admit, also, that this book has not been written with any hope of benefiting those who thirst and search for the volumes of popular pulpiness and gush so eagerly devoured by the indolent hordes of sickly sentimentalists in literature. The name of this class of readers is legion. They peruse pages with a pernicious habit of thoughtlessness; and their morbid stupidity is more alarming than wonderful. It indicates an effeminate tendency of the age when the popular mind, so inflated with the sweetened wind of fallacy and fiction, has no longer any considerable relish and admiration for those facts and beauties in science which can be ascertained and seen only through the process of laborious mental effort. It is because the general mind has been educated to take an easy surface view and make a superficial search for the cause of things, that stupendous errors have come to prevail in science. When truth is hard to find, error is a convenient substitute. Thus eminence is made easy, and some men become pre-eminent fools. In science, as in religion, those tenets which offer an easy and superficial explanation should be looked upon with suspicion. The shallows murmur with plausible jargon, while the silent deeps are filled with stores of knowledge for those who take to their intellectual diving-bells and leap after the hidden wealth which is never found floating upon the surface. To all such this book comes greeting in the name of revolutionary truth. Its mission is to renew the gage of battle and continue the issue made by Dr. Hall when the ‘Problem of Human Life’ was thrown into the arena of the greatest scientific combat the world has ever witnessed,’ etc.

CHAPTER X.

THE NATURE AND PHENOMENA OF SOUND.*

The Substantial Theory of Acoustics.

QUESTION 1. What is sound?

ANSWER. Primarily, sound is that form of physical force by which the sense of hearing in men and animals is addressed and affected.

Q. 2. Has sound any other meaning?

A. Yes; by a *trope* which we call *metonymy* the effect is often put for the cause, and thus sound signifies the *sensation* itself in our consciousness, which we call *hearing*, and by which we distinguish tones, or recognize their various peculiarities.†

* The questions and answers constituting this chapter are condensed, substantially, from the various writings of Dr. A. Wilford Hall on this branch of physical science, as found recorded in his "Problem of Human Life," the five volumes of the *Microcosm*, and the *Scientific Arena*, of which he is editor. This will be partly shown by the copious foot-readings accompanying the text as the discussion proceeds.—J. I. Swander.

† SOUND, LIGHT, HEAT, ODOR, FLAVOR, ETC.

CLAYPOOL, KY.

Dr. Wilford Hall :

DEAR SIR,—I have read some extracts from your "Problem of Human Life" on the subject of Sound, but do not know that I perfectly understand you; hence, I would be pleased to have your definition of sound—what is it, and what relation does it sustain to aural beings?

Q. 3. What are these chief peculiarities of sound?

A. They are intensity, pitch, duration and quality, the latter expressed under the general term *timbre*.

Q. 4. What is meant by the pitch of sound?

A. It is that peculiarity of tone by which we recognize sounds as high or low, sharp or grave.

Q. 5. What is the chief use of pitch in sound?

A. It is the main foundation of all music, and the basis of harmony, as when more sounds than one are employed at the same time. It is also one of the essentials of ordinary vocal expression, by which words are modulated in conversation.

Do you mean that it has any real, extrinsic existence? Or, in other words, do you mean to teach that it has any existence apart from that particular condition of matter found in the structure of the ear? It has occurred to me that sound is only a sensational phenomenon, and, like all other sensations, dependent upon *nerve* matter; but if I perfectly comprehend you I have an incorrect idea of it—that is, if you are correct. Hoping that you will take pleasure in answering my question, I am very respectfully yours,

W. S. JONES, M. D.

REPLY BY THE EDITOR.

Sound, as well as any other of the sensation-producing causes in nature, must of necessity be one of the physical *forces*, and consequently must first exist outside of our sensations before it can act upon the sense-nerves to produce its characteristic effect.

Sound, in its primary sense or signification, is not at all the sensation in our consciousness, as Dr. Jones thinks, which we call *hearing*, and is only used in that sense by accommodation of language, or by metonymy of speech, the effect being put for the cause. Still, the use of such metaphors in our language is both common and proper. The true and unfigurative meaning of scientific terms, however, should always be preferred in our philosophical discussions to any form of trope.

Sound, strictly speaking, is that *force* in nature which by entering the ear, and by contact with the auditory nerve, produces in our consciousness the sensation of hearing. *Light* is that *force* in nature which by entering the eye, and by

Q. 6. What causes pitch in sound?

A. As sound is developed by the vibratory action of some sound-producing body, by which this peculiar form of natural force is generated or liberated from the force-element of nature, it follows, and has been abundantly proved, that the pitch of sound depends upon the number of such vibrations in a given time by which any particular sound is produced and conveyed to the ear.

Q. 7. What is the range or extreme limits of such vibrational rates, for producing the various audible sounds in nature?

A. From the most refined experiments it has been

contact with the optic nerve, produces in our consciousness the sensation called seeing or sight. *Heat* is that *force* in nature which by entering our tactile nerves, which are distributed all over the body, produces in our consciousness the sensation called warmth, and metaphorically also called heat. *Odor* is that *force* in nature which by entering the nose, and coming in contact with the olfactory nerve, produces in our consciousness the sensation we call smell. And *flavor* is that *force* in nature which by contact with the palate and gustatory nerve produces in our consciousness the sensation we call taste.

If there is no such thing as sound in nature outside of our ears and auditory nerves, then there surely is no such thing as light outside of our eyes, no such thing as heat outside of our tactile nerves, no such thing as flavor outside of our gustatory membranes, and no such thing as odor outside of our noses. Are the old theorists, who wish to confine sound to our sensations in order to avoid Substantialism, prepared for the application of their logic to light, heat, flavor and odor? If not, let them do a little sober reflecting before making their points. Let us now put the matter in the form of a few very simple questions and see how it will hold together.

If there is no sound as a physical force outside the ear, is it not plain, as just hinted, that there is no light as a physical force outside the eye? But would not the sun shine just the same if all eyes were put out? Suppose all sensuous beings should shut their eyes at one time; would that extinguish the

determined, that sounds can be heard by the best ears from 16 up to about 16,000 vibrations in a second. (Some authors place this upper limit much higher, but it is manifestly a mistake.) The average range of tone, however, in orchestral music is believed to extend from about 30 to 8000 vibrations per second.

Q. 8. Do any tones exceed the extreme limits of vibration here given for the capacity of human ears?

A. It may be fairly inferred from various natural analogies, that sound-force is really generated both by lower and higher rates of vibration than those named as producing audible sound, but that its form, in such cases, exceeds the capacity of our sensations.

light of the sun? If all light (like sound is claimed to be) is in our sensations, then what produces the chemical effect on a metallic plate, changing it into what we call a daguerreotype? Has that inert, inanimate piece of metal an optic nerve? Would not the same chemical effect have taken place by the action of the light under the same conditions, if there were no eyes in existence? Then again: If heat (like sound is supposed to be) is only in our tactile sensations, and not a physical, substantial force outside of them, how does it burn down a building? Does a frame house possess tactile nerves and a conscious sensation?

Then, coming right home to the question in hand, if sound is only in our sensations, and not a real, substantial force in nature outside of our conscious being, what is it that sets a stretched string into sympathetic vibration? Has a steel wire got ears? Does a tensioned chord possess an auditory nerve and animal consciousness? Would not that stretched wire be thrown into action by sympathy all the same, under the same circumstances, if there were not an ear in existence? If so, what could do it but the external, physical force called *sound*? And how could sound do it, if sound exists only in conscious sensation?

No, Doctor, we may rest assured that the lightnings would flash, and the thunders would roar, and the windows would rattle all the same if there were not an eye or an ear in the universe to take cognizance of them; and that the wild rose would continue to "*blush unseen* and waste its *fragrance* on

Q. 9. From what natural analogies may this be inferred?

A. From all the other sensation-producing causes. Heat, for example, may be so trifling that we cannot feel its warmth, while very refined instruments, such as the most sensitive galvanometers, will plainly detect and show its presence. A light may be so faint as to be wholly unrecognizable by our sensations, yet a cat could so gather and utilize the rays, as to see and distinguish objects. Odor may be entirely unrecognizable by our sense of smell, and yet be intensely recognizable by certain species of hound;* etc., etc. So, in like manner, some

* A hound of a certain breed, with highly-sensitive olfactories, will follow the direction of a fox over hill and dale, through for-

the desert air" all the same if there was not one olfactory nerve on this earth to recognize it.

We feel sure, judging by the candid spirit of Dr. Jones' letter of inquiry, that he is honestly desirous of information concerning the teaching of the new philosophy. And we believe there are hundreds of others in the same state of mental suspense. We have, therefore, taken particular pains to make the answer clear.

It is impossible, however, to elucidate everything involved in the great philosophy of Substantialism in a few paragraphs, or even in a few numbers of the *Arena*, and which has taken us more than a decade of years to elaborate. Had Dr. Jones, and many others who make similar inquiries, read our five volumes of the *Microcosm*, beginning with the "Problem of Human Life," they would have found all such inquiries fully answered in advance. We give due notice to all new readers of the *Arena* that they can, at this late date, scarcely ask a question relating to the elementary laws and principles involved in Substantialism, that has not been discussed and answered in some portion of our previous writings. Still, this is not to forestall inquiries. We desire to receive candid questions on all proper subjects, and we will endeavor to answer all such as have an important bearing on the current discussions in the *Arena*.—From the *Scientific Arena*, Vol. I., p. 78.

animals, such as hares, will hear sounds from a distance entirely too faint for human beings to recognize. It has also been proved by the *microphone*, that even small insects have conversational sounds by which they communicate one with another, but which are far too delicate for our unaided ears; just as animalcules have the visual power to see and pursue each other, even when they are beyond the reach of our natural vision, and in fact of the most powerful microscopes.

Q. 10. What is signified by the *intensity* of sound?

A. Inside of our sensations it signifies loudness, but externally or objectively, intensity signifies the strength or quantity of this force generated, and is that attribute

est and jungle, hours after it has passed, and even when it has reached a score of miles ahead. Yet the hound does not depend on touching the tracks of the fox with his nose, or even of following its exact path; but, as observed by the writer (having seen a fox pass hours before, and noting the exact path taken by its feet), will frequently vary rods from the true path, yet, keeping on in the general direction, will pursue his game with unerring certainty.

So defined and substantial are the odorous particles emanating from the footfalls of the fox, that a dog, on striking a trail hours old, will almost instantly decide, by the arrangement of the atoms in the air, the direction it has taken; but, if momentarily mistaking the back-track, the difference, probably, in the intensity of the surcharged air warns him of his error, and leads him to reverse his course.

Before stopping to quibble about the impossibility of sound being substantial emanations from its inconceivable tenuity, let us try to grasp the marvelous lesson taught by this fox and hound. Though the wind may blow across the trail, carrying off for hours the odorous clouds which have risen from the instantaneous impress of the feet upon the earth, filling thus, perhaps, vast areas along the trail with those magical atoms of perfume, exceeding, possibly, in extent many times the four square miles of air surcharged by the locust, yet sufficient odor remains, extending for rods on both sides of the trail, to enable the hound to pursue his distant game with infallible precision.

of sound by which its range of observable distance is caused and determined.

Q. 11. In what does the intensity of sound, external to our senses, chiefly consist?

A. In the amount or quantity of this force generated or liberated from the force-element of Nature, by the various vibratory processes ordained to that end, just as any other form of force, magnetism for example, may exist with greater or less intensity.

Q. 12. On what law or principle does this sound-force travel when thus generated or liberated from the force-element of Nature?

A. By the same law or analogous principle on which

I now ask the puzzled reader, who fails to see how the locust can fill an area two miles square with sonorous substance and not appreciably reduce its weight, to tell me, approximately, how much *reynard* has reduced his feet in size and weight by the clouds of odor diffused along his track for a hundred miles? Though the feet may have deteriorated by the roughness of the journey and their two hundred thousand impacts upon the hard earth, yet I venture the suggestion that the cubic miles of odorous substance which encompassed the trail and guided the hound, did not diminish the weight of either foot an appreciable fraction of a grain. Yet those miles of odor-surcharged atmosphere were filled with *substantial emissions*, as all science unites in assuring us, though not so tenuous, probably, as sonorous substance, yet sufficiently near it to cause the imagination to retire discomfited and confounded.

The reader thus has a rational answer to his question in this somewhat analogous substance of odor, showing that it is not at all among the impossibilities, nor is it even improbable, that the locust should fill such an area with sonorous substance, from this analogue in the fox's feet—whilst not the shadow of an answer can be offered by the advocates of the wave-theory of sound for the reasonableness of corporeal results equal to the mechanical energy of a *million locomotives* ascribed to the physical strength of a single insect.—Dr. Hall, in "Problem of Human Life," p. 135.

any other force of Nature travels, as, for example, electricity, magnetism, light, heat, gravity, etc. Sound travels by a law of conduction or radiation suited to that peculiar form of force, and which law (at present unknown to man) is adapted by the all-wise Author of nature to the various bodies through which sound passes at varying rates of velocity, according as their material particles are variously arranged and held together by the force of cohesive attraction. This involves the law first set forth in the Substantial Philosophy, and alluded to in one of the foregoing chapters of this book, that no form of physical force, aside from cohesion, acts directly upon matter, but that all other forms of force affect matter alone by their co-operation with, or opposition to cohesive force.

Q. 13. What has the vibratory tremor of the conducting body, as, for example, air, to do with sound as a force?

A. Any tremor or vibration observed in air or other sound-conducting medium constitutes no part of sound-force itself, but is either the effect of such force in its action upon material objects, or is incidental to the vibratory process or operation by which sound-force is generated and liberated.

Q. 14. Are there any proofs from natural analogy that this is the correct view?

A. Yes; especially as seen in the case of electricity when generated by the whirling motion of the dynamo-machine. Not only will this generating process produce an incidental tremor of the air, of the conducting wire, and even of the whole building in which the work is carried on, but the electric force itself, thus conducted along the wire, will cause additional motion in an electric engine miles away from the dynamo-machine. As well call this incidental tremor of the wire and of the building, or this running of the distant engine, the electricity

itself, as to call the incidental vibration of the air, or the sympathetic vibration of another instrument near a tuning-fork, the sound-force itself. Both classes of phenomena are equally incidental to, or effects of, these different forms of force, and are no more the force itself, than is the tremor of the flint and steel, when struck, the spark or light-force thus generated and sent forth.* Thus there is not only the incidental motion of

* But the *Standard* critic seems really to have struck a happy thought, and supposes he has effectually caught the substantial philosopher napping at last. He seems to think he has him as safely secured in the meshes of his logical network as any octopus ever had a helpless porgee with his formidable antennæ wound about it. He has discovered that if sound is an *entity*, according to Substantialism, and if the locust *generates* these substantial pulses by its stridulation, then the insect actually creates *something out of nothing*, by scraping its legs across the nervures of its wings! This is plain, he thinks, because no sound was there till the scraping began. Or, if this substantial entity is not created out of nothing, then it must be manufactured out of the insect's organism, so that the poor little thing ought soon to use itself up in its own substantial noise! And still worse, what becomes of this sound-substance when it ceases to be audible? Is it annihilated? etc., etc. I have made the case even stronger than did the critic, to give the Substantial Philosophy a rare opportunity to show its powers of solution and explanation. And here its founder comes to the task, by the remark: "How easy it is for even great men to be mistaken, especially when attempting to criticise something they do not understand or have not thoroughly investigated!" a very sensible remark, by the way. He then proceeds substantially thus: According to Substantialism, the incorporeal *force-element* in Nature, from which sensuous sound is generated by whatever sound-producing instruments, *exists in all matter and space*, not as audible sound, of course, but as its elemental basis, and which only requires the vibratory and atomic process ordained in the economy of Nature for transforming this force-element and thus calling it forth in that *definite form of force which we recognize as sound*. This same universal but indefinite force-principle, by the process of the battery or dynamo-machine, leaps forth in the definite form

adjacent bodies, as the effort of the vibrating instrument which generates sound, but sound-force itself will also produce vibrations in bodies against which it strikes, as for example, the diaphragms of phonographs, telephones, etc., in close proximity to sounding instruments.

Q. 15. As sound-force is not the incidental tremor of the air or of other conducting medium, is the vibration of the fork or of the string itself, by which the sound is produced, any part of the sound-force thus generated?

A. No; this harmonic or pendulous motion, or in other words this synchronous swing of the fork or other sounding instrument, is no more identical with the

of electricity, with its own peculiar properties, and *which has no existence in that form in the air or battery until so transformed and evolved* from this force-reservoir of Nature. Clouds also act as a battery and produce a similar transformation. The same universal element of force, by the peculiar but mysterious relations of the atoms of the steel magnet, pour out transformed into the shape of *magnetic rays* of real incorporeal substance that will lift a bar of iron at a distance even through impervious glass. So also with the substantial light-rays, which are but another transformation from the same fountain or universal element of force, evolved to the sensible form of *light* by various processes ordained in Nature to that end. But it by no means follows that electricity is created out of nothing or returns back to nothing when its substantial manifestations cease; nor is it created out of the substance of the electro-magnets in the dynamo-machine *which will last indefinitely without the slightest wear or deterioration of their material substance*. So a locust, while thus generating substantial sound-pulses, not out of nothing, but evolving them from this same universal, substantial fountain or *force-element*, uses not a particle of its physical organism as a constituent of such sonorous form of force. The *fire-fly*, as the editor shows in the March *Microcosm* in reply to Prof. Goodenow, though but a hundredth part the size of the locust, can be seen half a mile of a dark night, and, therefore, must fill that much space in all directions with its substantial but incorporeal light-corpuscles which it generates at each flash from its thorax, not out of nothing, but out of that same force-

sound-force thus liberated and sent off through the air 1120 feet a second, than is the rotary motion of the dynamo-magnets identical with the electric force sent off through the wire at a velocity of thousands of miles a second. The force and the motions in both cases (both causal and incidental) are entirely distinct from each other. But as the incidental tremor of a building, caused by the running of a dynamo-machine, may also be made to generate other electricity, when properly utilized, so the incidental and synchronous tremor of a conducting medium may itself also cause additional sound. This is illustrated by the sound generated at the distant end of a mechanical telephone wire. The

element which pervades all Nature and supplies each force, when definitely evolved, with properties peculiar to itself. The physical substance of this diminutive insect has nothing to do with constituting that form of substantial force called *light*, since, after thus filling hundreds of cubic miles night after night with actual substance, it has not exhausted its corporeal structure in the least! But what becomes of the *light*, the *sound*, the *electricity*, the *magnetism*, or any other peculiar form of force thus generated, after serving the purpose thus designed in Nature, or after ceasing to manifest itself? It falls back from its definite form into the same indefinite force-element or reservoir from which it was evolved by the process appointed in Nature; and *thus only can the law of the conservation of the forces be true*. Thus also, as the founder of this Substantial Philosophy teaches in his "Problem of Human Life," the vital and mental force of the lower animals at death falls back into the universal fountain of life and mentality from which all substantial life and mind must have originally come, and which reaches back to God himself. He insists that no scientist dares to deny him the right thus to postulate such a universal force-element or fountain from which all forms of manifested force with all their peculiarities come, since this Philosophy solves so many otherwise absolutely inexplicable problems in science, while contradicting nothing that we know surely in any branch of natural philosophy. It would be with an ill grace for scholasticism to deny this right to assume a universal force-element which rationally

sound-force of the voice, caused by the vibration of the vocal organs, may shake the intervening air and set the transmitting diaphragm of the telephone into motion; this communicates the tremor to the conducting wire, which continues it on to the receiving diaphragm, which takes up and communicates these various links of incidental tremors to the air, thus conducting the sound pulses to the ear, all of which vibratory links conspire to keep up reproducing as well as conducting the original sound. Hence, let the vibration of such a mechanical telephone wire be stopped off any where along the line by a rigid vise, and no audible sound will be communi-

solves all the mysterious phenomena of science and which have so long puzzled the schools, when the same scholasticism assumes an all-pervading and *material* luminiferous *ether* for the sole purpose of getting a substance out of which to manufacture light-waves and thus to make light harmonize with an erroneous theory of sound-waves, and all, too, without any rational necessity either for such assumption or such a substance.

But in conclusion, take one more case which the author of the new theory cites as an illustration of the importance of Substantialism in giving a rational solution of Nature's mysterious problems. The flint and steel are perfectly *dark, cold, and silent* bodies. Neither *light, heat, nor sound* addresses our senses as we *look* at them, *feel* of them, or *hold them to our ears*. But bring them together in suitable substantial contact and forthwith there leap away from them a ray of substantial *light*, a flash of substantial *heat*, and a hiss of substantial *sound*! Where were these three substances, or forces, concealed before this contact? Had they no existence in any form, and were they, therefore, created out of nothing? By no manner of means. Plainly, as Substantialism answers, they were all previously locked up, in essence at least, in the all-pervading force-fountain of which we have been speaking, and they only required this substantial contact of the two material bodies to enable them to come forth in the three manifested forms of definite and substantial force as observed. Such are a few of the beauties of the Substantial Philosophy now appealing to the people through the columns of the *Microcosm*,—Eld. Thos. Munnell, in the *Microcosm*, Vol. III., p. 307.

cated to the receiving diaphragm, thus showing how essential is vibration to the usual methods of generating sonorous force.

Q. 16. But does not this view involve the doctrine of sound as a mode of motion?

A. No; sound is one of the forms of physical *force*, and as such, is an objective entity or an immaterial substance. As well call electricity a mode of motion because this form of force moves along a wire, and is usually generated by a motion which shakes the wire as its conducting medium, also shaking the air and the building where the machinery runs. It requires close thinking, but it is scientifically essential to keep up this distinction between any form of *force* liberated and the *mechanical process* or operation which liberates it. Both sound and electricity are usually generated by modes or methods of mechanical motion, but when generated they are analogous forms of force-energy, and are thus real substantial entities.

Q. 17. Is all force necessarily substantial?

A. Yes. Nothing in Nature can directly cause a phenomenon, or produce a positive effect upon our sensuous observation, unless it is a substantial entity or objective thing. Every force of Nature, therefore, must be a substantial entity, as it is the direct or immediate cause of sensation, or of observed phenomena.*

* Having thus reached this field of research, what do we discover? Is it possible in reason that in stepping over this boundary-line of material existences, we have left all real substances behind us when we have parted company with odor? It surely does not seem so to us, or that such a view can be rational to a philosophical investigator. Substantialism teaches, on the contrary, that we have only entered the hitherto unexplored and even almost unrecognized domain of the absolute physical, vital, mental, and spiritual entities which, though immaterial, underlie, manipulate, and control all material bodies, and from which

Q. 18. Does not this make out *motion* itself to be an entity or substantial thing, since it generates or produces *force*—as, for example, in the case of sound and electricity?

A. Not in any strict sense. The exact character or true nature of what is meant by *motion* is somewhat difficult to grasp and define, unless by the most careful mental effort. Strictly speaking, motion is nothing but space, or *position in space changing*. As pure space is nothing, mere position in space, whether stationary or changing, is also nothing. The substance which occupies space, and which is the subject of motion or change of position, is, of course, an entity, as is also that which

domain, as their source, all material worlds have their origin, and from whose delegated power all visible and sensible manifestations are now observed in sensuous phenomena. These real entities, from the most refined spiritual and mental substance in Nature downward through the lower mental powers and instincts and the coarser vital substances of the animal and vegetable kingdoms, still downward through the physical but substantial forces of gravitation, electricity, light, heat, sound, magnetism, etc., are all around us in space as real entitative existences, in ten thousand forms and operations, as Substantialism tells us, had we but the higher mental vision to behold them. And what is peculiar of incorporeal substances, unlike material bodies, they do not interfere with each other in space, but a thousand of such entitative existences can occupy exactly the same corporeal place at the same time. If the physical forces be really immaterial substances, as Substantialism insists, it is plain that gravity not only occupies the minutest molecules of material bodies, but that light, heat, sound, magnetism, and electricity can all occupy the same material atoms at the same instant of time without displacing or in any way interfering with gravity, or one with another.

Thus the mode-of-motion doctrine in the case of magnetism falls to the ground, as it totally fails to account for the action of a magnet on a distant body, leaving magnetic force, as an undeniable incorporeal substance, in peaceable possession of the field. We challenge the scientific world to make any reply to

causes such motion or change of position, which is *force* of some kind. But motion, *per se*, had no existence before the body began to change position, and it has no existence after the body comes to rest, which cannot be said either of the body itself or of the force or energy which caused it to move, both of which, being real objective existences, cannot be annihilated or cease to exist, but must persist in some form. Superficially, therefore, we may say that sound is produced by the motion of the tuning-fork; but, scientifically speaking, sound is produced by the substantial mechanical force or energy which overcomes the inertia of the fork and puts it into motion. As motion is a nonentity, it therefore,

this argument for the absolute existence of immaterial substance—an argument which alone annihilates the mode-of-motion doctrine as applied to other natural forces, leaving them all *entities*, just as required by the Substantial Philosophy. For, plainly, if magnetism is thus proved to be a real substance, by the utter inadequacy of any mere motion of material substance to explain the facts, then gravity must follow as a real, immaterial substance, by applying the very same line of reasoning and illustration; and if these two forces of Nature are thus indubitably shown to be substantial emanations, why not all the others? The argument thus seems absolutely conclusive.

Indeed, may we not claim it to be a truism, so well settled in the very texture of science as to entitle it to be received as axiomatic by any mind capable of philosophical thought, that, as no ponderable body can move of itself, so no body, such as the iron armature referred to, can move unless acted upon by a real substance emanating from some source of power? Can any logical mind dispute such self-evident truth? If not, then have we not, in the most convincing manner, demonstrated in magnetic attraction and repulsion an active, powerful substance existing entirely outside of the domain of materiality, which defies all material conditions or material explanations, and which has not one material property?

True, this magnetic substance appears to cease to exist when it ceases its manifestations. But it does not and cannot cease to exist, in the very nature of things. As it is admitted to be a real *force*, the theory of the “conservation of the forces,” now

in a strict scientific sense, can produce nothing nor cause any effect.

Q. 19. If sound or electricity is generated alone by the mechanical force which gives motion to the fork or magnets, do not these resultant forms of force actually *come into existence* by such process?

A. Yes, in the sense of such manifested or special *forms* of force. But in the sense of the substantial force-element of Nature, the essence of all force, from which these forms of force were liberated or evolved by the physical process named, they did not come into existence by such process, but are the mere conversions from

accepted as science, precludes the possibility of such magnetic substance being annihilated. Whatever becomes of it, and however it may be dispersed throughout space, or be diffused so that its active effects cease to be recognized by us, it nevertheless continues to exist in some essential and substantial form, or the so-called "conservation of the forces" of Nature cannot be true.

Here, then, is where *Substantialism* practically began. Here is where it drove its first stake, pitched its tent, and from which point it took its first philosophical bearings. If one of the acknowledged physical forces, namely *magnetism*, is thus shown to be not a mere technical vaguity or meaningless myth of science, but a real immaterial substance, as we have here found it to be, then reason would tell us, yea does tell us, as just intimated, that every other force is equally substantial, *unless some insuperable difficulty shall be found to interfere which necessarily precludes such substantial hypothesis*. But no such interference in any of the forces, after the most critical and searching investigation, occurs. On the contrary, rather, once admit the existence of immaterial substance as a settled fact, as magnetism compels us to do, and then admit four of the natural forces—*magnetism, gravity, electricity and heat*—to be really substantial, as the first one irresistibly forces us to do, and is it reasonable or philosophical, after such data, not to include every other natural force, or whatever produces sensuous manifestations, in the same category? Thus logically were we led step by step into Substantialism.—Dr. Hall, in *Microcosm*, Vol. III., pp. 270-311.

such force-element, into these forms of force for special manifestations. As substance in the *primordial* sense can neither absolutely come into existence, nor cease to exist, and as this is an indisputable scientific axiom, hence everything in the universe, material and immaterial, must in its finer essence or ultimate substance have always existed—not as gross matter, nor even as the crude force-element, for that matter, but as the infinitely sublimed primordial and incorporeal element or essence from which and out of which the infinite and intelligent *Ego* created all the manifested forms of substance in the universe. The law of the conservation of force, so universally taught and believed, not only proves force in every form to be an entity, but it precludes the possibility of its destruction, as much so as if it were matter itself. If it would be impossible for matter to be annihilated, or converted into *nothing*, it would be equally impossible for matter or any form of force to be created out of nothing. Hence, it is the rational philosophical view, that all substances in Nature, including the forces as well as the force-element from which the various forms of force emanate, were originally, or in their last analysis, the exterior element or substantial clothing, so to speak, of the infinite, substantial, uncreated, and intelligent First Cause of all the entities in the universe. It is therefore regarded as the more rational and philosophical view to take, that the universe was created out of *something* rather than out of *nothing*, since something in abundance may have existed from eternity, as *the things which are not seen—the invisible things of God*—out of which to create every thing, even without involving the idea of the eternity of matter.*

NEW YORK, September 12, 1885.

* *Dear Dr. Hall :*

Your argument in reply to Dr. Stone in the September *Microcosm* has thrown a flood of light on the subject of Creation.

Q. 20. On what analogical ground should sound be regarded as a substantial entity, and not as a mode of motion, as present science teaches?

A. On the analogical ground of the consistent and harmonious uniformity of Nature's laws and principles of proceeding. As heat, electricity, magnetism, etc.—all phenomena-producing causes in Nature—are among the self-evident substantial or entitative forces of Nature, it would be incongruous and out of all consistent harmony, for sound and light, equally phenomena-producing causes, not likewise to be substantial forces or objective entities. And as the senses of *smell*, *taste*, and *tactility*

Clearly, if Dr. Stone's view is correct, *nothing* must be the exact equivalent of an entity, as you have logically insisted. If I were able to "frame" a house out of *nothing*, as the worlds were supposed by Dr. Stone to be "*framed* by the word of God," even if I possessed infinite power, I should regard *nothing* as a good enough *entity* for all practical purposes of material construction. The very fact that God must be immanent or present in Nature, in order to sustain it, according to the faith of most Christians, and the very fact that without the immaterial force of cohesion, as you have shown, all material bodies would at once disappear, is sufficient proof that it is through and by means of the physical forces that God's presence is made manifest in Nature. And if God is actually present in Nature, and controls it through the immaterial force-element in its various manifested forms, there is nothing illogical or irreverent in supposing that this same immaterial element was the original portion of God's exterior essence out of which the worlds were made. How natural, then, is Paul's statement that the worlds were "framed" of *things that do not appear*, or in other words, of the "*invisible things of Him*." Heb xi. 3; Rom. i. 20.

The argument advanced by you in reply to the Rev. Dr. Barr. of Philadelphia, as printed in the "Problem of Human Life," at page 52, is one of the strongest scriptural arguments against the *nothing* theory yet presented, and I cannot imagine how any one would attempt to answer it, namely, that the "*Word was God*," and the "*Word was made flesh*." As the flesh of Christ was literally *material*, it is plain that God did, at least in one instance, himself change into *matter*, and it is equally true

can only be addressed, and their sensuous impressions produced by substantial contact with these organs, it would be entirely unwarranted to suppose an abrupt change to nonentitative motion in the sensations of hearing and sight.

Q. 21. Are there any direct and positive proofs that sound does not consist of air-waves, or of condensations and rarefactions, as taught in the present theory of acoustics?

A. Yes, many such proofs. One is, that if sound is constituted of condensations and rarefactions of the air, caused by the to and fro vibrations of the sounding

that the mere flesh of Christ, after its creation, was no more a part of God than is the flesh of any other person. Then the argument is overwhelming, if *God* as the *Word* could be made into *material flesh*, dare we assert that God as the *Word* could not be made into a material *World* or a material universe? It is also very plain that in the creation of Adam the soul or spiritual part came direct from God, as a part of his own spiritual essence, and by which man was made in the image of God. Is it likely that God made one half of Adam out of his own essential being, and that the other half (or that out of which it was made) came from nothing? Is it not more probable that the whole man, soul, body and spirit, came directly or indirectly from the substantial being of God? Would it not be well for those who advocate the *nothing* hypothesis to stop raising trivial objections long enough to answer a few of your strong arguments?

Query,—If God was in the habit of making *things* out of *nothing*, why did he change his plan and make Adam's body out of the *dust of the earth*? Why did he not consistently adhere to his uniform process and make Adam's body out of *nothing*? If it was actually necessary for God to use some previously existing substance out of which to make so *small a thing* as Adam's body, is it at all likely that he could make larger things, such as *worlds*, out of *nothing*?

ROBERT ROGERS, Office Editor of the *Scientific Arena*.
—*Microcosm*, Vol. V., page 45. See also Chapter I. of this volume.

body, it would follow that the vibrating body of a given size, which makes the greatest condensation and rarefaction of the air, or which swings furthest at a given rate of vibrations per second, should necessarily cause the most intense sound, and consequently should be heard throughout the greatest range of distance.

Q. 22. Are there any exceptions to such a principle in sounding bodies? That is to say, are there any sounding instruments which produce *little vibration or mechanical effects on the air*, and which, at the same time, produce more sound than other instruments of the same pitch of vibrational number which produce *vastly greater atmospheric condensations and rarefactions*?

A. Yes; there are many such conclusive illustrations among sounding bodies. For example, let us strike a tuning-fork heavily when held in the fingers, or thrum a heavy string when stretched over iron supports, and neither of them can be heard more than six or eight feet away, notwithstanding its powerful action on the air in generating so-called condensations and rarefactions. Yet a species of locust, an insect not a thousandth part as heavy, and with not a tenth part as much vibratory motion as the tuning-fork or string, though of the same rate and pitch of tone, when sitting on a green leaf, can be heard a mile in all directions, or more than eight hundred times further away, than can either the fork or the string, while by the actual space filled with its tone, it generates more than 80,000,000 times as much sound. This is conclusive proof that sound does not in any manner consist of air-waves, or of atmospheric condensations or rarefactions, as claimed by former physicists.*

* Now it is a fact that a tuning-fork of the largest size, when caused to vibrate at its best, cannot be heard, held in the open air, half-a-dozen feet away, while one of these locusts, having not a tenth part as much surface by which to act on the air,

Q. 23. Is it possible to generate sound without the vibrating instrument producing condensations of the air?

A. Yes; when the vibrating instrument moves through the air at a velocity so low, that the mobility of the air suffices to restore its equilibrium without its undergoing compression.

Q. 24. Has any such exceedingly slow vibratory velocity ever been observed and measured?

A. Yes; it has been mathematically determined by

and not a tenth the vibratory action or distance of swing, can be distinctly heard more than a mile away, and so loud is its sound when within a few feet of it, that it is almost deafening! If, then, both this insect and the tuning-fork produce their sound by the air-pulses sent off, and by nothing else, will some Prof. Mayer, Tyndall, Stokes, Rood, Helmholtz, Lord Raleigh, or Sir Wm. Thomson rise and explain why it is that the vastly larger and more powerful air-waves or condensations and rarefactions sent off from the tuning-fork make no sensible tone six feet away from their source, while the vastly less agitation of the air by the vastly less surface and less extent of swing of the locust is distinctly audible a mile in all directions? Come, gentlemen, this is a serious matter for your theory, and must be explained unless you intend to abandon it. You dare not ignore the difficulty, or pretend that it is of no consequence. It is of the greatest consequence, because of its great simplicity in reaching the popular mind. The smallest child in school and the most unscientific old lady in the land can see its force against the wave-theory, if they ever saw a tuning-fork or ever heard a locust stridulate. Were the problem involved as deep and abstruse as the density and elasticity formula with Laplace's generation of sonorous heat, or as the mobility and compressibility problem discussed this month, then you might hope that its popular effect would be limited. But you have no such hope in this case. Schoolgirls will soon begin to laugh at the wave-theory of sound as an absurdity, unless you explain how the diminutive locust, not one-thousandth part as heavy as the tuning-fork, with not one-hundredth part as much air-wave-producing effect, can be heard a mile away, while the fork cannot be heard six feet, and still sound be nothing but air-waves!—Dr. Hall, in the *Microcosm*, Vol. III, page 218.

absolute mechanical measurement, that a tuning-fork will sound audibly, held in the fingers, when its prongs, though alternating rapidly, have so nearly come to rest, and consequently when they are moving over such an infinitesimal space at each swing, that their actual velocity of travel, at the swiftest portion of the oscillation, is less than at the rate of *one inch in two years, or about twenty-five thousand times slower than the hour hand of a family clock!*

Q. 25. By what mechanical process is it possible to measure such slow motion?

A. It is done by a method discovered and first announced by A. Wilford Hall, founder of the Substantial Philosophy, as set forth in the *Microcosm*, Vol. III., page 90, and carried out mathematically by Capt. R. Kelso Carter, Professor of Higher Mathematics in Pennsylvania Military Institute, as set forth in the same volume, page 154. This method, though very simple, requires too much space for these answers; so the reader is referred to the volume containing it.*

* We have *demonstrated*, in the *mathematical* sense of the term (and we will not keep the *modus operandi* a secret), that a tuning-fork will sound audibly, held in the fingers, when its prongs are not traveling *to and fro* a distance of the *one sixteen-millionth of an inch!* Doubling this distance, for the swing both ways, and we have the *one eight-millionth* of an inch as the entire travel of the prong through one complete vibration. Let us then use a fork having 256 vibrations in a second and we have the entire distance traveled by such prong but the *one thirty-thousandth of an inch in a second!* Counting the swiftest velocity of the prong's travel at its centre of swing as three times this aggregate distance passed over, which is more than the facts require, and we have, as the unanswerable result, *a fork sounding audibly when its prongs are traveling only at a velocity of the one ten-thousandth of an inch in a second at its swiftest motion, or at the rate of about one-third of an inch in an hour!* Is any professor of physics in America or elsewhere prepared to assert that such velocity of travel by a tuning-fork's prong will con-

Q. 26. By what law of physics is the necessary velocity of a body moving in a free fluid determined in order to outstrip mobility and begin to produce compression?

A. By what Dr. Hall was first to announce as the *union-limit* in every fluid between its mobility and its compressibility, or the point at which velocity of motion has so increased that mobility alone cannot restore displacement quick enough, and compression must therefore begin. This union-limit is lowest of course in the lighter and more compressible gases, and becomes higher and higher, requiring greater and greater velocity of the moving body, as the compressibility of the fluid increases.

dense the air and send off air-waves at the velocity of sound, or 1120 feet in a second? Yet it is a positive fact that Prof. Tyndall describes this very motion of the prong—one *third of an inch in an hour*—as “*swiftly* advancing,” while the greatest living physicist—Prof. Helmholtz—declares that such prong, in order to produce sound, must travel “*very much faster*” than the pendulum of a clock in full swing! Is it possible that the professors of our great colleges will not be able to see and feel the annihilating force of this demonstration against the received theory of acoustics?

But the scientific student naturally asks, and has a right to ask, how is it possible for you to “demonstrate” mathematically and mechanically such an astonishing result, and thus actually measure the travel of a prong when swinging to and fro a distance of only the one *sixteen-millionth* of an inch? We answer, easily enough. It only requires a little practical, original common sense, after first entirely ignoring the misleading text-books on the subject, and any beginner in natural philosophy, having a good tuning-fork, can make the same demonstration. Here it is, and let wave-theorists take particular notice.

From *Microcosm*, Vol. III, page 91. The following is Capt. Carter's confirmation and description of Dr. Hall's demonstration:

CAPT. CARTER'S REPORT.

DEAR DR. HALL,—According to my promise, as printed in the November *Microcosm*, I now proceed to give you my report of experiments on the slow motion of a tuning-fork's prongs, in confirmation of your “finishing demonstration” as given in

The union-limit for such compression-velocity is rationally to be calculated from the two factors, namely, the superficial area of the moving body, and the density of the fluid.

Q. 27. What general proof is there that this law of union-limit between mobility and compressibility must hold good?

A. The fact that water is practically incompressible, except when great mechanical force is employed, and the ease with which mobility entirely suffices for restoring equilibrium when the weakest fishes can make rapid headway through it, thereby allowing of easy displace-

reply to Prof. Stahr, in the October *Microcosm*. The following are the results of my experiments:

I used a large Koenig fork of 256 vibrations. Striking it heavily and holding it upright in my fingers, I found that its sound was clearly audible (either held to the ear or through a long rubber tube,) at the end of *four minutes*. By means of a finely graduated scale I easily measured the amplitude of the fork's swing: I found it to be at first 4-60 (1-15) of an inch. At the end of fifteen seconds it had reduced to 1-60 of an inch amplitude. At the end of fifteen seconds more, its motion was barely visible against the sky. Now I can easily see a line of 1-240 of an inch in breadth, which proves that the amplitude had again diminished to one-fourth. In the third fifteen seconds, the motion had become totally invisible, even through a good magnifier. Safe to assume another fourth, or a reduction of amplitude to 1-960 of an inch for each swing.

Now there are sixteen times fifteen seconds in four minutes, hence I have the 1-15 of an inch swing reduced by four as a divisor, sixteen times, or in round numbers to 1-64,000,000,000 of an inch at each swing. As the prong swings through this amplitude, counting both directions, 512 times in a second, we have the entire distance the prong travels, while still sounding audibly, but the 1-123,000,000 of an inch in a second. There are in round numbers 31,500,000 seconds in a year. Hence the prong moves at the rate of only about *one inch in four years!* Allowing one-half for the swifter travel of the prong at the center as compared with its average travel throughout a swing,

ments and restorations of this fluid by mobility alone. Then the additional fact that water, even if this small fraction of remaining compressibility were removed, would still be practically as mobile as it is now, causing fishes to experience no more inconvenience in making headway through it than at present, is a clear proof that mobility in air is all that is needed for the restoration of equilibrium without compression, especially when a body moves slowly through it, as is the case with all vibrating instruments, their very swiftest travel being of less velocity than a dozen feet in a second. Should the remaining small fraction of compressibility be removed from

and we have the astounding fact that the fork continues to produce audible sound *while its prongs, at their swiftest motion, are not traveling at a velocity of more than one inch in two years!* As your demonstration only brought down the prong's swiftest travel while still sounding to *one inch in three hours*, I have, therefore, made the proof more than 5000 times stronger against the wave-theory than you had it, instead of 400 times, as I promised last month. Let physicists dispose of these figures if they can, or forever after hold their peace.

Yours, for the truth,

R. KELSO CARTER.

REMARKS ON THE FOREGOING, BY DR. HALL.

We sincerely thank our excellent contributor, Captain Carter, for his efficient aid in carrying out our demonstration against the wave-theory to its legitimate result, by means of his superior fork and his mathematical skill. Think of the astonishing fact of a fork sounding audibly when the swiftest travel of its prongs is only at a velocity of *one inch in two years*, and then compare this with the well-known teaching of the text-books! As proof that this demonstration leaves the wave-theory hopelessly broken down, we simply quote the following from Prof. Tyndall's text-book, which is a standard authority on acoustics in all colleges:

"Imagine one of the prongs of the vibrating fork *swiftly advancing*. It compresses the air immediately in front of it, and when it retreats it leaves a *partial vacuum* behind, the process being repeated at every subsequent advance and retreat. The *whole function* of the tuning-fork is to *carve the air into*

water, the union-limit in such case would rise to infinity, mobility alone answering every purpose of restoring equilibrium and adjusting displacements, whatever the velocity or superficial area of the displacing body might be.

Q. 28. What is the logical inference intended to be drawn from the foregoing facts and laws?

A. If mobility alone could suffice for the restoration of all displacements, even if a cannon ball should pass under full velocity through such a fluid, and without necessitating any compression whatever, is it not positive proof that the velocity of a moving prong 25,000 times less than that of the hour hand of a clock, does not condense the air at all? This being so, is it not proof equally positive, that the sound heard in the case of such slow motion, is not the result of air-waves, but that it

these condensations and rarefactions."—*Lecture on Sound*, p. 62.

Professor Helmholtz, the highest living authority on acoustics, maintains the same view; and insists in various ways, that the vibrating prong or string must pass swiftly through the air, in order to condense it and send off air-waves. Here is a specimen of his teaching:

"The pendulum swings from the right to the left with a uniform motion. . . . Near to either end of its path it moves slowly, and in the middle *fast*. Among sonorous bodies which move in the same way, only *very much faster*, we may mention *tuning-forks*."—*Sensations of Tone*, p. 28.

How preposterous all this now appears after reading the startling facts as arrayed in Capt. Carter's Report!

We now earnestly ask every candid student of science to examine this unavoidable teaching of the wave-theory in the light of the absolute facts here developed that the prong instead of "*swiftly advancing*," sounds audibly *when moving more than 25,000 times slower than the hour-hand of a family clock, and more than 300,000,000 times slower than any clock-pendulum ever constructed, instead of "very much faster," as Helmholtz teaches!*—*Microcosm*, Vol. III, pages 154, 155.

must be a substantial force, evolved and sent off, analogous to electricity?*

Q. 29. If air-waves, or atmospheric condensations and rarefactions, do not constitute sound, how are we to account for the fact that no sound is heard from a ringing bell in an exhausted receiver?

A. Substantial sound-force requires a conducting medium as much as substantial electric force. The air being the ordinary conductor of sound, it follows that the sound of a perfectly insulated bell in an exhausted receiver has no medium of conduction to the outside air,

* Having thus premised, let us in all seriousness come directly to the merits of the discussion, and see if this controversy cannot be ended. Now I assert, as a scientific proposition, that the motion of a body *below a certain velocity* in a mobile fluid *can produce no compression or condensation whatever, either at the commencement of the motion or at any part of its continuance.* In other words, I undertake to show that *mobility alone* is abundantly sufficient to provide the facilities for restoring equilibrium in the disturbance of every mobile fluid, and thus to prevent any possible condensation of its particles *if the velocity of motion causing the disturbance is below a certain rate*, which rate I will approximately assign as the discussion advances. But as the reasoning and proofs leading to these important conclusions necessarily involve laws and principles of physics never before presented, and not of course to be found in any scientific book, I will be compelled to be somewhat prolix in their introduction, so that one addicted to the old grooves of science like yourself may comprehend their force and bearing.

In the first place allow me to state that *mobility* and *compressibility* in a given fluid, such as air or water, are two separate and distinct properties of matter; but they necessarily co-operate in the phenomena of condensations, rarefactions, pulses, etc., such as we are here discussing. Now let me state a law before attempting to go further. That law is this, that in a given fluid the properties of *mobility* and *compressibility* have a point of *union-limit* as to velocity for co-operation; below this limit no velocity of a moving body can produce compression either at its start or anywhere else. That is to say, the *mobility*

and hence cannot be heard. But let the bell rest on the wooden bed of the receiver, and it can be heard about as well in the vacuum as with the receiver full of air, since the wood now becomes the sound-conductor to the outside air, and through it to the ear.

Q. 30. What part does resonance play in the production of sound?

A. It augments or multiplies sound by more widely distributing this substantial force through the air, some-

of the fluid has such effect as to restore equilibrium or equalize the displacement of particles before and behind the displacing body without any compression whatever taking place until the velocity of motion has reached this point of *union-limit* between the two properties, when compression first begins, and then increases more and more in the exact ratio as the velocity of motion is augmented. Thus we begin to see light shining upon a problem which your bare assertions about the commencement or the "first instant" of a motion exceeding the limits of mobility, would leave forever in the dark.

If the compressibility of a fluid be very low, that is, if it requires very little force to compress it, as in the case of air, then the *union-limit* of the two properties in that fluid is correspondingly low, and the velocity of motion required to compress is low in the same ratio; that is to say, it requires but a very moderate velocity to reach this compression-point or limit and begin condensation. But if the compressibility of a fluid be high, that is, if it require great force to compress it, as in the case of water or quicksilver, then the *union-limit* in that fluid, as well as the velocity of motion needed to begin compression, must be correspondingly high. Hence a condensation in such a fluid (nearly incompressible like water) requires manifold greater velocity in the moving body than in air.

Now, I purpose to startle you by an assertion which, if correct, upsets all you have written or ever can write on this subject, but which assertion will be borne out by facts and reason, namely, that *there is absolutely no limit to the property of mobility in a mobile fluid like air or water, and that no motion of a body, however high its velocity, could overcome the effect of mobility to restore equilibrium without condensation even in air if this property were alone involved.* But compressibility comes

thing as heat-force of a given quantity would have a more intensified radiation if spread out over the surface of suitable metal.

Q. 31. Is not the resonant increase or augmentation of sound caused by the increased vibratory surface of the sound-boards employed in musical instruments, such as pianos, harps, violins, etc.

A. No, not in the slightest degree. A tuning-fork, for example, will increase its sound a hundredfold in

in as a correlated property of fluids, and as soon as the restoring effect of *mobility* has reached their *union-limit* of velocity, compressibility joins in the effect, and then part of the effect which mobility, if alone, would easily have accomplished in producing restoration of equilibrium is converted into condensation and a consequent pulse through this co-operating property of compressibility. Let me now demonstrate this law and general statement to be true in science. Air is known to be fully 10,000 times as compressible as water, yet the mobility of water is the same exactly as that of air, so far as any difference can be detected by science. Now, as water is almost wholly incompressible, it is reasonable to believe if it were reduced to absolute *incompressibility* that it would still be just as mobile as it is now, since no lessening of mobility occurs in 10,000 reductions of compressibility from that of air. The grand scientific result and conclusion follow, and which annihilate your pivotal argument, and with it of course the wave-theory, that in such an incompressible fluid *the mobility of the particles alone would allow any and all displacements to be restored, whatever the velocity or size of the moving body, since, as a matter of course, no condensation or pulse could occur, under whatever velocity, in an incompressible fluid!* Hence mobility, *per se*, is absolutely without limit in its capacity for allowing, when necessary, the restoration of displaced particles in a mobile fluid.

Thus our new scientific law is sustained, and your supposed overwhelming argument, to save the wave-theory, and upon which you have fatally staked the whole controversy, has been logically turned against you, since you must see how easy it is for our position to be correct, that mobility is all-sufficient to permit the restoration of equilibrium among air-particles, *under very low velocity*, without touching the *union-limit* of com-

range and intensity if held against a block of suitable resonant wood of no more surface area to act on the air than the fork itself; while, if held against a piece of iron of the same size, and causing an equal augmentation of atmospheric disturbance as will the block of wood, this added iron surface will not add perceptibly to the volume of tone caused by the naked fork, thus proving that the increased tremulous action on the air is not the cause of resonance.

pressibility, and without the slightest condensation or pulse resulting either at the commencement of the motion or at any other part of it, *since this same mobility would defy the highest possible velocity in air, and alone adjust all disturbances but for the mere contingency of the presence of the correlated property of compressibility!* When *mobility alone*, in an incompressible fluid, would be all-sufficient to restore any possible displacement without a condensation, as you now find yourself forced to admit, have you any logical right to deny our velocity-limit in air, up to which mobility alone suffices for restoring equilibrium without calling to its aid the other property of compressibility?

Let me, however, before leaving this revolutionary point, tighten up the cords a little about the neck of the now already strangled theory of "condensations and rarefactions" as constituting sound, by asking a few questions: Would you pretend to believe that a fish now moves its fins any easier owing to the present inappreciable fraction of compressibility remaining in water? Do you seriously believe that a tadpole swims by actually compressing the water and by sending off condensations and rarefactions as it waggles its tail? Or do you take the common-sense view, as I have just presented it, that the *mobility alone* of this almost incompressible fluid is all-sufficient for the needs of the tadpole in its displacing operations? But finally—I put the question in all candor: Suppose the remainder of the water's small fraction of compressibility were removed, would not a fish displace the water with its fins just as easily as it does now? and would it not make its usual headway by using the *mobility of the water alone for displacement, just as at present?*—Dr. Hall, in *Microcosm*, Vol. IV., p. 313; written at request of Dr. Henry A. Mott, in reply to one of his scientific correspondents.

Q. 32. Is there any difference in the velocity of sounds of different pitch or different intensity?

A. No; the velocity of sound is the same in a given medium, whether the sounds be soft or loud, high or low, simple or complex. The velocity of all sounds in air is about 1120 feet in a second, at the temperature of 60 deg. F. If colder, a rearrangement of the air-particles takes place under the action of cohesive force, causing sound to travel slower. This fact of the uniform velocity of all sounds in air at a given temperature is verified by listening to the playing of a band of music at a distance, all the sounds, however varying in intensity and pitch, reaching the observer in perfect time.

Q. 33. What causes all sounds to travel at a given velocity in a given body?

A. This natural law of sound-conduction in different bodies, like the law of resonance or sound-augmentation, is not entirely known at present, any more than it is known on just what law or principle electricity travels with greater facility through some substances than through others, and will not even travel at all, *perceptibly*, through some bodies—as, for instance, glass. The most rational solution of these differences is given in the correlation of the physical forces. The substantial force of cohesion, which originally arranged and now holds the particles of all bodies together, co-operates with the other physical forces such as sound, light, heat, electricity, etc., in their passage through material bodies, thus permitting their passage with greater or less freedom, or refusing their passage altogether.

Q. 34. Has not the relation of density and elasticity something to do with this rate of sound-velocity through different bodies?

A. No; since this old formula of the ratio of sound-travel is contradicted in almost every separate substance tested. Lead, for example, one of the most inelastic, as

well as one of the densest of bodies, conveys sound many times faster than does air, one of the least dense, and one of the most elastic of all known bodies.

Q. 35. But has not the relation of density to elasticity in *air* been proved exactly to correspond to the observed velocity of sound at different temperatures?

A. No, but right the reverse. Sir Isaac Newton, who formulated this law of the relation of density to elasticity in air and other bodies, as the basis of the current theory of sound-velocity, found that the observed velocity of sound in air exceeded such formula by 174 feet a second, or nearly one-sixth of the velocity, thus himself breaking down the wave-theory of sound by the very law upon which it was based. But not supposing any other theory of sound possible than that of wave-motion, or of the condensations and rarefactions of the air, Newton was at a total loss to explain this apparently fatal discrepancy between the formulated theory and actual observation.

Q. 36. Has there been no explanation of this discrepancy since Newton's time by which to make this theory of sound-velocity in air conform to observation?

A. Yes; there has been a hypothesis suggested by Laplace, and elaborately illustrated by Prof. Tyndall, that the condensations and rarefactions of the air, supposed to constitute sound, alternately generate heat and cold by squeezing the particles of air together and by which the elasticity of the air is augmented sufficiently to increase the velocity of sound one-sixth or 174 feet a second. In other words that the sound itself, in passing through the air, so changes the relation of its density to its elasticity, by the alternate condensations and rarefactions of the sound-waves themselves, as to make up this discrepancy found by Newton a hypothesis which no scientist since the time of Laplace has questioned.

Q. 37. Is it really possible that this explanation or solution, as invented by Laplace, is now adopted by the colleges and universities of the world as an essential part of the wave-theory of sound?

A. Undoubtedly. Scientists could conceive no other theory of sound, save that of air-waves, and although the theory itself was fairly broken down by Newton, they clung to it as better than no theory at all, and hence accepted the hypothesis of Laplace, weak as it was, which is now set forth in our text-books, and is universally taught in our colleges and universities as an essential part of the wave-theory of sound, since to abandon this solution of Laplace would be to abandon the theory itself.

Q. 38. What evidence is there that sound itself cannot thus generate heat, and augment the elasticity of the air as Laplace supposes, sufficiently to add 174 feet a second to sound-velocity?

A. Such evidence exists in the very nature of the mechanical operation producing sound according to the wave-theory. No compression of the air can be produced at a distance from the sounding body, by which such sensible heat can be generated as to add this large per cent of velocity (one sixth) to the sound itself, unless that compressing energy be actually exerted mechanically by the vibrating instrument itself. This would seem to be a mechanical truism, requiring no proof. Now to increase the elasticity of the air one sixth throughout the known range of sound, by the added heat thus caused by mechanical pressure, must require an enormous squeezing force to be exerted by these sound-waves as they travel, all of which mechanical force must be originally exerted by the vibratory motion of the sounding instrument itself at the origin of this system of condensation and rarefaction. But the worst feature of this supposed generation of heat by atmospheric condensations, is the fact that it was shown by the new law discovered by Dr. Hall, that

no appreciable heat is generated by the compression of air, the intensified heat observed in suddenly compressed air, being almost solely the heat which was in the air before compression began, such observed heat being merely the original heat concentrated to a smaller space.*

Q. 39. Can any special example be furnished in which such mechanical result as supposed by Laplace would be impossible, even if heat is generated by compression?

A. Yes; take the locust for example, which weighs but a few grains and can exert but a correspondingly minute mechanical force upon the air, yet whose sound can be heard more than a mile in all directions, thus filling four cubic miles of air with these supposed condensations and rarefactions. If the view of Laplace be correct, this enormous mass of air must be so compressed and rarefied by the physical energy exerted by this trifling insect alone, as to add one sixth to the elasticity of the air, and thus augment the velocity of the insect's sound, 174 feet a second.

Q. 40. Has any high authority in this department of physics ever calculated the real mechanical energy which is exerted in the compression of a sound-wave by which such a requisite amount of heat and electricity can be added to the air as required by the solution of Laplace?

A. Yes; Prof. Alfred M. Mayer, of the Stevens Institute, Hoboken, N. J., the highest authority on the subject in the United States, in his article on sound in "Appleton's New American Encyclopedia," says:

"This compresssion gives for the compressed half of the wave an increase of 1-679th *to the ordinary density of the atmosphere!*"

Now as each cubic inch of air in the four cubic miles

* See the new law of the cause of heat in compressed air, as first announced by Dr. Hall, copied near the close of the Eighth Chapter.

filled by the insect's sound is either compressed or expanded 1-679th more than the ordinary air (and it requires the same mechanical energy to rarefy as to condense, at least up to fifteen pounds rarefaction), it follows that this insect must exert a mechanical compressing and expanding energy of more than 5,000,000,000 tons on this mass of air, in order to change it 1-679 from its normal density, and thus make the sound of the locust fit the formula of Laplace. Any one can verify our figures by a little effort.*

* This want of scientific intelligence, however, is not a mere mental lapse on the part of our eminent physicist, but is chargeable chiefly to the inherent incongruity of a theory of science false to the very core. Daniels, of Scotland, the author of the ablest text-book on physics ever published, and which has recently been issued, falls into the same prodigious error in trying to account for the wonderful difference in loudness of various sounding bodies, which, as observation assures us, is out of all proportion to the mechanical effects they exert upon the air, and which so clearly conflicts with modern science. Being wholly unaware of the aid which Substantialism renders in such cases, and without one ray of light from the wave-theory to help him, he grasps wildly in the dark at the only straw in reach, namely, that the observed loudness of certain insects, for example, *is due to their pitch—that is, to their great number of vibrations in a second!* (See Daniels on "Principles of Physics, p. 368.) Had this high authority chanced to read the "Problem of Human Life," or several recent articles in this magazine on that question, he would have been informed to his surprise that the famous locust, which can be heard a mile, makes the loudest part of its stridulation at the pitch of A (440 vibrations in a second), at which pitch a naked tuning-fork, with more than ten times as much mechanical effect upon the air as that exerted by the insect, *cannot be heard six feet away, and consequently can produce but the 1-80,000,000 as much volume of sound as does the insect!*—See *Microcosm*, Vol. IV., pp. 318, 381; Vol. V., p. 38.

Had Prof. Daniels stopped to reflect, he would have been overwhelmed with confusion by the simple fact that a very small tuning-fork held in the fingers, or a very fine, short wire

Q. 41. Is not the great force of sound which is exhibited in the destructive effects of magazine explosions, such as the destruction of buildings and the breaking of windows miles away, favorable to the hypothesis of Laplace?

A. These destructive effects observed as the results of magazine explosions, are not caused by the sound at all, as mistakenly supposed, but result from the instantaneous

stretched over rigid iron supports, when vibrating four thousand times in a second, can be heard no farther away than when vibrating one-fiftieth as often, or only eighty times a second! Indeed, the facts in the case are directly the reverse of what Prof. Daniels sets forth, since the tuning-fork of very high pitch cannot be heard nearly as far as one of a vastly less number of vibrations! How neatly would this simple little fact have wiped out his "insect" illustration of the supposed cause of the marvelous loudness of such sounds based on their supposed pitch! Yet that famed authority was not capable of evolving so simple an overturn to his fallacious explanation.

His oversight, however, was manifestly due to his theory, and not to his intellect. He was prevented by the misleading nature of that theory from grasping the essential LAW of physical science: *that sound, instead of being the mechanical effect produced upon the air by the vibrating instrument, and conveyed through it in pulses or atmospheric waves, is a real substantial, but immaterial force, and depends for its intensity or quantity upon the sonorous character of the sounding instrument itself vastly more than upon its mechanical motion, just as the amount of substantial electricity issued from a dynamo machine depends chiefly upon the electrical quality of the magnetic apparatus, and secondarily upon the mechanical rotation given it.*

This important law we have given in substance in the different editorials to which we referred a moment ago, but we have not before emphasized it as we now do, as an impregnable law of science, upon which the substantial character of sound as one of the forces of Nature may alone rely without the fear of successful assault. It stands, as a new and overwhelming discovery, in the same relation to *sound* that the law announced last month (page 160) occupies in relation to the substantial nature of *heat*, and these two laws should be placed side by side in the ultimate formula of the Substantial Philosophy.

generation of an enormous quantity of powder-gas, which, by its expansive force, drives the air away on all sides in a condensed wave, and which produces all the destruction witnessed. This addition of gas and this condensation of the surrounding air thereby, occurring as they frequently do to distant observers simultaneously with the sound-report, have been mistaken by physicists for the sound itself, and hence the most learned investigators, including such men as Profs. Tyndall, Mayer and Helmholtz,

We thus begin to realize the revolutionary value of the fact so frequently reiterated in these pages that the locust with one-tenth as much vibratory action on the air as that produced by a tuning-fork of the same pitch, can be heard 880 times farther away, while it actually generates 80,000,000 times as much sound! This beautiful revelation of science, which has been hidden from the eyes of the world through ages past, remained for the Substantial Philosophy to unfold. No better proof of the far-reaching value of Substantialism can be required than the marked contrast thus pointed out between the best outgivings of modern science and the new departures in the realm of physics here unfolded.

In the light of such discoveries (and this is but one in a score equally important recently announced in the *Microcosm*), how invincibly must the Substantial Philosophy appeal to the intelligence of mankind in its mighty sweep through the wildering mazes and mysteries of physical science! Substantialism sees no more difficulty in solving the seeming inexplicable problem of the vastly varying intensities of different sounds, without any reference to atmospheric disturbance, against which Daniels, Mayer, Tyndall, and Helmholtz stagger and turn pale, than it originally saw in correctly explaining the blowing out of a candle by the clapping of two books at one end of a long tin tube, or in solving the mystery of the breaking of windows by a "sound-pulse" miles away from a magazine explosion, upon which Prof. Tyndall found himself and his theory totally at sea. Had the great physicists we are noticing possessed the magnanimity and fairness which should characterize all true scientific investigators, they would long since have cheerfully accepted the aid in their perplexing physical researches which the Substantial Philosophy alone can give.—Dr. Hall's reply to Prof. Mayer, *Microcosm*, Vol. V., page 231,

have taught that it was the *noise* or *sound-wave* which caused the observed destructive effects near exploding magazines. Whereas the sound-report of such explosion *per se* would not stir the feather of a bird, except by sympathetic vibration, which exerts no appreciable mechanical force.

Q. 42. Is there any direct proof that sound itself has nothing to do with these destructive effects, and that all scientific writers on acoustics have heretofore been mistaken?

A. Yes; there is the direct proof that the most intense sound-report which ever addressed human ears—as in the case of a crash of thunder right in the building where the bolt strikes, produces no destructive effect whatever, not a pane of glass being cracked or disturbed, except in the very path of the electric bolt in reaching the earth. The reason for this is plain, namely, that this thunder-peal is unaccompanied by any addition of gas by which a condensed air-wave is generated and sent forth on its destructive errand.

Q. 43. Why has not this apparently self-evident solution of the problem in question been given by former physicists?

A. Because the wave-theory, which teaches that sound consists of condensations and rarefactions of the air, had a blinding and misleading effect on the minds of its adherents, causing them, without due reflection, to jump to the conclusion that the manifest condensation observed at a magazine explosion, by which windows are crushed miles away, must be that of the sound itself, which occurs at the same time. Having accepted an impossible theory of science, they were naturally led to distort irrelevant phenomena in its favor.

Q. 44. Is there any way of proving that the sound-report and the condensed wave of air at an explosion of powder, are two separate and distinct phenomena?

A. Yes, by a plan originally suggested in the "Problem of Human Life," by its author, to arrange and cause an explosion of powder to occur at a definite instant, and then to time the separate arrivals of the sound-report and of the compressed wave, at stations fixed at different distances away, tested and recorded by suitable instruments. It was predicted, and will no doubt be verified by experiment, that at or near the start, in case of a heavy explosion, the compressed wave, or the atmospheric concussion, will vastly outstrip the sound, while at a greater distance they will arrive simultaneously, but at a still greater distance, that the sound will pass and outstrip the lagging concussive shock by some seconds. The reason given for this probability is, that sound travels at a uniform rate of velocity, by its law of conduction, throughout its entire range, while it is equally evident that the condensed air-wave, caused by the instantaneous addition of gas, must travel much faster at the start of its journey than after it has progressed some distance, or after it has become weakened in force by increasing the quantity of air under compression, according to the well-known law of the square of the distance from the explosion.

Q. 45. Will sound-force, *per se*, produce any sensible effect in disturbing or displacing material bodies?

A. Yes, it will, as recently hinted, move a body unisonantly into sympathetic vibration. Such body, however, must be capable, firstly, of itself producing sound, and secondly, must be tuned in unison with the actuating instrument in order to be stirred sympathetically. The substantial sound-force, issuing from the sounding instrument in sonorous pulses or jets of force corresponding to its vibrational number, strikes the unison instrument, which being tuned to the same pitch, stands ready to act sympathetically and respond by absorbing the force, so to speak, thus reproducing the same tone, though with much less intensity. There is nothing

more surprising in this sympathetic action of a suitable instrument by substantial sound-force, than in the action of substantial magnetism, which draws a piece of metal which happens to be in sympathy with it, such as *iron*, for example, while producing no physical-effect whatever upon unsympathetic metals, such as gold, silver, copper, etc.

Q. 46. Would not sound if constituted of air-waves, also explain sympathetic vibration in a distant unison instrument, by the continuous dashing of such waves against it synchronously with its own vibrational number, until it finally gets into motion?

A. No; in the first place it would be physically and mechanically impossible for a vibrating tuning-fork, for example, to send off air-waves or atmospheric pulses 180 feet, and thus put another fork into motion by their material contact with the prongs. Yet one fork, heavily bowed, has been known to start another that distance apart, both being in sympathetic unison and mounted on their resonant cases so as to have their sympathies augmented by the sonorous or resonant quality of these wooden cases.

Q. 47. What experiment, if any, will tend to confirm this view, namely: that it is the substantial sound-force which affects and starts the distant forks into sympathetic action, and not the condensations and rarefactions of the air, as the wave-theory teaches?

A. Remove the two forks from these resonant cases of *wood*, and place them on *iron* cases of the same size, which will vibrate and disturb the air with even more mechanical force than will the wooden cases, though with but a small fraction of the volume of sound; and however heavily the actuating fork may be bowed and set into vibration, no sympathetic effect will be produced on the other fork, even if only one-tenth that distance or eighteen feet away, notwithstanding the same or even

greater action is thereby transferred to the air. The reason for this is plain, that the sympathetic effect is only caused by, and proportional to, the sound-force which reaches the distant unbowed fork, and has nothing whatever to do with the supposed air-waves sent against the distant fork or its resonant case.*

Q. 48. How about the law of *sound-interference*, by which two systems of sound-waves may travel in such relation to each other, as to extinguish both sounds and thus cause total silence?

A. There is no truth in that law, though it has always been taught as an essential part of the wave-theory, and should be true if there is any truth in that theory. It was naturally inferred, since sound consisted, as supposed, of atmospheric undulations, that the same inter-

* As a proof that the sympathetic vibration of a unison body is not caused by the periodic impulses imparted to it through air-waves sent off from the actuating string or fork, I refer the reader to the unanswerable fact that a body may vibrate or oscillate ever so nearly to another body tuned in perfect synchronism with its own swing, and ever so rapidly, but so long as no audible tone is produced by these vibrations no motion whatever will be communicated to the unison neighbor, though it necessarily and continuously receives the synchronous air-waves driven against it by the actuating body. I have carefully tested this in the following manner: I arranged two pendulum-balls, with very short rods of equal length, to cause rapid swings as closely together as possible without touching, being careful that their supports had no immediate connection (except the air) by which any impulse might be communicated from the moving ball to the one at rest. Though their swings were in perfect synchronism, *moving with twice the aggregate velocity of a tuning-fork's prongs*, and although they were so near together that the air-disturbances caused by the moving pendulum must necessarily strike the other periodically, or as nearly so as it is possible for air-waves to travel, yet no motion whatever was communicated to the one at rest, for the best of all possible reasons — *there was no tone produced.*

This is also illustrated in the case of a sonometer-string, if

ference should necessarily take place in sound-waves, as in the case of water-waves where undulations do actually exist. In water-waves it is well known, that if two equal systems of waves so travel together that the crests of one system shall fall into the troughs or sinuses of the other system, the two will substantially neutralize each other, and cause a quiescence of the water. Now if sound in air consists of waves of condensations and rarefactions, it is plain, if two sounds or systems of sonorous air-waves, of equal wave-length (pitch), and of equal degree of condensation and rarefaction (intensity), should so travel together that the condensations of one system shall fall into the rarefactions of the other system, etc., that quiescence should result as truly in air-waves

taken from its sounding-board and stretched over isolated pieces of rigid iron; though it will vibrate when plucked just the same, and "carve" or "mold" the air into waves, as Prof. Tyndall expresses it, just to the same extent exactly as when in connection with its sounding-tray, yet its sounds can scarcely be heard by a person standing near it, for the want of a resonant body to augment its tone by diffusion, as will be explained after a little. A string in this condition will not start a unison body into sympathetic vibration even if but a few inches distant, and then only in exact proportion to the intensity of its sound, and not at all in proportion to the amplitude of the air-waves "molded," "carved," and sent off by its oscillations, which are exactly the same whether such string is connected with the sounding-board or not. If the air-waves are really molded and sent off by the harp-string, with "condensations and rarefactions" traveling 1120 feet a second, as so explicitly taught by Prof. Tyndall (see extracts 7 and 8, pp. 78, 79), and if these air-waves are really the cause of sympathetic vibration in a distant unison string or fork, then pray tell us why the sonometer-string can cause no response to its unison neighbor a foot from it, though it "carves," "molds," and sends off the same air-waves it does when placed on its sounding-board? The air-wave hypothesis must therefore completely break down as the solution of sympathetic vibration.—Dr. Hall, in "Problem of Human Life," p. 81.

as in the case of water-waves, and that consequently the sound, which consists only of such atmospheric disturbances, should cease to be heard by such interference.

Q. 49. Is this the law of interference as taught in the wave-theory of sound, or as at present taught in our schools?

A. Yes; this is the law as laid down in all text-books on acoustics, and it is taught, or at least was taught, as settled scientific truth in every college on earth, previous to the publication of the "Problem of Human Life," a few schools and colleges since that time having abandoned the wave-theory for the substantial theory as was announced and maintained by Dr. Hall, and as here, for the first time, put into formulated shape.

Q. 50. Does any text-book plainly teach, in accordance with this law, that if two unison instruments were sounded half a wave-length apart, they would neutralize or destroy each other's sound?

A. Yes, in the plainest language imaginable. Prof. Tyndal's book on sound, for example, lays it down as an experimental fact, that two unison forks so sounded, half a wave-length apart, will totally destroy each other's sound by causing quiescence in the air, on the same principle as quiescence in the case of water-waves is super-induced when in a state of interference; and, as it would seem, lest the scientific student of his book, or the teacher should fail to grasp the fact, Prof. Tyndall illustrates it by a diagram of two turning-forks thus placed, first a wave-length apart (with dark and light shadings of the air) so as to augment each other's sound, and then a half wave-length apart, in which position, by an even or uniform tint, he graphically represents quiescence of the air or absolute silence.

Q. 51. Have any counter-experiments been actually tried by which to disprove the alleged truth of this law

of interference as illustrated by the sounding of unison instruments half a wave-length apart?

A. Yes, repeatedly, no effect whatever being observable in the intensity of the sounds when the two instruments are placed and sounded variously, first in supporting relation, or a whole wave-length apart, and then in a supposed interfering relation, or half a wave-length apart. The student of science can instantly prove (by having two assistants sound unison instruments in all possible relations as to distance apart, and then listening in all directions from them) that this fundamental law of interference, on which the wave-theory is based, is without a shadow of foundation in fact.

Q. 52. Are there no experiments or phenomena referred to by scientists by which to prove the truth of this supposed law?

A. Yes, several; but each one of which is an entire misapprehension of the phenomena observed and referred to as proofs. Take the one instance most commonly referred to, namely, the fact that the two prongs of a tuning-fork will so interfere that if held cornerwise close to the ear, there will be no sound perceived. But so far from this having anything to do with the supposed law of interference in the two supposed systems of sound-waves sent off from the two prongs of the fork, the essential theoretic half wave-length, absolutely necessary to this law, has to be entirely ignored, since the two prongs are within an eighth or a quarter of an inch of each other; whereas in an A-fork the half wave-length should be fifteen and one-quarter inches, or in other words these prongs, in order that their unison-waves should interfere, should be fifteen and one-quarter inches apart. Then instead of only interfering cornerwise, they should produce silence in all directions, especially in the direction of the swing of the two prongs. As this silence is thus shown not to be interference of atmospheric undulations

at all, according to the wave-theory, it remains what it manifestly is, a mere vacancy or absence of sound-force in the direction of these prong-corners, caused by the peculiar manner in which a tuning-fork liberates its sound from the force-element of Nature.

Q. 53. Is not the interference of the double-siren, as shown by the experiments of Profs. Tyndall and Helmholtz, a confirmation of the truth of this law of half-wave-length interference?

A. There is no interference at all produced in the case of the double-siren, nor anything that can be construed into it, according to the plain admissions of both those eminent physicists. When the two perforated disks of the siren (each having twelve apertures) were arranged in such relation to each other that their respective series of puffs should alternate, or in other words, when the twelve puffs of one disk were adjusted to occur in the spaces or between the puffs of the other, it is plain that this would make twenty-four puffs, instead of twelve, at each turn of the spindle to which the disks were secured; and as the two sirens of twelve puffs each, when occurring simultaneously, produced a loud fundamental tone, it is manifest to any acoustician that when placed alternately, and producing twenty-four separate puffs to each rotation, they would produce an exact octave of this fundamental tone, but greatly weakened in its intensity. Now, strange as it may seem, this is exactly what both Prof. Tyndall and Prof. Helmholtz heard, and they confessed it to be the real result, even after claiming the double-siren as a clear proof of the law of interference, and that the two disks when so adjusted as to puff alternately would interfere and thus produce the absolute extinction of both sirens. Thus is it shown in like manner to turn out with every experiment which has ever been claimed by advocates of the wave-theory to favor this law. The facts when analyzed do not show in-

terference at all; and yet the theory has been held and taught and explained for centuries in this way, just because no other theory could be imagined as accounting for the facts, phenomena, and appearances of sound.

Q. 54. Does not the decrease of sound-intensity or loudness as the square of the distance from the center of motion, go to favor the wave-theory?

A. Even if it were a fact that sound-intensity (in the sense of loudness), does decrease as the square of the distance from its source, which is not the case, it does not oppose the theory that sound is a substantial force, radiating from a center like light and heat, and that it must become less in quantity according to this same law. Surely if the substantial atmosphere becomes less in quantity as the square of the distance from the center, substantial sound, light, and heat, ought to do the same thing.

Q. 55. But if the *quantity* of substantial sound-force actually does become less or decrease as the square of the distance from the center, the same as the quantity of air, how is it that the *intensity* or *loudness* of sound does not decrease by the same law?

A. The actual *quantity* of sound and the actual *loudness* of sound have no necessary relation to each other. The quantity of sound relates to the external force itself, whether it is heard or not, while the intensity of sound, in the sense of loudness, relates to the sensation produced in the animal consciousness. A sound may be just as loud to our conscious sensation as another sound of many times its absolute quantity of sonorous force, simply because our auditory capacity is not capable of receiving and perceiving, as loudness, more than a certain limited quantity of this force. It is plain, if sounds too low or too high for our capacity cannot be perceived, that sounds too little, or overplus sounds too much, for our capacity would be of no effect on our sensation.

Q. 56. What does this teach as to the decrease of sound as the square of the distance?

A. It teaches, that while sound itself, as a substantial physical force, must decrease as the square of the distance from the center, like all other radiating forces, its loudness or intensity in our sensations depends on the nature of the sound itself, and its external intensity or absolute quantity at the source. A very powerful sound might thus be just as loud to a sensitive ear fifty feet away as ten feet away from its source; whereas there are twenty-five times as much sound in a cubic foot of air ten feet from such source of sound as at fifty feet away. The reason why the loudness might be the same in our sensations in the one case as in the other is, that our auditory apparatus can utilize no more than its full capacity, just as a pinch of sugar scattered over the gustatory membrane will taste as sweet as a whole mouthful.

Q. 57. Has there been any experiment to show that the loudness of sound does not decrease according to this law of squared distance inverse?

A. Yes; Capt. R. Kelso Carter, Professor of Mathematics in the Pennsylvania Military Institute at Chester, in the summer of 1881, at the suggestion of Dr. Hall, instituted careful experiments with suitable apparatus and competent observers, and after repeated trials in an open field, the fact was abundantly demonstrated, that with common pitch-pipes the supposed law completely broke down, and as Capt. Carter reported:

“Of one thing I am certain, that a pitch-pipe blown at one yard and at ten yards does not vary in loudness more than one half.”

According to the law of squared distance inverse, the one blown at one yard should be a hundred times as loud as the one blown at ten yards away.

Q. 58. Is the *timbre*, or quality of sound, consistent

with the doctrine that sound is a substantial force and not a mode of motion?

A. Entirely so. The notion that the overtones or auxiliary tones of a loud fundamental sound (which are known to constitute the *timbre*, or quality of sound), consist of the superposition of different sizes and forms of air-waves, is too irrational a view ever to have been accepted as science but for the fact that the wave-theory of sound was looked upon as a foregone necessity, no other theory being conceivable to the minds of past or even present physicists up to the appearance of the "Problem of Human Life."

Q. 59. By what experiment is the existence of these over-tones, which constitute the quality or *timbre* of sound, determined?

A. By what is called a *resonator*, an instrument which can be tuned in unison with any particular supposed overtone in a given fundamental sound, and being in unison with that particular tone, it will augment it while obscuring all other sounds, thus enabling the listener to hear it if it is present. By thus adjusting the resonator to every supposed or probable overtone in a given fundamental, the presence of all such supplementary sounds can be detected and noted.

Q. 60. How many such supplementary sounds or over-tones have been detected mixed up in any one given fundamental?

A. As many as six or eight, or even more tones of different intensities and rates of vibration or pitches, have been plainly detected by a patient search with a nicely adjusted resonator; and even several of these more prominent overtones, such as the *octave*, the *fifth*, the *third* and the *sixteenth*, have been plainly distinguished in some fundamental tones by a cultivated ear, and by a powerful act of attention, even without the aid of a resonator. But the supposition is inconceivable that

this number of air-waves, all of different forms, sizes, and vibrational rates, can be superimposed and occupy the same space at the same time, making the same number of movements in the ear membrane. The reason for this is, that it is a self-evident and inflexible law of mechanics, that no particle of matter can occupy more than one determinate position, have more than one determinate motion, in one determinate direction, and with one determinate velocity, at the same time. To suppose the contrary is to make a draft on human credulity that reason will not approve, since our experience furnishes no analogous example in any other department of science. Yet if these various sounds, contained in a single fundamental tone, are caused by air-waves, and if our distinct recognition of a hundred different sounds at one instant, produced by an orchestra of as many instruments, depends on the superimposed motions of the air leading to the tympanic membrane—a column no larger than a common lead pencil—then it must follow that the above self-evident and inflexible law of mechanics is false, and that these air-particles, filling the passage to the ear, must be capable of occupying scores of different positions, taking scores of different directions, under scores of different velocities, all at one and the same time. This stupendous error of science is actually taught and insisted upon by every advocate of the current theory of acoustics, though no doubt without realizing that he is in open defiance of the physical laws.

Q. 61. Is there anything in Nature and science that would go to support the substantial theory of sound-force in the light of this problem of *timbre*, as caused by over-tones?

A. Yes; this substantial view of mixed tones, by which the quality of a fundamental sound is produced, is plainly corroborated and easily shown by the innumerable qualities of mixed odor, which the whole scientific world

admits to be substantial, and in no possible sense superimposed waves. An experienced perfumer will instantly detect by the nose alone, a number of different perfumes promiscuously mixed together in the same bottle, naming each separate ingredient constituting the mass of fragrance, both fundamental and supplementary, and of course there is no such thing as superimposed air-waves, or odor-waves of numerous vibrational directions or velocities to untangle, but simply an analysis, by means of a sense-organ alone, of a combination of substantial entities, which go to make up this quality of *timbre* of the odor in question. And while a human being can thus analyze a mixture of half a dozen of odorous ingredients, and point out the presence of each, a certain species of fox-hound can analyze and untangle a hundred mixed smells, selecting out one, and following it in spite of all the confusion or odorous complications, which the ingenuity of man has the power to invent.*

* Readers of this surprising story of facts (the tracing of negro convicts by southern hounds), who have previously been inclined to doubt the basic principles of Substantialism, can now open their eyes and see for themselves. If a dog has the ability to select and isolate one single form of odor from a hundred other almost exactly similar forms, with these various forms of smell intermingled in the most confused and tangled manner possible, as here shown, and, at the same time, with odor a real objective *substance*, as the whole scientific world admits, is it not reasonable to suppose that the well-known ability of a practiced ear to select and isolate one single tone from an orchestra of a hundred different instruments, must come in like manner from the *substantial nature of sound*? If not, then what sense or meaning can there be in the so-called analogies of Nature?

The attempted reconciliation with the wave-theory of this single orchestral fact has cost many ponderous volumes on acoustics, involving the most abstruse mathematical calculation and theorizing. Lord Rayleigh, the eminent English scientist, has produced a book on sound of some four or five hundred pages, devoted almost entirely to these singular mathematical

Q. 62. As it has been proved by experiment that sound will reflect according to the angle of incidence in a manner similar to light, does not this constitute a proof that sound consists of air-waves?

A. No; it is right the opposite, since there is no such thing as true reflection in any kind of wave-motion, according to this law of the angle of incidence. Water-waves, striking a perpendicular wall at an angle, give no trace of true reflection, according to this law, but fall back and break up in confusion among succeeding waves, thus instantly losing their identity. Nothing can reflect which has not a substantial forward movement. A wave

wave-formulas, by which to vindicate the practical possibility of the truth of the current theory, and to show how the almost infinite complexity of air-motions, necessary to the hearing of so many sounds at one time, can result by the intermingling of condensations and rarefactions, and the superposition of various systems of air-waves upon each other.

He may have succeeded in representing all this on paper, by which to prove that one little membrane called the tympanum—not a third of an inch in diameter—shall take on all these superimposed forms of wave-motion at one time, and thus communicate them intelligibly to the brain. But the fatal difficulty in the way of all this complexity of mathematical theorizing by Lord Rayleigh can surely apply only to the air, or, rather, to his printed formulas, as it can never be reproduced as motions in the ear-drum of any living creature. This is proved from the fact that the tympanic membrane is not a stretched or tensioned diaphragm at all, but is a loose or flaccid mass of sensitive tissue incapable of any sound-vibrations whatever.

For centuries the scientific world has labored under the misapprehension that the tympanum is a “drumskin” stretched across the passage leading to the inner ear, ready to respond by sympathy and reproduce all the supposed complex motions of the air as formulated by Lord Rayleigh’s mathematical ingenuity. But this notion concerning the ear-drum, so long in vogue, is totally false, as now proved by anatomy, and hence all this laborious effort, to show mathematically what is possible as to complex motion in the air, turns out to be a pitiable scientific

is only the forward movement of the form of the water's disturbance, and not of the water itself, the particles constituting the wave having only an oscillatory motion to and fro in a direction at right angles with the direction of the wave or swell itself. This is even seen in a field of grain, and especially of flax in blossom, in which true waves are produced by wind, but in which it is evident no reflection at the angle of incidence is possible. This law of angular reflection is only conceivable in bodily forward movement, under velocity, of the very substance which is reflected. A discharge of rubber balls from a gun against a plain surface, at an angle, gives a correct

abortion, since no vibrations are possible in such a flabby piece of tendinous tissue as this ear-drum.

In contrast with this incomprehensible mathematical mystification by Lord Rayleigh, how easy and simple is it to conceive of the possible hearing and analyzing of any number of the most complex sounds at one time, on the basis of the contact of substantial sound-force against this delicate and sensitive auditory membrane, especially in view of the demonstrable illustration just given of a hound snuffing a hundred complex but substantial odors at the same breath, and by means of his nasal membrane alone, without any vibratory motion whatever, isolating one of these smells out of the hundred and retaining it in spite of all the complications that could be invented by man! Of what use, then, in the name of all that is reasonable in science, is this complex superposition of air-waves in accounting for sound-sensations, when in the adjoining sense next to it, namely, that of smell, every purpose of nature is served by the substantial contact of odor, and that, too, amid a confusion of conflicting smells which would make a volume of Lord Rayleigh's worst mathematical superpositions appear like simple reading?

But suppose odor to consist of vibratory motion, which certainly should be the case if it is true of sound, and then imagine that poor dog, before selecting the special form of odor he was to follow, being obliged to figure out with his nose over a little patch of dirt one of the easiest of Lord Rayleigh's superpositions as applied to odoriferous condensations and rarefactions in order to determine which angle of the parallelogram to select before he could start on the track of the right convict! Then imagine

illustration of this angle of incidence at which light and sound reflect, each ball rebounding at the same angle of direction it had in striking the plane surface, thus showing the true law of all reflection, especially of both sound and light as substantial entities having an analogous forward and bodily motion.

Q. 53. Is this law of substantial forward motion also in harmony with the well known method of concentrating sounds to a focal point, as in an ear-trumpet, and other funnel-shaped tubes?

A. Yes; the concentration of sound by an ear-trumpet, is only a succession of reflections of forward-moving

these odorous vibrations caused by the impacts of the convict's shoes to have been made an hour in advance of the dog's starting—pray how could his olfactory membrane be made to respond sympathetically to such vibrations an hour after their motions had ceased to exist?

Jesting aside, why cannot Lord Rayleigh be induced to give us a book on the mathematical superposition of odor-waves, with suitable geometrical diagrams for showing the blending curves and cross-angles of three or more fundamental smells, including their harmonics, by which to explain in his usual lucid style how this hound succeeded in tracking the convict, as the effect of the combination chord of odorous vibrations as they tickled his olfactory nerve? Then let the distinguished savant write an appendix to the same work, formulating the scientific law of the *conservation of nothing*, or the *persistence of motion*, by which to prove that the vibratory effluvium from the convict's clothes could easily keep up their fragrant tremors against the twigs of the bushes during the two hours the "red dog" was swinging around the circle. Such a book would, no doubt, sell as a fitting companion-piece to his corresponding work on sound, and would be equally as scientific in every respect.

The truth is, this simple and serious fact that odor is a substantial force, impressing the nasal membrane of this dog and thus producing its complex sensations by substantial contact alone, and with which vibratory motion has nothing to do, is conclusive analogical evidence that sound sensations are produced in a similar manner. This beautiful and consistent view

substantial sound-force, following this angle of incidence, rebounding from side to side of that funnel, like infinitesimal india-rubber balls, thus collecting the larger quantity of sound-force admitted into the big end of the tube into a condensed form at the smaller end, just as substantial light rays, by the same law of reflection, would rebound from side to side of a similar trumpet-shaped tube, having its inner surface polished, and thus causing an intense focus of light and heat at the smaller end.

Q. 64. Does not the fact, that the sound of two books, when clapped together, will blow out a candle at the small end of a long tube, as illustrated in Prof. Tyndall's

of Nature would have been reasoned out long ago from the necessary analogies of physical science based on substantial odor alone, had the rational classification of all substances into material and immaterial entities suggested itself to any of our distinguished physical philosophers. But regarding nothing as substantial but matter, and stopping there, has hitherto barred the path of progressive advancement until Substantialism, with one fortunate stroke of its leveling ax, broke down this chief barricade of materialism.

Now we can see and understand, with but a modicum of rational reflection, that if the nose of that Georgia hound is capable of analyzing a hundred mixed smells on the basis of substantial odor, it would be the height of physical inconsistency to charge Nature with upsetting this substantial order of things by abruptly introducing for the next higher sensation a nonentitative mode of motion. We repeat our original statement, as given in the "Problem of Human Life," that a man who can suppose such an unnecessary incongruity in Nature's harmonious plans as a leap from actual substantial contact in one sensation to mere motion for the sensation next adjoining, when the latter sensation only requires a more refined form of substance to answer every purpose, has too trifling a conception of Nature to be reasoned with or to reason logically on any matter of science.

Dr. Hall's remarks on the exciting narrative of the tracing of convicts at the Georgia Penitentiary, by blood hounds.—*Scientific Arena*, Vol. I., p. 51.

lectures, prove that sound consists of air-waves instead of immaterial substance?*

A. Prof. Tyndall was mistaken, and so are all professors and teachers who repeat his experiments. It was not the sound from the clapped books which blew out the candle, but a puff of air driven through the tube, since a thin paper bag tied over the small end of the tube, with the atmosphere all pressed out, will be expanded and filled with the same puff of air which blew out the candle; and this will occur as often as the books are clapped in such a manner as to drive the air-wave into the large end of the tube. Surely we cannot bag up immaterial sound-force!

Q. 65. How has Prof. Tyndall, and how have all other physicists been so deceived by this experiment, if sound itself has nothing to do with the effect of extinguishing the candle?

A. They have all taken for granted that the wave-theory of sound must be true, since to them no other theory has seemed possible. Hence, it was easy to fall into this error, and to suppose that it must be the sound-

* "At the distant end of the tube I place a lighted candle, c, fig. 4. When I clap my hands at this end, the flame instantly *ducks down*. It is not quite extinguished, but it is forcibly depressed. When I clap two books, B B, together, *I blow the candle out*. You may here observe, in a rough way, *the speed with which the sound-wave is propagated*. The instant I clap, the flame is extinguished; there is no sensible interval between the clap and the extinction of the flame. I do not say that the time required by the sound to travel through this tube is immeasurably short, but simply that the interval is too short for your senses to appreciate it. To show you that it is a *pulse* and not a *puff of air*, I fill one end of the tube with smoke of brown paper. On clapping the books together, *no trace of this smoke is ejected from the other end*. The *pulse* has passed through both smoke and air without carrying either of them along with it."—"Lectures on Sound," p. 12, copied "Problem of Human Life," p. 271.

pulse which blew out the candle, when the books were clapped, instead of the puff of air which was driven away from the books into the open tube at the same instant. This superficial error is almost precisely similar to that which led physicists to suppose that it was the sound-pulse or noise which broke windows at a distance from a magazine explosion, instead of the wave of air caused by the added gas, as examined in answers 41, 42, and 43.*

Q. 66. Are there any other direct proofs besides the paper-bag test to show this tin-tube experiment to be erroneous?

A. Yes, many. Let the books be clapped in a direction away from the open mouth of the tube, so as not to force any air into it, and whatever the intensity of the sound thus generated and passed through the tube, no effect will be produced on the candle flame at the small end. But a better test is to strike a bell or gong right at

* "The most striking example of this *inflection* of a *sonorous wave* that I have ever seen, was exhibited at Erith after the tremendous explosion of a powder magazine which occurred there in 1864. The village of Erith was some miles distant from the magazine, but in nearly all cases the windows were shattered; and it was noticeable that the *windows turned away from the origin of the explosion suffered almost as much as those which faced it*. [This effect is simply explained by the tremendous shove given to the air, causing it to compress around the buildings equally on all sides. Professor Tyndall thinks it was the "sonorous wave" which *inflected*, and doubled its two ends around the building, thus crushing the windows!] Lead sashes were employed in Erith church, and these being in some degree flexible, enabled the windows to yield to the pressure without much fracture of the glass. Every window in the church, front and back, was bent inward. In fact, as the *sound-wave* reached the church it separated right and left, and for a moment the edifice was clasped by a *girdle of intensely compressed air*."— *Lectures on Sound*, p. 23. Quoted and criticised in "Problem of Human Life," at page 105.

the large mouth of the tube, and although the sound may be almost deafening, no effect is produced on the candle flame, notwithstanding this sound is concentrated upon it in great intensity at the small end of the tube. Then to reverse the original experiment, let the two books be clapped as was done by Prof. Tyndall, but, let them be prevented from coming entirely together by a piece of soft rubber secured between them, and though no sound will be produced, yet the candle will be blown out all the same and alone by the puff of air sent off in both instances.

Q. 67. As puffs of air do not thus appear to constitute sound, does the movement of air impede or aid the travel of sound?

A. Not perceptibly to our sensuous observation. Yet it is evident in strict science, that so much must be added to or deducted from sound-velocity, as will correspond with the bodily movement of the conducting medium, either with the sound or in the opposite direction. To illustrate: As sound travels in still air at sixty deg., at a velocity of 1120 feet a second, it is manifest if the air itself were traveling in the same direction, in a breeze of thirty feet a second (or about twenty miles an hour), that we would have to add these thirty feet to the real velocity of sound as measured from one fixed station to another, making it 1150 feet a second instead of 1120. But, if we change stations, and send the sound against the breeze, we must necessarily deduct the thirty feet a second from the actual velocity of the sound, making it only 1090 feet instead of 1120. So it would be with electricity traveling through a wire by an analogous law of conduction at, say, 1000 miles a second. If by any means we could cause the wire to move one mile a second at the same time, this mile of travel would have to be either added to or deducted from the velocity of the

electricity, according as the wire moved either with or against the electric current.

Q. 68. Are there any experimental proofs that sound is not perceptibly impeded when traveling against a wind?

A. Many such proofs are on record, as observed from coast signaling stations, in which fog-horns and steam-sirens have been heard for miles against a heavy gale, when they could not be heard half as far with the wind. Also there are many proofs that steam-sirens and signal-guns which have not been heard by observers stationed a few miles out at sea, were plainly audible to other observers far beyond the first.

Q. 69. How are such erratic phenomena of a sound to be explained according to any possible theory of acoustics?

A. They are rationally explicable according to the Substantial Philosophy which makes all the forces or forms of energy real, substantial entities, instead of mere modes of motion. If sound is such a substantial form of force, analogous to electricity, it must travel through any material body by its laws of conduction in correlation or co-operation with the governing force of cohesion which arranges and holds the particles of all conducting mediums together, as explained in answers to 33 and 34. Now, it is readily supposable that the arrangement of air-particles is constantly undergoing change by the action of heat and cohesion, aided by the presence or absence of aqueous vapor, barometric changes, electricity, etc. Hence, there might be much more favorable conditions and arrangement of air-particles for the travel of sound against a given wind than in the opposite direction; and even the *grain* of the atmosphere, so to speak (as known to be the case with the different cohesive arrangements of particles in the *grain* or fibrous structure of wood), might thus prevent the travel of sound through certain masses

of air, causing it to bound back, thus producing an echo, or to glance over the heads of observers therein stationed, and thus reach others more favorably surrounded many miles beyond.

Q. 70. Are not such atmospheric conditions equally favorable to the wave-theory?

A. They are directly opposed to it, because air-waves are merely mechanical displacements or material disturbances, and no difference what the cohesive arrangement or conductive grain of the air may be, or what vapors might be present, mere mechanical undulations would not be affected one way or the other by which to cause such conductive phenomena as echoes, or the glancing of sounds over the heads of near observers, while reaching those still further distant.

Q. 71. Are there any analogies which go to favor this substantial view?

A. Yes. Let a rod have two branches close together, one of copper and the other of iron. Now, as copper is a better conductor of heat than iron, owing to the cohesive arrangements of its substance, let us place the end of the rod in fire, and it will be found that the heat, in traveling along the rod, by its law of conduction, in co-operation with the force of cohesion, will glance around the iron branch, following the copper texture as better suited to it under the correlation of the forces. Try a powerful current of electricity through the same rod, and it, too, by sufficiently fine tests, will be found to glance around the iron, and to follow the copper with much greater tenacity. Then try sound, and by the same correlation of force, it will be found to prefer the iron to the copper, glancing around the latter, and accepting the iron as better adapted to its co-operation with the ruling force of cohesion, which holds the seat of honor in all material bodies.

Q. 72. Is not the greater elasticity of the iron, and its less density over the copper, the true reason why sound selects it and travels through it with greater facility?

A. Not at all. This is abundantly proved by an iron pipe, open at both ends, and extending for a few miles. Let a sound be made at one end by striking the pipe, and it will be found that this sound will travel seventeen times faster through the metal than through the air of the tube, though the air is one of the most elastic as well as one of the least dense of known bodies. By the formula of Sir Isaac Newton (which assures us that the velocity of sound should increase in proportion as the *elasticity* of a conducting body is great and its *density* is small, and *vice versa*) it is manifest that sound should travel many hundred times faster through air than through soft iron; and as this is the formula on which the current theory of sound is based—the law of necessity breaks down the theory in iron, as its founder also proved it to break down the theory in air. See, also, answers to Questions 33 and 34.

Q. 73. As the generation of sound-force was attributed, near the commencement of this chapter, to the vibration of some sound-producing body, are there any other means known to science than vibratory action for sound-generation?

A. Yes, by the conversion of one force into another. It has been proved that an intermittent ray of light directed against certain substances, such as lampblack, cotton fiber, etc., inclosed in a glass tube, will cause an audible sound to issue from the tube of a pitch corresponding to the intermittent beam of light. As light has been proved to exert no perceptible mechanical effect in displacing a material body, however powerfully concentrated upon it, it is fair to infer that sensible vibrations of the glass tube or of its contents could not have

been produced by the impact of such ray; and as no changes from heat to cold, causing vibrational expansion and contraction, could possibly take place with sufficient rapidity to produce a high pitch of tone, it follows unavoidably that the light-force thus intermittently projected against the tube must have been directly converted into sound.

Q. 74. Is there any proof that other forms of force have ever been directly converted into sound, or that one form of force can be certainly converted into another?

A. Yes; we have many proofs of such conversion of the forces. It is well known that an electric telephone will convey sounds without any vibration having been produced, first, by converting such sounds into electricity, thus augmenting the intensity of the current, and then at the receiving diaphragm reconverting the electricity into sound, making the words audible, and that, too, without any mechanical vibration occurring at either diaphragm.

Q. 75. By what experimental proof, if any, is it known that no vibration occurred at the transmitting diaphragm of the telephone referred to when the message was spoken against it?

A. It has been repeatedly shown that the vibration of a disk at the transmitting end is not at all essential to the conveyance of speech over the electric wire. This has been done by substituting a solid and rigid disk of iron, an inch thick, for the flexible disk commonly employed, and it has been found that words have been distinctly conveyed thereby over the wire. Indeed, messages have been spoken against the naked ends of the transmitting magnet, without any disk at all, and the words have still been sent, and heard at the receiving end all right. And as no vibration at the receiving disk could be detected by the finest tests that could be applied, and the message heard, even when no receiving

diaphragm was used, it was but reasonable to infer that the spoken sounds striking the magnet were converted directly into electricity, conveyed in this form to the far end of the wire, and there reconverted into sounds.*

Q. 76. Is there any direct proof that electricity is ever converted into other forms of force besides sound?

A. Yes; many such proofs. Electricity passed through a wire, will, by sufficiently increasing its intensity, be converted into *heat* till it will melt platinum. In doing this it is also converted into the most intense light by incandescence, and it can also be converted into another form of light, evolving no heat, as seen in the *aurora borealis*. But the most indubitable proof of force-conversion, is in the passage of a current of electricity several times around a piece of soft iron, thus con-

* But the phenomena of the *Telephone* are entirely different. It is true its diaphragm may vibrate when spoken to with force, as does that of the phonograph; but such vibratory motion is not necessary to the conveyance of a message through the electric wire. It has been proved by Dr. R. M. Ferguson, Ph. D., F. R. S., the eminent Scotch physicist, as published in the *Scientific American Supplement*, No. 120, and also by Count Du Moncel, the renowned French electrician, as published in his work on the telephone, that the action which is conveyed from the telephone through the electric conductor, and which is heard at the receiving instrument, must be regarded as "*molecular*," since the most refined observation shows no vibratory motion whatever in the receiving diaphragm. In fact, both these high authorities have shown that no diaphragm is necessary either at the receiving or transmitting end of the line, since *messages have been sent by speaking against the naked poles of the magnet*, and heard at the receiver without any diaphragm or other body capable of vibration. Hence, they have recently announced to the scientific world that the theory of sound will have to be reconstructed, since *molecular action* of some kind is forced to take the place of the supposed vibratory motion in the telephone. This is no doubt correct, as far as it goes, but we may reasonably expect that these eminent scientists will go still further, and in due time make another announcement, that the entire *wave-*

verting the electric force into magnetism, a form of force entirely different from that of electricity, since the magnetic form of force requires no conductor, but will pass through all bodies alike, and as freely as if nothing intervened, while electricity not only needs a conductor, but is almost completely stopped by certain substances such glass. Heat, also, as in a thermal pile, is not only converted into a powerful current of electricity, but can be converted into the most brilliant incandescent light if sufficiently intensified. Now, if all these conversions of one form of physical force into another is rationally evident, is it not reasonably manifest that both light-force and electric force, as substantial entities, may be converted into sound-force, in accordance with the illustrations here given?

Q. 77. If sound is a substantial force, analogous to

theory will have to give way to the molecular and corpuscular hypothesis.

As sound-pulses are thus shown, by the highest authorities on the subject in Europe, to pass through the electric conductor without wave or vibratory motion, I may safely claim one-half of my new departure as accepted, and for the remaining half it will only be necessary to arrive at a better understanding of the correlation and interconvertibility of these incorporeal substances, such as sound, electricity, light, heat, etc., and we will readily comprehend how substantial sound-pulses, spoken against the magnetized transmitter, may combine with the substantial electric fluid, and thus be conveyed in its embrace, so to speak, to the distant receiver without the assistance of any corporeal movement whatever of the wire, magnet, or diaphragm. This view, of course, involves *molecular* motion, not of the material substance of the magnet or wire, as these physicists have hastily supposed, but rather the molecular and corpuscular motion of the two blending and correlated substances—*sound and electricity*—the only active substances involved in this operation. The explanation thus given is not only consistent with the phenomena in question, but it fully corroborates the view of sound taken in this monograph, as any one can see who will take the trouble to read it.—Dr. Hall, in "Problem of Human Life," p. 334.

electricity or heat, as these answers show, and if the air-pulse theory is a mistake, why is it that the velocity of sound through air, inclosed in a long tube, is the same exactly as that of a condensed atmospheric pulse caused by suddenly forcing a piston into one end of such tube?

A. This concluding premise is not correct. The highest authorities in physical science have assumed such to be a fact, but without ever having tried the experiment. The reason for such confident assumption is manifest and unavoidable in the very necessities of the wave-theory of sound. As all sounds, loud and soft, were universally believed to consist of air-pulses, or atmospheric condensations and rarefactions, and as all sounds were known to travel through air at the same uniform velocity, hence the doctrine stood unquestioned that a pulse, caused to pass through a tube by forcing a piston into one end of it, would necessarily obey this law of sound-velocity, no matter what force should be applied to the piston, what degree of condensation the piston should produce, or what distance it should be instantaneously driven into the tube. Dr. Hall was the first writer to call this law in question, as he was the first to announce the numerous abrupt departures from physical science set forth in this chapter.*

* The foregoing being the unperverted and undeniable logic of physicists, let us for a few minutes turn to the record. By reference to "Appleton's American Encyclopedia" and its elegantly written article on "Sound," fortunately within the reach of all students desiring to investigate the matter, Prof. Mayer, the highest authority on sound in this country and called by many the Helmholtz of America, makes use of this very illustration of the tube with a movable piston at one end, and actually assumes and teaches that the velocity of the atmospheric condensation caused by a sudden shove of the piston must necessarily be the same as that of sound, or must of necessity travel 1090 feet in a second at a temperature of thirty-two degrees Fahrenheit, since that is the admitted velocity of sound. As surprising as it may seem to the unscientific reader, and in exact conformity to the foregoing argument, this physicist makes

Q. 78. On what ground is it assumed that this old law of pulse-travel and velocity through a long tube, must be incorrect?

A. The assumption is based on the self-evident principle of mechanics that the greater the force with which a body is projected, other things being equal, the swifter will it go; and that, by the same necessary law, the greater the condensation produced instantaneously in the air of one end of the tube by a movement of the piston, the swifter must such condensed pulse travel toward the other end. Hence, if sound consists of air-pulses, as the old theory teaches, it must as certainly follow that loud sounds, constituted of heavy condensations of air, will travel faster than faint sounds. As this is known not to be the case (see answer 32), it follows that the wave-theory cannot be true, and therefore that sound must consist of something besides atmospheric pulses. What else is there for sound to be, unless it be a substantial force?

no distinction whatever in the velocity of the condensed wave thus generated, whether the piston is moved one inch or ten feet so the movement is instantaneous; and, consequently, he points out no difference in the speed of such a pulse, whether the spring-force of the condensation generated by the piston's movement be equal to a pressure of one ounce or one thousand pounds! He assumes this velocity of the condensed wave along the tube to be the same as that of sound—nothing more and nothing less—and hence it must be the same necessarily, whatever the spring-force employed to drive it, since the velocity of sound through this tube at any definite temperature, as already shown, is always the same.

As this writer fails to note this distinction, but rather ignores it, the same as did Prof. Tyndall in reference to the magazine explosion and the destruction of the windows at Erith by a "sound-wave," I am therefore compelled, as I did in the other case, to definitely point out the law governing the transmission both of the sound and of the atmospheric condensation through this tube, and thus to indicate the manifest difference between them, which science and its exponents so far have failed to do.

Q. 79. Has this new and opposing theory of pulse-velocity ever been tested by which to show that the wave-theory of sound cannot be true?

A. No. The originator of this substantial theory simply makes the prediction, based on his general discoveries, that whenever any college shall go to the expense and trouble of making the test with suitable tubing, the result will be found to conform to the law he has announced, namely, that the pulse thus generated by moving a piston into one end of a tube, will necessarily travel with varying velocity, just in proportion to the distance the piston is instantly moved and the strength of the spring-power of the pulse thus generated. The founder of the Substantial Philosophy willingly risks the fate of Substantialism upon the absolute truth of this revolutionary position.

Q. 80. Does the same law of sound-conduction, according to the substantial theory, prevail in solids, liquids, and gases?

Let us suppose the piston to be moved instantaneously into the tube a certain distance by the blow of a hammer, which also makes a sharp report at the same time. This simultaneous sound of the blow and atmospheric wave produced by the movement of the piston might or might not travel with the same velocity toward the far end of the tube. It would, of course, depend entirely upon the distance the piston was driven by the blow of the hammer, or, in other words, upon the quantity of air (in effect) thereby added to the atmosphere of the tube. It is evident that a true distance for the piston suddenly to move by this blow might be arrived at by experiment which would furnish just enough spring-force to carry the condensed wave through the tube with a velocity equal to but not exceeding that of the sound-pulse caused by the same blow of the hammer. But it is likewise evident that a distance might be selected for the piston to move (say *one-sixteenth of an inch*) which would produce so little compression of the air in front as to cause the condensed wave to lag behind, and possibly not travel one-tenth as fast as the sound of the hammer. In this case, however, the

A. Precisely the same, namely, the cohesive arrangement of the particles of the various material substances serving as sound-conducting mediums, and the correlation of cohesive force and sound-force in relation to these various arrangements of such material particles. Just as electric-force or light-force will travel better through some bodies than through others by the co-operation or opposition of the regnant force of cohesion, and without any reference whatever to the elasticity, density, mobility, or compressibility of such material bodies, so will sound-force travel through air, the various gases, water, wood, iron, glass, etc., by the same correlation or co-operation with cohesive force, and the various different ways in which that force has arranged and now maintains the material particles of various bodies to facilitate or impede such sound conduction.

Q. 81. At the twenty-ninth answer it is taught that the sounding bell in *vacuo* is not heard outside of the re-

condensation, as before remarked, would probably travel through the tube at a uniform velocity from end to end, though the sound would vastly outstrip it. The speed of so slight a condensation would resemble that of a condensed wave from a magazine explosion when it had nearly spent itself by expansion and rarefaction, as already explained. And, finally, it is evident that a distance could be determined for the piston to move (say ten, twenty, or forty feet) simultaneously with the blow of the hammer, provided it could be instantaneous, which would add sufficient spring-force to carry the condensed wave with a velocity twice or even three times that of sound. Is not this simple and clear.

Yet these palpable and manifest distinctions, lying at the very basis of pneumatics and acoustics, as any analytical mind must perceive, have never entered the thoughts of these great physicists. Why? The answer is plain. Simply because the universally accepted wave-theory of sound is obliged to lay down as its fundamental principle that a sound-pulse of any kind consists in and is propagated by means of a *condensation* of the

ceiver for want of a conducting medium for its sound-pulses. Does the bell in vacuo thus struck by clock-work generate sound-force the same as if it were in air?

A. Yes, just as a dynamo-machine in vacuo, and perfectly insulated from outside objects, would generate electricity. But in both cases the force thus generated, not having a conducting medium by which to manifest itself outside, returns to the force-element or force-reservoir of nature whence it came, thus losing its form or identity as fast as liberated by the appropriate processes for its generation.

Q. 82. Would not a bell thus rung continuously in

air, and can only travel as such compressed atmospheric pulse. Hence, after starting out with this fallacy, it became necessary, in order to harmonize natural phenomena, to compel all kinds of atmospheric condensations to conform to this law, and thus to travel at the observed velocity of sound! As physicists were unable to separate the concussive shock of a magazine explosion from its sound-report, but must suppose the two necessarily to be one and the same thing, according to this wave-hypothesis, it is asking altogether too much of them now to distinguish between the velocity of a condensed wave in a tube and its accompanying sound derived simultaneously from the blow of a hammer! It is owing entirely to the blinding effect of this all-pervading fallacy of atmospheric sound-waves having "condensations and rarefractions," generating thereby "heat," and thus adding "one-sixth" to the elasticity of the air and the velocity of sound, that we see Prof. Tyndall deliberately and almost pitifully jumbling a "sound-wave" or a "sonorous pulse" with the "girdle of intensely compressed air" *which crushed in the windows at Erith!* And it is owing to the same reason that we see Prof. Mayer, one of the most brilliant intellects of America, laying down his law that the velocity of a condensed wave in a tube, caused by the sudden shove of a piston, must necessarily be 1090 feet a second, or, in other words, must conform to the observed velocity of sound, without the least regard to the amount of condensation the piston produced, or the force thus brought to bear in propelling the wave.—Dr. Hall, in the "Problem of Human Life," p. 109.

vacuo be reduced in its material substance, and finally be entirely dissipated in the form of sound-force?

A. No. Herein lies the superficial mistake of those who oppose the Substantial Philosophy. They do not grasp the broad distinction between material and immaterial substances. A ringing bell gives off none of its material substance in the production of sound, and is only the material instrument by which the force-element of nature is reached and this peculiar form of force developed and manifested to our senses through proper conducting media. Lucretius vaguely caught the same idea of sound that Newton taught for light in his emission theory, namely, that by exercising our vocal organs, material sound-particles were emitted, thus in time wearing out the voice, causing hoarseness, consumption, etc. It was impossible for any investigator to grasp the true nature of light and sound, as in no way constituted of the material particles of the luminous and sonorous bodies, until the Substantial Philosophy had classified the substances of nature into material and immaterial entities.

Q. 83. But would not a bell continuously rung, finally be worn out?

A. Yes. Any body which requires its own vibratory action or tremor in order to generate or liberate a given form of natural force, must, in the nature of things, disintegrate or reduce itself by continuous wear in such process of liberating force. But surely, a student of science should be able to see that such wear and deterioration of the instrument is no more a part of the immaterial force thus liberated, than are the particles of the mill-stones worn off and dissipated in the process of grinding wheat a part of the flour thus produced. A bell may be worn and partly dissipated to dust in the process of vibrating and sounding, but every part of that dust still remains in existence as metallic matter, and if

collected would again produce the same bell intact by recasting.

Q. 84. Is this reasoning applicable to the generation and liberation of light-force by a consuming taper or other luminous body?

A. Yes. The process of consumption in a burning candle, or the substance thus undergoing disintegration or dissipation, constitutes no part of the luminous rays which pass off into space by the unknown law of luminous radiation at a velocity of nearly 200,000 miles a second. This process of disintegration in the luminous body does not change one particle of the material body into light-force, just as the disintegrating process of the liquid battery does not change one particle of the zinc or acid into electricity, since such a battery, operated for days and so inclosed as to avoid loss by evaporation, will weigh the same, notwithstanding the thousands of volts of dynamic electricity which have passed away from this battery to do mechanical work at a distance. The true solution of these various material processes, for liberating different forms of physical force, rests on the same general law, namely, the wear or disintegration of some form of matter by which, through certain disturbances of cohesive force, to tap the force-element of Nature, and thus develop and liberate that form of force desired, without such form of force consisting in the slightest degree of the matter thus disintegrated.

Q. 85. As luminosity in the consuming taper is both caused and accompanied by heat, is heat also evolved from this universal force-fountain of Nature?

A. Not always directly, but more often by the conversion of other forms of force into heat. The property of combustibility in matter, which is owing to the peculiar cohesive arrangement of its particles, is a powerful condition for the conversion of cohesive force into heat. Thus a spark may start a conflagration which, after the

initial conversion, expands by what it feeds on. No particle of the combustive material is consumed or destroyed in the absolute sense, but it exists as completely as before, though in different forms, such as ashes, vapors, gases, etc. The great manifestation of light and heat-energy witnessed in a conflagration, is but the substantial force of cohesion, which held the combustible matter together, changing its form to that of heat and light. The light and heat, thus resulting from the breaking up and conversion of cohesive force, after their energy is expended, find their way into the force-element of Nature, where, by correlation with other forms of expended force, they become one, and whence they are again ready to emerge by the demands of natural law in the same or other forms of force, but especially that of cohesion in its process of rebuilding forests of combustible material out of the ashes, vapors, and gases into which heat had separated those existing before.

Q. 86. But is disintegration necessary to the development of every form of force known to science?

A. No; some forms of force, after having been separated from the force-fountain of Nature, become permanently fixed or located in material bodies for definite manifestation. Cohesive force, for example, as also gravitational force, has, by the economy of nature, been definitely located in all matter to its infinitesimal constituents, and there resides always ready to act. So with magnetic force, as seen in the loadstone or permanent magnet. Such magnet, by the peculiar relation of cohesive force with its constituent particles, is enabled to draw continuously from the force-element of Nature this form of force called magnetism, and thus pour it off in cycling currents, by which other material bodies, whose cohesive arrangement of particles puts them in sympathetic relation with these magnetic streams, are dynamically drawn or repelled, as the case may be. Thus harmoni-

ously are all the forces or forms of energy in Nature brought into consistent relationship one to another under the magical solving power of Substantialism, without forcing us to resort to so-called modes of motion in physics which neither accomplish nor explain anything.

Q. 87. What is meant by the wave-lengths of sound, and what relation, if any, do they sustain to the Substantial Theory of Acoustics?

A. As the Substantial Theory does not recognize air-waves as constituting any part of sound-force, it has no use for wave-lengths in sound. Besides, the idea of wave-length where there is no wave-amplitude, or no to-and-fro motion of the wave-substance (since no such amplitude as constituting sound, aside from incidental tremor, has ever been seen even under a microscope), is an incongruity so repugnant to reason as to be at once discarded by an unbiased student of science.

Q. 88. What are some of the wave-lengths of sound according to the current theory, and in what way do they conflict with our reason?

A. This theoretic idea of wave-lengths depends upon the velocity of sound in different mediums, and the number of vibrations of the sounding instrument required to make any given pitch of tone. The higher the pitch of sound, and the slower its velocity, the shorter the wave-lengths become; and *vice versa*. To obtain the wave-length of any given sound through any given substance, according to the theory, divide the velocity per second by the number of vibrations per second. Thus, as the velocity of sound in air is 1120 feet per second, it follows that the note A, or the sound made by the second string of the violin, having 440 vibrations per second, must have wave-lengths of thirty and one-half inches. The highest note in the common orchestra (*D* of the piccolo flute) gives a wave-length of about three inches, which is determined by dividing the velocity of sound

(1120 feet), by about 4,700 vibrations per second. The lowest note of the church organ (sixteen vibrations per second) gives a wave-length in air of seventy feet. Were this note to be sounded in water, in which sound travels with four times its velocity in air, its wave-length would be 280 feet from condensation to condensation, or from the center of one wave to the center of the next. But if this organ pipe should be sounded in connection with an extended mass of iron (in which sound travels seventeen times faster than in air), its system of waves from center to center of two adjoining ones, would have the prodigious wave-length of 1190 feet, or several times the wave-lengths of the largest ocean billows. But notwithstanding these actual wave-lengths of nearly a quarter of a mile from the center of one iron undulation to that of another, there is no amplitude or to-and-fro motion of the iron particles discoverable under the microscope.*

* But I have not yet reached the culmination of these logical and common-sense reasons for rejecting air-waves as the principle of sonorous propagation, nor have I touched upon the greatest absurdities which such an assumption necessarily involves. I have already stated the logical fact, that, if *sound-waves in air* constitute *air-waves*, as Prof. Brockett teaches, and as admitted by all writers on the subject, then *sound-waves in iron* constitute *iron-waves*. It is impossible to evade this. Further, as atmospheric sound-waves are formed by "a small excursion to and fro" of the *air particles*, thus constituting their "amplitude," without which air-waves could not exist (see many quotations to this effect, *Evolution of Sound*, p. 78), it follows that *iron sound-waves* must also be formed by "a small excursion to and fro" of the *iron particles*, thus constituting the necessary "amplitude" of *iron-waves*, and without which a "wave" is a nonentity! But as no such "excursion to and fro" of the iron particles occurs in a solid mass of iron when conducting sound, even when examined under the most powerful lenses, and consequently no "amplitude" exists in such supposed iron undulations, it demonstrates that there is no *wave-motion* in iron as the result of sound, and hence that sound

All correct ideas of undulatory or wave motion should make water billows, having a wave-length of 1190 feet, at least 100 feet high from crest to sinus, according to the proportion which prevails in all systems of water-waves. Another insurmountable difficulty connected with this theory of enormous *wave-lengths* in sound is this: As sound can only travel in *waves* through any substance, it follows that the sound of this organ-pipe could not be heard passing through iron, say ten feet thick, since it would only furnish room for less than the one-hundredth part of one wave at a time! How could such waves be appropriated as sound, with 1180 feet of each wave missing for want of a piece of iron big enough? Thus does reason revolt at the very foundation of the wave-theory as an undulatory movement based upon

must pass through iron by some other law; and if through iron then through air, as there evidently can be no two different modes or principles of sound-propagation through different substances—one *wave-motion*, and another something else! Hence, the undulatory theory of sound, even in air, breaks down of its own inherent weakness.

Should it be said, here, that in the propagation of sound through iron the particles may move "to and fro," producing the necessary "amplitude" as required in all wave-motion, but not sufficiently to be visible under a microscope, then I answer that such *invisible* and *infinitesimal* motion, even if it occurs, would not constitute sound capable of addressing the human ear, because the *eye* is admittedly one of the most refined and sensitive of the avenues to perception; and this being so, these supposed motions of the iron particles, which can be so easily heard by the unassisted ear, should, if they take place at all, be plainly visible to the naked eye! But as this assumed "amplitude" or motion of the particles cannot be seen when the sight is magnified a million-fold, it is conclusive evidence, on its face, that such motion, if it takes place at all, is a million times too trifling to be heard! Thus, again, does wave-motion in *iron* break down; and with it, as a necessary corollary, wave-motion in *air*.—Dr. Hall, in the "Problem of Human Life," p. 339.

enormous wave-lengths, having an infinitesimal amplitude that is purely imaginary, and which exists only in theory.

Q. 89. What is the general conclusion to be drawn from this catechetical investigation of the nature and phenomena of sound?

A. From the various incongruities of the current theory and necessarily attaching to it, as developed in these questions and answers, notwithstanding the wisdom of ages and the ripest scholarship in science the world has ever known have been applied to its formulation and defense, it follows rationally that such a theory cannot be true. While the harmonious consistency and the internal evidence of correctness which attach to the substantial theory, as here set forth at its very first formulation into a text-book, would seem to indicate to a logical, scientific, and unbiased mind that such a system of acoustical science cannot be false.

[We add the following, referred to in one of the previous chapters, as a specimen of Dr. Hall's method of solving physical problems:]

HYDROSTATIC PRESSURE—A MECHANICAL PARADOX.

NEW YORK, Oct. 11, 1886.

A. Wilford Hall, Ph. D., LL. D.:

DEAR SIR,—Will you kindly give the readers of the *Scientific Arena* a rational explanation of hydrostatic pressure? The problem may be stated substantially thus: Suppose a frictionless piston of one square inch superficial area entering a tank full of water. Now, if I press my finger against this piston to the extent of one pound, I produce a pressure of one pound upon every superficial inch of the inner surface of the tank, as well as upon the surface of every object immersed in the contained water,

even should such objects amount to tens of thousands of square feet of tinfoil, so separated that the water may circulate freely between the sheets.

This problem is appropriately styled the "hydrostatic paradox," and, no doubt, involves the most profound mystery of any problem known to physical science. Having failed to find an explanation of this enigma in any work on physics, I appeal to you as the one most likely, in my opinion, to solve it. By giving it your early and careful consideration you will greatly oblige me as well as render a most valuable service to the scientific world,

Yours very cordially,

DR. HENRY A. MOTT.

REPLY BY THE EDITOR.

THE problem of hydrostatic pressure is truly the problem of problems in physics, and its rational solution is unquestionably of the greatest importance to the scientific world. It is every way fitting, therefore, that this solution should appear first in the columns of the *Scientific Arena*, and we are glad that Dr. Mott, led by his very careful investigations square up against this problem, should so judiciously have thought of this journal. We shall, therefore, try as briefly as may be to give him and our readers what we believe to be the first detailed scientific explanation of this supposed mechanical paradox ever published.

Before commencing our solution let us prepare the way by a gradual introduction and consideration of minor mechanical problems involving precisely similar results, but so much more simple or less complex than the main problem here propounded that they are observed and passed over by physical investigators without at all considering their paradoxical character. Take, for example, the simplest of all facts in mechanics—if we press down a pound weight on two sheets of paper lying one on the other, we manifestly press two pounds on the two

sheets of paper, since the actual pressure is substantially the same on each, the transfer of the pound pressure being direct from the one to the other. If instead of two sheets of paper we press one pound upon Webster's Unabridged Dictionary, consisting of 1000 sheets of paper closely piled one upon another, it is evident that we press one pound on each separate sheet of paper constituting the book, thus making the pressure on all the sheets 1000 pounds. Nay, this is not all; each sheet of paper not only receives the pound pressure transferred from the one above it, but each sheet below retransfers back upon the sheet above it, by reaction, the same pound pressure it had received, making one pound of actual pressure on each side of each leaf of the book, or 2000 pounds pressure in all. This is no less apparently paradoxical than the more complex problem involved in hydrostatic pressure acting in all directions upon the inner surface of an inclosed tank of water by the movement of a piston as described. Indeed, there is no more real mystery involved in such a complex mechanical effect, when fully understood, than in the fact of the simplest mechanical action and reaction, such, for example, as if we press one pound with our finger against a table, the table must press one pound against our finger, thus making two pounds of actual pressure.

The whole problem, as presented by Dr. Mott, will be found involved in this simple law of mechanics: that action and reaction are always and of necessity equal, and therefore that reaction is a simple duplication of action and a necessary repetition of the original force of such action, however many times transferred from body to body by means of the various mechanical powers such as lever, wedge, screw, incline plane, pulley, etc., all of which are but mechanical modifications of the lever and its effects. The man who can solve the simple paradox of the one pound pressure of his finger against the table

producing one pound pressure of the table against his finger, can master this mighty hydrostatic paradox or any other complexity in mechanics, as will soon appear.

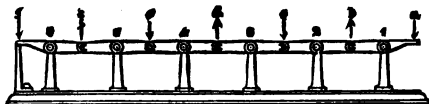
But before coming to the details of hydrostatic or fluid pressure infinitely repeated, let us try further to prepare the reader's mind for the more mysterious phase of the problem by simpler stages of this fundamental law of action and reaction, and thus show how its duplication and repetition may be extended on *ad infinitum*, and still be as simple as if but transferred a single time from our finger to the table, and by reaction from the table to our finger, thus duplicating the pressure once.

Take, for example, a number of common spring-balances hooked one to another, as a step toward these minor illustrations. Now it is evident if we pull one pound on the end balance, supposing the series to lie at zero on a frictionless table, we will pull one pound on each and every balance in the string, and the dial or graduated scale of each balance will record one pound even should the chain of instruments be a mile long. This is a beautiful illustration of the endless effect of action and reaction without the slightest loss of force, if the mechanical conditions are favorable. One of these mechanical conditions for the registering of one pound by each balance, is the fact that the mechanical *motion* of the pound pull must be duplicated for each balance added, since such *motion* or distance traveled by the pound pressure, represents the work done upon each spring in causing its duplicate registry of this same pound.

The problem thus illustrated involves the same principle in mechanics as the raising of a hundred-inch piston, entering a tank of water and loaded with one hundred pounds, by pressing down one pound on a one-inch piston entering the same tank. The large piston will be raised only *one-hundredth* as far as the small piston

is pressed into the tank, on the universal law of leverage, that what is gained in power must be lost in motion. But this forms no part of the explanation of the great problem of hydrostatic pressure, as some have mistakenly supposed. Such pressure involves no appreciable mechanical work, since it involves only an infinitesimal motion among the particles of the fluid employed. Let us illustrate the real paradox in the case by the imperfect action of a system of levers whose ends simply *press*, but which do not *move* so as to perform mechanical work.

Take a series of rigid, straight levers with fulcrums in the center, and with their connected ends hinged to each other, the end of the last lever in the system being prevented from moving by a stop, as shown in the accompanying cut. By a careful examination of this diagram



the student of physics will see the law of action and reaction exemplified in its simplest as well as in its most intricate relations to mechanics, and thus better than in any other way have his mind prepared for the true solution of the hydrostatic paradox in hand, and for a comprehension of the real form of mechanical power which applies directly to that problem.

Referring to our diagram, let us for the moment confine our experiment to the first lever, extending from *a* to *b*, and let us suppose it to be frictionless as it hinges on the fulcrum at 1, with its end at *b* fixed. Now if we press down with our finger one pound at *a*, we just as certainly press up one pound against the fixed support at *b*, while with equal certainty we press down two pounds at the fulcrum at 1, thus making four pounds of pressure on that lever. But this is not all: by reaction the end of

the lever at *a* presses upward against our finger precisely with the same force that our finger presses downward upon it, thus making two pounds of pressure at that point. The same, of course, must occur between the other end of the lever and its stop, the two surfaces of contact mutually pressing a pound apiece against each other; while the pin in the fulcrum, at 1, returns by reaction against the lever the same two pounds of pressure there borne down upon said fulcrum, thus fairly and mechanically producing eight pounds of actual pressure through that lever by the communication of a single pound downward pressure at *a*. How can there be imagined a more startling paradox than this?

But the enigma becomes more complex and mysterious when we discover that if the first lever is connected with a series of similar frictionless levers, the same eight pounds of mechanical pressure will be transferred and produced in each lever added to the series, first down at *a*, then up at *b*, down at *c*, up at *d*; first *action*, then *reaction*, and so on to the end of the series, even should the system of levers extend for miles, and should they be so connected as to operate in all conceivable directions—up, down, laterally, diagonally, criss-cross, etc. We have thus not the slightest difficulty in seeing how a tank could be ingeniously filled with minute levers and fulcrums, and even by connected systems of levers piled on systems by which an approximate paradoxical pressure in all directions could be produced similar to the one in hand.

But this is by no means the solution of this great problem, nor does it begin to grapple with the mystery involved, although by such a conclusive illustration of the unlimited duplication of pressure by action and reaction, the reader's mind is no doubt by this time thoroughly prepared for the real solution when it comes. Plainly nothing similar to rigid levers could be imagined

as existing among the infinitesimal particles of any fluid substance in order to cause an infinite duplication of the pressure between them, and by which they are forced apart and separated in all directions.

Since leverage, proper, will not solve the problem, what other form of the mechanical powers will meet the case, since it is manifest that it can only be accomplished by mechanical power in some form? We answer that the mystery is completely and satisfactorily solved by the action of the *wedge*, and that it can be solved by no other form of mechanical power.

Let us first show the application of this form of mechanism to the separation of two objects only, before extending the principle. We have first to suppose a perfectly frictionless *wedge* of infinite taper, entered between two frictionless bodies. Now it is plain that if a pound force be applied to this wedge, it will act with a pound pressure against each of the two bodies in the tendency to separate them. If this frictionless wedge should have an infinite taper in all directions, approximately like the point of a needle, it is plain, should it be pressed between a nest of frictionless bodies, all touching it, that each of these bodies would be forced outwardly with the pound of pressure the same as if the wedge acted upon but two bodies. Then let us suppose that all of the bodies thus pressed outwardly are themselves also frictionless wedges of infinite taper, each entering between similar nests of bodies, which again are of the same wedge construction; and, finally, let us suppose that every particle of matter, to its infinitesimal size, which fills the tank, is itself a frictionless wedge of infinite taper, and at once we see how the initial pound pressure against the first entering wedge-particle is duplicated and repeated by action and reaction against every similar wedge-shaped particle in the tank, and consequently against every part of the inner surface of the tank itself, as well as every object within

the tank against which such frictionless wedges can come into contact.

Now it is a fact that a tank of water, constituted of a substantially infinite number of frictionless particles, each of infinitesimal size, is practically made up of just such a system of frictionless wedges as we have described, since being infinitesimal in size they are equivalent to an infinitely tapering wedge. Then we have only to begin our experiments with an imaginary piston entering this tank, of the diameter of a single one of these frictionless wedges, and we can see at a glance how the particular wedge against which the piston is pressed with a given power must be forced between other similar particles, these between others, and so on throughout the entire mass of water, thus giving the full pressure of the piston against every infinitesimal particle or wedge the tank contains, as well as against every similar particle of the tank's surface. If this be true, and if it gives a rational view of the question with reference to the action of such a piston, it is unquestionably true and rational with reference to a larger piston, *such frictionless wedge-pressure in all directions corresponding exactly to the force applied to the piston and the number of infinitesimal wedge-particles against which the piston presses.*

This is the solution and this is the law of hydrostatic pressure; and thus only can the apparent paradox be explained.

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