"SCIENTIFIC TRI-UNITIES."

About the date of the paper read last session on "Pressure" by Mr. McFarlane Gray, the Council of this Institute were exercising themselves very much about how to make the Institute serviceable and attractive to young men graduating in the trade and profession of Engineering.

This was not an outlying detail that happened (as it were) to fall within the scope of a general scheme, but was always considered a main essential feature in the formation of the Institute, and as such was fully set forth in the Preliminary Circular and took a prominent place in the formulation of the "Articles of Constitution" now happily ratified. The Institute has been registered with the approval of the Council of the Board of Trade; the Certificate is granted by them as to a constitutional and commendable scheme, *it is* therefore worthy of your best support to make it a *power* and a *success*.

At this time also the Council was cheered and encouraged, not only by the sympathy of gentlemen in the front ranks of the engineering profession, but also by their practical interest and solid work. You have seen this exemplified in the cases of those who have occupied the chair, of those who have stood *here* before me, as well as of those on the present Session's Syllabus, whom we have yet to hear. I hope more will yet come and prove in this way that they are not of the *sign-post class* "who show the way but do not go themselves," thus encouraging us by their help in that which is already marking the progress of the Institute, giving it a high character, and maintaining the Standard of its literature.

Referring you back to the time already indicated, those who had the pleasure of hearing Mr. J. McFarlane Gray's paper (the reason I refer specially to it is because his remarks are mainly responsible for suggesting the ideas in this paper) will

doubtless remember his closing remarks addressed (as this paper is) to our young men, in which he favoured us with some of his own early experiences, and an account of the episodes which marked the turning-points of his career, and came pretty close down to some of our own experiences.

These episodes suggested something besides the moral that was so pointedly drawn from them by the speaker. What did they suggest to us? and to you Graduates particularly? Was it not something like this; that handiwork qualified by application won for him his first distinction in the shop, so "*his*" handiwork must have had special characteristics differing from and superior to that of his shop-mates. Therefore handiwork HAS characteristics, and in merely removing this axiom from a particular case to the status of a general principle, I think it will be equally obvious and acceptable to you all.

The questions—What are the "Characteristics of handiwork, and how are they shown in practice?" are at the foundation of the present paper, and I thought would be suitable to our young men for working out.

The title "Tri-unities" as the result of building on this foundation may or may not be justified; it will explain itself presently. There are details passing daily before you which you have only to collect and arrange in the form of an interesting paper; such having been my aim, I trust to have your forbearance if I fail to put the result before you intelligently.

The "characteristics of handiwork," I should say are the singular qualities exhibited in the finished product of a person's labour or manufacture, which distinguish it from that of other persons, and accordingly give it a distinctive character that is observed to be peculiar to that person's workmanship. The characteristic thus has origin in individuality and owes its formation to some principal feature, some powerful phase of disposition or constitution, something predominating that exercises a ruling tendency over physical and mechanical operations and impresses its stamp on these, conferring a distinguishing mark or qualification on everything done and particularly obvious on anything *made* or *operated upon*.

To illustrate this take as example a person's writing. You are all well aware of the wide dissimilarities that distinguish the art of caligraphy, and though in common daily practice to the extent almost of universality you will scarcely find two who write alike, it is in this and such as this that we find a proof of our deductions on this subject. In his writing it is marked or recorded by each one

in his own particular manner, which to others acquainted with him—observant of his style and peculiarities, or his way of executing his work—becomes as it were a sort of trade mark of individuality by which he is known and identified by them even when he is not present. It grows into a natural connection with him in their minds, and thus becomes disseminated through them to others who have never seen him; his writing, productions or work is recognised by them as his and inseparably connected with his name, perhaps long after he has ceased to exist, according to the merit or excellence of his characteristics.

Notable examples will readily occur to you in the names of Burns, Shakespeare and Bunyan in the Literary world, Newton and Galileo in the Scientific world, Trevithick, Newcomen and Watt in our own profession, with Caxton, Rowland Hill, and a host of others made immortal by the "characteristics of their handiwork."

Other instances we have in which the handiwork of an expert workman bears his impress so clearly as to be unmistakable, even for centuries; such we find in cathedrals or great national edifices, extending even to the perishable work of artists, as the paintings of an Angelo, or the still more familiar instance of the violins of Stradivarius; these by virtue of their excellence of handiwork are valued at a King's ransom now-a-days.

This same principle we find extensively in our daily surroundings as a manufacturing and commercial people, depending for our existence upon the work of our hands, and desiring to profit by the result. In the case of a speciality, which we find associated with a name, or firm, for the purpose of identifying or particularizing it among others, the object is to reap the benefit of a particular handiwork, and we see its exclusive character fully developed, when in addition it is placed under protection of our *Patent Laws*, which were framed for the very purpose of securing to individuals the benefits accruing from their own handiwork, having special characteristics entitling it to claim a place there. *As a result of all this we are flooded with proofs that handiwork has characteristics, and that we would do well to cultivate them.* I will illustrate this in a way you will readily understand, viz:—It is quite common to hear remarks indicative of the characteristics of different Firm's Engines, so also of valve-gear, feed heater, forced draught system, pumps, and so on; each recognised by make, arrangement, or other peculiarities, extending even to the minutest details; there are many other instances of ordinary occurrence.—A visit of congratulation to a familiar member on his arrival, or on his promotion to a greater I.H.P., or better still, his new steamer, as

affording more scope for friendly critisisms in the character of the fittings and construction. As you walk round the platform, a peep under a lifted cover reveals a "Buckley's Piston," the presence of which does not surprise you, and its merits engages you both colloquially until a recognition of another familiar arrangement facing you in a snug, airy corner of the casing all by itself changes the subject to a mutual approval of the "Maginnis' Steering Gear and Engine."—A look into the well appointed store room; and you notice with satisfaction everything in order and in its place, with spare gear, accessible and available for instant service; in doing so, you observe a regularly graduated series of corrugated discs outlined against the bulkhead, and you are at once aware the engine is fitted with "Beldam's Metallic Valves," and picking up a scrap cutting of material from the locker as you emerge into the better light of the engine-room sky-light, you recognise the same Firm's "Metallic Packing."

These are only several illustrations of the recognition of handiwork, by and through its characteristics, and these I have selected from many we are pleased to find within the family circle of our membership.

As to the commercial and financial value of special characteristics, I cannot prove this better than by reading an extract from the *Evening News and Post* of this date, published only a few hours ago, and referring to the value of "Patents," as follows:—

EVENING NEWS AND POST *of Monday, 2nd September.*

PATENTS.

A FEW FACTS AS TO THE ENORMOUS WEALTH THERE IS IN THEM.

The Government Commissioner of Patents estimates "that from six to seven-eights of the entire manufacturing capital of the United States, or six thousand millions of dollars (£120,000,000 sterling) is directly or indirectly based upon Patents." A calculation of the same kind in this country reveals a still more surprising result, the capital invested being enormous. It has been computed that Siemen's inventions have produced more than five millions sterling, and have indirectly benefited the poor of this country largely, by creating new industries, or by reviving flagging ones.

Lord Brougham often said that he would gladly have exchanged his honours and emoluments for the profits and renown of the inventor of the perambulator er sewing machine.

Howe, the originator of this invention, derived the princely fortune of £100,000 a year from it, and, from their mechanical improvements, the celebrated Wheeler and Wilson are reputed to have divided for many years an income of £200,000; while the author of the Singer sewing machine left at his decease nearly £3,000,000 sterling. "More money," says a well-known writer, "has been and always can be made out of patented inventions than by any other investment or occupation." The telephone, the planing machine, and the rubber patents realised many millions, while the simple idea of heating the blast in iron smelting increased the wealth of the country by hundreds of millions. The patent for making the lower end of

candles taper instead of parallel, so as to more easily fit the socket, made the present enormous business of a well-known firm of London chandlers. The "Drive Well" was an idea of Colonel Green, whose troops during the war were in want of water. He conceived the notion of driving a two-inch tube into the ground until water was reached and then attaching a pump. This simple contrivance was patented, and the tens of thousands of farmers who have adopted it, have been obliged to pay him a royalty, estimated at £600,000. A large fortune was realised by the inventor who patented the idea of making umbrellas out of alpaca instead of gingham, and the patentee of the improved "Paragon Frame" (Samuel Fox) lately left by will £170,000 out of the profits of the invention.

I now come to the second section of the subject, having defined what the "characteristics of handiwork" are, we will now consider how they are shewn, made apparent, or applied, in science and practice.

In looking up all the highest authorities, modern, mediæval and ancient, as in courtesy to you and in duty to my subject I was bound to do with the utmost care, for the best and most pertinent illustrations in confirmation of the principles involved in the subject, or aids to its better understanding, I found, much to my surprise, that they were so numerous and abounding, and had such an enormous scope that I was made to feel at this stage of the preparation of the paper, that there was plenty of material to justify my entertaining the idea of taking on a contract for the whole series of Papers for the Session.

I have not strayed far from my intention except in starting, and as this is the *first paper* dealing with *first principles*, on the *first night* of the session, the *first addressed specially* to our young men, we may be held excused if, for the sake of a proper start, we have to refer to the "*Primary*" sciences in which there is so much to interest us. After progressing so far with this Paper, I thought it well to change the title. Such a change as this may have been within the experience of you young engineers, in the course of your daily work. Doubtless you have had a rough casting or forging dumped beside your bench, presently the shop foreman comes with a plan or sketch and gives you explanations of it, sets it off, with instructions how best to manipulate this rough forging into a finished piece of mechanism. You proceed through all the various processes of chipping, file-shoving, turning, etc., persumably with all the intelligence at your command, bent on properly interpreting the plan, gauge, sizes, etc., until you have completed the whole work of preparing this rough piece of iron and turning it out of your hand as a finished piece of mechanism, or perhaps, as the case may be, the foreman might call it by the less dignified title of *scrap iron*.

This may serve to explain how the name of a thing becomes changed, and generally in the course of prepara-

tion. It so happened in my case, with this difference, that I was made to feel that it was by far the best way to arrive at the soundest conclusion, so much so that at this point the subject itself (though in no way departed from throughout) was completely over-shadowed by the subject-title the paper now bears, viz :— "Scientific Tri-unities," the connection between which and the "Characteristics of Handiwork" is so very *close and strong*, that I hope to be justified in considering that any other title would have been misleading.

I will now proceed to shew the connection :—

In the first place what is a *tri-unity*, the word itself is a compound one, derived from two Latin roots, viz , *tres*, signifying *three* and *unus* meaning *one*, therfore a *tri-unity* is literally what the simple sense of the translation implies, a *three-one-ity* (so to speak) and signifies a thing, *one* thing that has or bears a three-fold character, each distinct and separate, but when combined make up one grand consistent whole.

To illustrate this simply, you are met here to night as an audience to hear a Paper read (a unity in one capacity). I am here to read the paper (a unity in another and rather more questionable capacity), and our esteemed chairman is here presiding over us (a unity of a third distinct capacity) ; there are thus three units, all combined together for the *one* grand purpose of forwarding the interests of the "Institute of Marine Engineers." That is one tri-unity, but I daresay you will agree with me it is not a very scientific one. Another illustration of tri-unity less complex than that, and beautiful in its simplicity is the flag of our country, the "*Union Jack*." There you have the three separate flags of the three countries of England, Scotland and Ireland, with their symbols in heraldry — the crosses of St. George, St. Andrew and St. Patrick united and blended in one flag, the Union Jack, forming the National Flag of the United Kingdom of Great Britian and Ireland (a tri-unity that holds good up till date at least). Well, these are ordinary tri-unities, and in dealing with them I came upon the scientific ones while searching the old authorities for suitable illustrations among the early mechanics and their historical feats of engineering, and was successful in tracing them back to the deeds and dates of the Pyramids. I was even further than that and in many curious places hunting for tri-unities. I was down the fore peak of the Ark one night (in a dream) and, by the way, I thought I saw a job or two down there—at least things were not quite in accordance with Lloyd's Rules; I could see neither a sluice valve in his collision bulkhead, nor a pump, but I said nothing about

it from sheer force of habit, and partly out of reverence and respect for the grand old shipbuilder, Noah, as he had left several tri-unities about loose and the fore peak hatch off; but I was so disgusted at being unable to find the engine-room, that I woke up and found myself in the chair with the midnight oil still burning and daylight full on.

I got several tri-unities there and at the Pyramids, but however seductive they might be to the author of a Paper who desired to take advantage of the opportunities afforded, of enlarging upon a subject, unfettered by disagreeable questions of fact, especially if he desired to get beyond the chances of contradiction at the discussion stage, I considered them not sufficiently satisfactory for the intelligence of this audience on the present occasion, so I will not touch upon the tri-unities adorning the dates referred to but merely remark that I found them.

I also found them earlier, and I will *enlarge* upon *them*, as I know they will commend themselves to your understanding—notwithstanding the apparent paradox. I now specially refer you to what is universally admitted to be the biggest bit of engineering known in history (ancient or modern), I mean the "*Creation of the World.*"

In a piece of handiwork of such vast magnitude and importance as the Creation of the world, we even find "Tri-unities," clear and palpable in form, and in the front rank of first principles. Can this be accounted for, and placed within the category of "Characteristics?" If it is really necessary that I should make manifest the connection between "Tri-unities" and the "Characteristics of Handiwork" which I previously described as being close and strong), I shall do so now, and in the briefest possible manner. I shall merely indicate regarding the personalty of the Designer and Creator of the World, that we know, on His own indubitable authority, that the principal and distinguishing characteristic, permitted to be known to us mortals, is His Triune nature, and would draw your attention to the remarkable similarity of characteristics between the *Creator* and the *created*, the Designer and His *handiwork*. The latter bears the triune characteristic, qualification or reflection through all the essential principals, laws and features of created Nature, extending down through its several sciences to the professions and operations more or less under the influence of the will and necessities of human agency, even to the minutest details, where principles are involved, and this appears the more remarkable the closer it is studied.

Let us look at some proof examples of this theory, and see how far and how well the generally accepted Laws of Nature and

Triunities (so to speak), let us wander among these Sciences, with their phenomena, their teaching, their tendencies, their deductions, formulæ and results, with their effect on the practice of the professions founded on them, and demonstrated in the faith, facts proverbialisms and operations within the domain of ordinary life and daily work, more or less under the influence of human agency and will.

Beginning with the Sciences, I may *primarily* indicate that they have a *triunal* classification.

The Sciences are divided into three general classes, viz. :— "*Celestial Sciences*," "*Terrestial Sciences*," and what is generally known as the "*Social Sciences*." I need not here descant upon their several domains, as, if they are scarcely obvious, they will be made so in the course of the Paper, but I would merely mention with regard to the latter that are so-called because they are necessary, and in some instances indispensable to man for his investigation and enjoyment of the other two. A most reasonable distinction indeed, and without which this Paper would be sadly wanting in proof and detail of the theory put before you for consideration and discussion.

I will open with the science of Astronomy, meanwhile remarking that the more obvious the "*Triunities*" appear the briefer will be my remarks, and the more obscure they seem to appear in some of the abstruse sciences, on account of their being seldom in ordinary use or general study, I will endeavour to treat them more comprehensively, some (perhaps a good many) being beyond my own experience, will be authoritively quoted and acknowledged acordingly.

Of the "Celestial Sciences" then "Astronomy" is the first to which I would ask your attention. It is the study of the heavenly bodies, and treats of *three* principal features regarding them, viz. :—their *size*, *distance*, and *motions*. As to the bodies themselves *we* are confronted at once with the obvious tri-unity of the *Sun*, *Moon*, and *Stars*, this one includes them all. Again taking say the "*Stars*," of which there are three different kinds, viz., the "*Fixed Stars*,"—so-called because they keep the same position in the heavens relatively to each other—the "Planetary Stars" which revolve, or rather wander (as their name properly signifies) in regular orbits about the sun as centre of the solar system,* and "Comets," or erratic stars, which are sufficiently well understood as belonging to neither of the two former classes, and mostly all that seems to be well understood about them is this distinction.

* There is also this distinction between the fixed and planetary stars, that whereas the former shine with a steady light, the latter always twinkle.

The "Planetary aspects" most frequently alluded to, denoting their positions relative to one another are, the trio of *Quadrature*, *Conjunction*, and *Opposition*. Another Triunity I shall detail is the Laws that regulate the "Planetary Motions," called "Kepler's Laws," discovered by John Kepler, a celebrated German Astronomer of the 17th century, who thus won the title of the "Legislator of the Heavens," after the splendid discovery of this Tri-unity of Stellar Statutes, associated with his name.*

There are still more Triunities with which perhaps we are more familiar, such as the "motions of our own crazy old Planet, the Earth,"—first, its diurnal revolution in 24 hours, constituting our day—second, its annual motion round the sun making our year—and third, the oscillation of its axis upon the plane of our Ecliptic, having its slight influence on the relative length of days and nights respectively.

Excuse one more for its own sake; I now refer to the three well-known terms that express the ordinary and astronomic limits of this starry region, viz., the "*Horizon*," that bounds our vision on the plane of observation, the "*Zenith*" immediately overhead, and the "*Nadir*" immediately underneath.

The full power of this interesting trio is only brought out when we do not fail to remember that, "every point on the surface of the earth has a Horizon, Zenith, and Nadir of its own, and that these again are constantly varied in character by the continual motions of the earth."

Hanging this astronomical wreath of sparkling tri-unities on the Zenith to mark the progress we have made among the "twinkling constellations" tending to lure us further than time permits to-night, and descending from this airy cloud-land, we alight on the more solid "terra firma" of our own Earth, and *Geology*, the science that describes it, suggests itself at once. Geology treats exclusively of the three general properties of the Earth, viz.:—its *Size, Shape and Density.* (This is a fair beginning in the section of "*Terrestrial Sciences*," and I may also incidentally mention here that our Earth is divided "geographically" into three great continents, viz.:—The *Eastern* or European continent, the *Western* or American, and the *Southern* or Australian continent.)

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* Kepler's Laws—Astronomy.

First Law.—The orbits of the planets are ellipses having one focus in common, and in this common focus the sun is situated.

Second Law.—The Radius Vector of a planet passes over equal areas in equal times.

Third Law.—The squares of the planets' times of revolution round the sun are proportional to the cubes of their distances from the latter.

The Earth's Composition is further classified "geologically" as follows, viz.:—*Rocks*, the mineral and solid portions; *clays*, *sands*, &c., the plastic portions; *rivers*, *lakes*, *oceans*, &c., the fluid portions. Take one of these for further analysis, say *Rocks*, geologists further classify them as follows, viz.: —

1. "*Aqueous*" rocks (of sedimentary origin), so named because water plays the most important part in their formation.
2. "*Igneous*" rocks, in which fire was the principal agent, they having once been in a state of fusion.
3. "*Metamorphic*" rocks, which are *crystalline*.

These are all "again" grouped according to their mode of origin, thus:—

1. "*Mechanically-formed*" rocks, formed purely by mechanical means from the ruins of previously existing rocks.—(Shale is an instance of this group.)
2. "*Organically-formed*" rocks, consisting of accumulations of animal and vegetable remains. (Coal is an instance.)
3. "*Chemically-formed*" rocks, produced by chemical means in Nature's own Laboratory. (Rock salt, gypsum, &c., are instances.)

The times of formation (or ages) are divided into three great periods, viz.— The Palœozoic, the Mezozoic, and the Cainozoic periods.

Having now been for some time a visitor on the earth and explored its Geology and general features, what would next affect our consideration of it as a possible place of residence? Its climate. Well, this is embraced in the Science of *Meteorology*, which treats of the phenomena found in its (3) different zones—The "*Torrid*," the "*Temperate*," and the "*Frigid*" zones; and the details of "phenomena" that occur in these regions, are meteorologically classified, thus:—

"*Aerial*" phenomena such as winds or hurricanes.
"*Aqueous*" „ comprising rain, fog, snow.
"*Luminous*" „ as lightning, meteors, &c.

The first of this triunity for sub-division into three gives "*constant*," "*periodical*," and "*variable Winds*," representing "*Trade Winds*," "*Monsoons*," and the "*Winds*" of our own temperate climate, respectively in order.

Now all these rather suggest the discomforts of life out-doors, and the consequent desire to get indoors, especially about lunch time, for the indispensable necessity of food. *Food*, then is the principal section of the science of *Hygiene*, which informs us that the food of man is of (3) different kinds and for three different purposes (a sort of twin tri-unity this).

The Hygienic cla:sification of the food of man runs thus, "*Mineral*," "*Carboniferous*," "*Nitrogenous*" foods, and may be classed as "*Solvent*," "*Heat Givers*" and "*Flesh Formers*"—all required as "ailmentary food" (this word as used in Hygiene means "essential" or "indispensable"), examples of these are as follows, viz:—*Starches*, *Caseine* and *Salts*.

After a luncheon of such tri-unities, we are perhaps inclined to think the pleasures of life would be next in order, succeeding its comforts. What is to be the entertainment then? Song—(very well). In the science of Music and the Province of Acoustics, or Sound. I need hardly remind you, here, that the poet has graphically informed us that "*music hath charms*," and I am here to-night to tell you it has its tri-unities also, viz:—Music is produced by (3) effects, viz:—The *Production*, *Propagation*, *and Reflection* of sound. The science of Acoustics (of which "sounds" are the study) is itself only concerned to the triunal extent of their *Production*, *Transmission* and *Comparison*.

There are only three different kinds of musical instruments, or arrangements, severally and familiarly known as "*Stringed*" instruments, such as the violin or piano, "*Wind*" instruments such as the organ, and those that emit music by *Percussion*, such as a carillion of bells, musical glasses, or blocks of metal or wood struck by a hammer-like instrument. (I am not quite sure that the *drum* comes under this category, but perhaps the professional of the Institute, will strike this note clear in the discussion stage.)

In addition to all this, I may indicate that "*Musical tones*" have three leading properties in the science of Music, and these three we admire in its best exponents, *i.e.*, *Pitch*, *Intensity*, and *Quality*, and when these three are combined in one Artist, we have to book early to hear him comfortably. (I have personally investigated the "*kinds*" of music, and find they can be distinctly classified in the three comparative groups of *good*, *middling*, and *execrable*.)

Let us now take a morning walk in the garden, where we will find in full bloom the beautiful productions resulting from the study of the *Science of Botany—that Prince* of the "*Vegetable Kingdom*," to whom I previously promised, I would introduce you later on.

Now I dare say those who would court this Vegetable Prince successfully within his own domain (even though it is only a back garden) know to their cost that digging is a matter of first principles there, and it seems to hold good also metaphorically—buried as it is among the technicalities of the Science of Botany. By virtue of a series of sore backs, I might be supposed to have some slight knowledge of the secrets of this Tri-unity in

the Vegetable Kingdom, yet I ask you to accept a higher authority, that of Hutton Balfour, Professor of Botany, from whom I quote as follows, viz. :—"In arranging plants according to the natural system, the object is to bring together those which are allied in all essential points of structure. It is called natural because it follows the system of Nature, and thus takes into account the true affinities of the Vegetable Kingdom on a comparison of all their organs. According to these general principles, the Natural System is founded, and which is that adopted at the present day."

The whole vegetable world is so classified then, as follows, and divided into *three* distinct classes, accordingly, viz., the *Acotyledononous* plants, which have no cotyledons or seed-lobes, the *Monocotyledonous*, which have only one, and the *Dicotyledonous*, with two or more cotyledons or seed-lobes, the latter generally called *Polycotyledonous*, as it includes those having *many* seed-lobes. Completing the tri-unity graphically and in a more familiar form I may say that the "*Fern*" *family* of plants represent the first, the "*Orchid*" *family* the second, and the "*Rose*" *family* the third; specimens of each class are indigenous to Great Britain and also to that "Unity" of it called Scotland.

The proverbial "Old Man" now comes to water the garden, so we must leave, as we have met the liquid in the previous tri-unity of *Land, Water and Air*. Is there anything in water itself? There must be, as some good people pin their faith to it for very different reasons, I take it just now for its important contribution to our subject.

How does water illustrate this? In its three essential properties, viz.: the *fluid*, the *solid*, and the *aeriform* state. (I could scarcely afford to dispense with this watery tri-unity as I am sure it is so obvious and familiar to you all).

But "water" has a further charm for me. The laws that govern its pressures, under the science of *Hydrostatics* we find are only three in number:—

First Law.—Liquids subjected to Pressure transmit it undiminished in all directions.

Second Law.—Liquids influenced by Gravity alome press in all directions.

Third Law.—The Pressure of Liquids in every direction is proportioned to their depth.

As some might be disposed to question the principles by which these fundamental Rules, Laws and Properties are satisfactorily obtained and made manifest to the extent of general acceptance, they might be answered to the effect that it is principally

due to an intelligent and studious use of the opportunities that pertain and occur within the range of the very simple *science* of Optics, which primarily treats of the *Eyes*, then "what is visible to them," and third "the light or medium by which things are made visible," Therefore "Light" is the principle essential in the science of *Optics*.

The sources of *Light* are very nearly the same as those of *Heat* (which will be treated more fully in sequence, I need only indicate them here); they are the "*Sun and Stars*," also "*Chemical*," and "*Mechanical*" action. Then as regards the first important property of *Light*, viz., its "*Power of Transmission*," bodies are divided into three classes, *i.e* :—

"*Transparent*" or such as allow light to pass freely through them, as glass.

"*Translucent*" or such as allow light to pass through them, but *not freely*, as ground glass, thin paper, or horn.

"*Opaque*" or such as do not allow light to pass through them, as wood, stone, or the metals.

Next after "*Transmission*" comes the second property of "*Reflection*." The "Great Laws of Reflected Light" are best investigated and explained by the aid of mirrors or lenses, of which there are only three kinds, the "*Plane*," the "*Convex*," and the "*Concave*"; the light reflected from them produces the three interesting optical effects of the Rays of Light described as "parallel," "converging," and "diverging," which differ when produced by each of the different kinds of mirrors.

From these are evolved the remarkable phenomena of the "*Solar Spectrum*," with its prismatic production of the primary colours, and more remarkable still that through the medium of the Solar Spectrum comes the distinct definition (as a contribution to general scientific knowledge from the branch Science of Optics), that every ray of ordinary sunlight has three (and only three) distinct properties, viz., "*Brightness*," "*Heat*," and "*Actinism*," the meaning of actinism in this connection is "the power of producing chemical effects," and (as illustration) forms the basic principle of the art of the photographer, and leaving these optical tri-unities in his care for development, our *vision* will now be sufficiently clear to pass over the stepping-stones of the brook on the borderlands of our own particular unity in the Sciences, viz., Mechanical Science. We find "*Geometry*" is located within this borderland, and rightly so, as he is a good and helpful neighbour.

Geometry is the science which treats of "Magnitudes." Theoretical Geometry treats of the properties of Magnitudes and

Practical Geometry of their construction.

There are three kinds of Magnitudes which have also one, two, and three dimensions respectively, viz. :—"*Lines*," "*Surfaces*," and "*Solids*," and may be represented by diagrams.

"*Lines*" are made up of an infinite number of points, "*Surfaces*" of an infinite number of lines, and "*Solids*" of an infinite number of surfaces. Most young graduates know of course what a *line* is and how many different kinds of "*lines*" there are? The three different kinds are the "straight" line, the "curved" line, and the "spiral line; all other lines are combinations of these (as shewn in Diagram).

Although *lines* form the simplest elemeut of this science, they are capable of demonstrating triune principles still further in their *measurement*, which to be complete has three necessities, an *initial* point, *terminal* point, and *distance between them*. A *line* has still three more characteristics, which give it all its importance in geometrical figures or diagrams, *lineation* (or *continuance*) *direction* and *position*.

What properties has *Surface*, the second of the geometrical trio? Would we not be correct in speaking of its length, its *breadth*, and its *configuration* or *area*?

Solids are the third, regarding which it would be only plain common sense to describe their main characteristics, as *length*, *breadth* and *depth* or *thickness*.

While remembering that these are the fundamental principles which the *whole theoretical* fabric of our own particular division of the science is raised and regulated by, you will be led to perceive that arrangements, or combinations of lines, surfaces and solids go to form a *design*, which brings us within the sphere of practical geometry as applied to constructive purposes.

Ideas are represented in a Plan or design of a proposed Erection, and to be fully serviceable for this purpose it requires to exhibit the three distinct essentials of *plan*, *elevation* and *section*—these are the principal characteristics of a complete *design*.

Proceeding intelligently, our next step would be to test theoretically the qualifications of the *Design*, its accuracy and fitness for its purpose of reproducing the structure correctly. This is principally effected by calculation, within the science of Arithmetic, into which we might enter for a little.

Arithmetic is one of those educational accomplishments that are freely referred to by incipient School Board candidates during election times, and so generally understood in this connection that

it is raised to the dignity of a proverbial expression, well-known as one of the "three" *R's*. (A casual Tri-unity, which I can scarcely afford to take advantage of seriously at present.)

The leading elementary exercises in arithmetic are well within the experience of graduates and you will recognise them as *Addition, Subtraction and Multiplication*. *Division*, as you know, being simply another method of subtraction, and as such does not find a place in some recent elementary books, one of which dated 1884, I now hold in my hand. These are the fundamental exercises, then, on which the others are based. If we go a little further we are confronted with the indispensible *Rule of "Three,"* the importance of which is irrefutable. If another proof is desired, and the key note of this paper is sounding round the figure 3, might we not expect to find something special or exceptional about the numeral itself? The figures 1, 3, 6, and 9 occupy the principal positions of our numerical scale, 1 the unity of 3 and the only one it is capable of being divided into, occupies the premier and initial place, 9, its square, occupies the terminal position, itself and its double power tri-unity, 6, occupies the intermediate. Thus the principle positions of *initial, intermediate and terminal* importance in our numeral scale are held by its unity, its single and double, and triple power, as tri-unity.

That its triple power has special and important attributes I now wish to show you briefly, and I have prepared a diagram illustrating it. I have no doubt the seniors are acquainted with it, but it might interest the graduates. * This peculiar power of our numeral tri-unity tripled (viz.: the figure 9) is a property neither approached nor possessed by any other figure in the numeral scale, and is largely taken advantage of and utilised by accountants and others dealing with extensive calculations, for the important purpose of checking their accuracy and is much depended on by them. There are others in connection with this science but (speaking in a graduate sense) it is time to part from the drawing office or theoretical department and accept the promotion of a course through the shops, where its principles are applied and we are early brought into contact with the properties and application of the various mechanical powers.

In the first place we must not forget that Mechanism is governed by certain well-defined principles, and has stated or prescribed functions to perform; we will deal with the latter now that we are in the shop. What is the function of mechanism? not the *general*, you know, but the reverse, the *particular* function of mechanism. Is it not to *receive*, *concentrate*, and *apply* power? All these three, for the purpose of *overcoming resistance*. In the

* See addenda for illustration of this Addition, Subtraction and Multiplication.

simple mechanical powers themselves we are favoured with a remarkable instance of *twin tri-unities*, one member of which is the *lever*, *the wheel and axle*, and the *pulley*, these form what is known as the "*Lever*" series of powers, and the other member is the *inclined plane*, *wedge*, and *screw*, as the "*Wedge*" series. In further illustration, take of the former series, viz., the "*Lever*," there are three distinctly different *orders* of the simple lever itself. A lever of the *first* order, has the fulcrum between the power and weight; in the *second* order, the weight is between fulcrum and power; and the *third* order has the power between the weight and the fulcrum.

Those are the powers and their kinds and orders, but how are they all serviceably requisitioned—principally by *wheel-work* which enters more largely into mechanics than any other form or arrangement. The principal duties of wheel-work are three in number, viz., to *receive*, *transmit* and *give direction* to the power they are charged with, and this is effected in three different ways, viz., by *friction* of their circumferences, *by bands*, or by *toothed gear*, the latter being most extensively used, and of which there are again three distinct orders, viz., those with their teeth perpendicular to their axes, such as *spur-wheels*; those with their teeth parallel to their axes such a *crown-wheels*, and third, those with their teeth set at an angle such as *bevel-wheels*. These then are the methods generally used for transmitting and directing power and motion which come direct from the SOURCE OF MOTION, a more or less complex arrangement of the foregoing different parts and principles, and situated conveniently for producing the power and motion required. Regarding this (the Engine) as an abstract subject, you are well aware that countless volumes have been written, and still they come. I am sure we are all proud to belong to a profession that can awaken such an absorbing interest, and call forth such apparently limitless literature, all centreing round the single word ENGINE. Our own syllabus testifies to all this and for fear of overlapping the province of the Papers indicated there, I will only give a few examples of tri-unity (and that in first principles) here,—beginning with the three principal kinds of steam engines, *i.e.*, the *fixed* or *Stationary* engines for manufacturing purposes, such as a shop's engine, then the *Moving* engines, such as Locomotives, and third *Marine* engines for propelling vessels. We have no *flying* or *jumping* machines yet, so you see there is great scope for you young grauduates. Again we have another tri-unity in the constructive differences of the classses of steam engines, viz.:—

The *Low Pressure* engine, in which the steam is discharged at a pressure under that of the atmosphere.

The *High Pressure*, with its steam discharged into and again-

the pressure of the atmosphere.

The modern *Compound engine* too familiar for description here.

But what is the use of engines without *motion*, the "breath of life" to machinery.

Motion.—In the province of Dynamics; how many kinds of motion are there, and what and how many are its laws?

There are three different kinds of motion, classed as follows, thus:—*Uniform, Accelerated and Retarded.*

Uniform motion, is that of a body which moves over equal spaces in equal times.

Accelerated motion, that of a body whose velocity keeps increasing as it moves.

Retarded motion, that of a body whose velocity diminishes as it moves.

By deep investigation into the principles of motion, Newton discovered the great established laws which govern it, and they are Tri-unity also, and I quote them seriatum:—

First Law.—Every body continues in its state of rest or of uniform motion in a straight line, unless acted on by some external force to change that state.

Second Law.—Change of motion is proportional to the impressed force, and takes place in the direction of the straight line in which the force acts.

Third Law.—Reaction is always equal to action, and opposite to it in direction.

It was this third law (the law of reaction), that upset the theory of the engineering genius of the early navigation days, who was exercised to invent a propelling power for vessels in calms, and carried it out to the full scale of practice by actually fitting up on the poop a huge bellows to blow into the sail, so that he would always have a fair wind.

It would'nt *hum* however, and he could'nt tell why till he went home in the evening, when his very sensible lady told him that he might as well have tried to jump up to the garret by pulling at the straps of his boots.

As it is in sequence, I may as well give a passing reference to another kind of *motion*, which has laws of its own, I refer to *pendulum motion* or *vibration*, they are also three in number. *First:* Pendulum vibrations are performed in the same time whether it moves through longer or shorter arcs. *Second:* Vibrations of pendulums of different lengths are performed in different times, and the lengths are proportional to the squares of their times of vibra-

tion. *Third Law:* Vibrations of the same pendulum are not performed in the same time, at all parts of the earth's surface, but being operated on by another great law in nature, differ according to its distance from the earth's centre.

The great law of nature just referred to is *gravitation*, which is itself distinguished by a tri-unity of established principles in its operations, thus:—

First: Gravitation acts instantaneously.

Second: Gravitation is not lessened by the interposition of any substance.

Third: Gravitation is entirely independent of the nature of "matter."

As we might unconsciously be led into subjects allied to this by going further in this direction, it might interfere with the scope of a Paper I notice on the Syllabus, and which we have yet to hear, and as our friend (Mr. Hawthorn) might be desirous of treating it more or less technically, I had better keep about the shop where we left off without ascertaining the *forces* that actuate the machinery there, or their *sources*.

Force.—In the province of statics; the science of Mechanics does not consider the nature of forces, but treats only of the properties common to all. *Forces* from different sources, however, may be compared with one another, and are thus capable of being determined by numerical valuation; and I have only to mention the three *principles of Force*, when this will be clear—1st. Its *intensity*; 2nd. The *point of application*; 3rd. The *direction*.

While it is a well-known fact that *heat* is a *source* of mechanical force or action, it is equally familiar that mechanical action is a source of heat.

"Heat," as an agent, was evolved in three ways in the primitive ages, as when the rude Indian obtained it from the rays of the sun or (when it was not shining) by "friction" (rubbing pieces of dried wood) or third by "percussion," striking metallic flints together) so in this way heat was obtained by "striking," as a source of mechanical action; but this, by the way, has an obverse too, the present deplorable circumstances forcibly exemplifying that "Striking is a source of complete mechanical inaction also"* but which we trust will soon be got over by the judicious exercise of the tri-unity of moral "Graces," "*Faith*" on the one side, "*Hope*" on the other and "*Charity*" on both, but especially on the part of the public generally.

*Alluding to the Great Strike at the London Docks.

We have improved upon the Sources of Heat in these modern days and classify their origin as "Mechanical," "Physical," and "Chemical," a familiar trio, I dare say. Having ascertained the Sources of Heat let us examine its properties, which again take the form of tri-unity, but *red-hot* this time and very convincing. The first illustrates "*Conduction*," as when heat passes from one particle of a body to another in contact with it (one end of the poker in the fire, the other end becomes heated by *conduction*). "*Convection*," as when heat is conveyed by the actual motion of some particles of a body such as obtains in any form of boiler, the particles of water first heated ascend, carrying heat with them and diffuse it by *convection* (or literally by being conveyed). This is usually demonstrated by means of the Florence Flask; being of glass, the action is observable through it. The third (and last) property of heat is *radiation*, that is when it passes from one body to another, not in contact with it, leaping over the intervening space between them. A joint of meat placed before the fire is roasted by *radiation*. What becomes of it after that, is scarcely within the province of this Paper, unless you may be interested in its composition, which I take it is generally well within the intelligence of a graduate, as being *lean*, *fat* and *bone* principally. There are many tri-unities connected with roast meat that are extremely interesting to graduates. When a joint of meat is being so warmed by radiation, what philosophic deductions are to be drawn from it in a purely graduate sense? Taking my stand upon personal experience, and which may be influencing most of us here at the late hour, I might ask does it not betoken the near approach of these triune blessings so dear to the soul of every graduate, viz.: *Knocking-off-time*, *supper-time* and *bed-time*.

This reminds us forcibly of the most important tri-unity in this paper, (as in many speeches), viz.:—Its *thirdly* and *conclusion*.

Although much remains to be considered in the sciences I have mentioned, and in many others not touched upon here—all of them rich and radiant with appropriate illustrations of *tri-unity*—I have been careful to select examples from those only that were plain and familiar and readily understood without reference, if by doing so I have cramped or crippled the importance of the general subject, I trust at least that the object in view was evident, viz.:—The moral I desire our graduates to draw from the paper (as indicated in the prefatory remarks) is to assiduously cultivate a sincere desire to excel in their great profession on every opportunity, and to prepare themselves accordingly by application, perseverance and thoroughness in practice, and their *handiwork* will thus obtain a *character* that will enable them to stand behind their work and let

it speak for them, for so surely as this is done, as certainly will it be made evident to those who desire to retain your services and avail themselves of their advantages.

Thus precedence will be given by virtue of a "characteristics of handiwork" and acceptance in the eyes of the great general triunity of *superiors*, *inferiors*, and *equals*, while a further distinction as a "Medallist" of the "Institute of Marine Engineers" awaits those whose "characteristics of handiwork" are in closest accordance with the spirit of the old Latin proverb, *Omne trinum perfectum* meaning, that "there is a *three-foldness* about all things perfect."

MR. M. PRIOR'S REMARKS.

I have listened with pleasure, and—at times where the Author has introduced his pleasantries—with some amusement, to the Paper just read on "Scientific Tri-unities," and I think we must all be very forcibly reminded of St. Patrick's visit to Ireland to demonstrate the "Tri-unity" of another subject, and Martin Tupper's remark in his Proverbial Philosophy "that there is a Tri-unity in all things." Although I am far from endorsing all that has been said by each individual member of this tri-unity, yet taking them in regard to time, as St. Patrick, Martin Tupper, and Mr. Craig, I can fully understand Mr. Craig saying that in writing on scientific subjects, the difficulty is not how to get matter sufficient for one paper, but how to give in one paper only a trace of some of the scientific questions. Therefore, I am not surprised that Mr. Craig has not entered into any one particular scientific question, but has given, for the benefit of our junior members, what may be called a "preface" to the study of scientific subjects. Now any one who can turn the minds of the junior members of the Institution to the study—ah! and the love of science—may well be taken as a benefactor to them, for we can all be assured that there is no profession, trade or calling, in which a general scientific knowledge is not only useful, but necessary to an engineer, and more especially to a marine engineer, for he must have the brain to guide, in some instances, thousands of horse power, over thousands of miles of the earth's surface, when thousands of miles from land, and without any extra help in cases of emergency. But whether we study scientific subjects or not, we all have to act on scientific principles from the first. In reading one of the works of Mr. Piazzi Smyth, the late Astronomer Royal of Scotland, I was surprised at a statement therein made, viz., "that all science consists of *observation* and *measurement*." This is not a Tri-unity. This statement seemed much too simple to be true, but taking it to be true, as I firmly believe it to be, every child before it can walk is to a certain extent a scientist, for if you place

t alone on a chair it is afraid to fall off, showing, that it has *observed* the distance to the floor, and found the *measure* too great for it to descend without help. We all have in ourselves the most wonderful scientific arrangements with which we must act strictly in accordance; but, constantly acting upon them, we seldom give much thought to them, and treat them as we are too apt to treat little things—with contempt. The least things are just as true to science, however, as the greatest. Taking only one instance to show how wonderful are the scientific arrangements of the Human body, viz., the human voice. On the authority of Dr. Talmage, of Brooklyn, the human voice is capable of producing *seventeen trillion* sounds. Now it would be a nice calculation to find how many of the best constructed organs it would take to make that number of sounds; no doubt it would take millions of them.

Mr. Craig alludes to the great discovery of Sir Isaac Newton; here I think a very good "Tri-unity" might have been made by taking Galileo's discovery of the earth's motion round the sun, Sir Isaac Newton's discovery of the attraction of gravity, and the greatest discovery of the present age, viz., that energy, like matter, cannot be created and cannot be destroyed. Before sitting down I should like to ask Mr. Craig if he is correct with regard to the number of planets between the earth and the sun, for without taking the poor moon into consideration, except as our despised satellite, another planet has, I think, been discovered between Mercury and the Sun.

MR. ROWE'S REMARKS.

In the interest of the younger members of the profession whose minds are in a plastic state, I should like permission to make one or two remarks. In the first place I desire to compliment Mr. Craig upon the great diligence shown in his exhaustive paper; and if young engineers would permit themselves to be influenced by so excellent an example, there would be fewer failures at examinations resulting from carelessness and idleness. Many men, both young and old, believe that professional success is due to superiority of natural parts—to genius in fact. Well, no two minds are equally endowed, but eminent men with a large knowledge of human history, have perceived that the greatest leaders of thought, and the grandest discoverers in science had, as a rule, shown no sign of their superiority whilst at school, at college, or at university. Senior Wranglers, become as a rule, lost to the world, and to fame, as soon as the university is left behind. The strongest mind was that which unaided overcame the greatest difficulties; and for purposes of discovery—of progress—it is desirable that some men should be to a great extent ignorant of and indifferent to authority,

for then their minds are free to receive without opposition, the results which spring from experiment and logical reasoning. Most men pass the greater part of a lifetime in conquering some errors learnt in youth. A century or two ago, children were taught by authority to believe that the sun revolved round the earth; and generation after generation of people (on the whole as good and nearly as intelligent as ourselves) accepted the teaching unquestioningly. May we not be living in a similar state of ignorance with regard to questions of high import; the fact is, all ages have been too ready to accept without verification the *ipse dixit* of preceeding generations. In saying that, I did not wish to inspire distrust of, and disrespect for the great minds whose teaching have stood the test of centuries, and are still the admiration of the wise. I wish rather to bring the student face to face with the great original thinker (each in his sphere) and seek from him instruction and support. Middlemen are my aversion. In my opinion 'tis good to be honestly sceptical. Doubt once established gives rise to investigation, and investigation experimental or otherwise, should lead to truth. Even should one's labours result in merely bringing one back to the starting point, the time will not have been wasted. The doubts, the experiments, the thoughtful conclusions arrived at, will have strengthened the mind, and prepared it for a clearer understanding of the problems yet beyond its ken. I would say to young men:—Pause, before uttering the words "I believe," let honest doubt be entertained, and whatever conclusion reason draws, accept it, whether it leads to emolument or penury; but in an enlightened age, no courteous man is ostracised for respectfully differing from his neighbours. Sir Humphrey Davy, a scientific genius, and one who rose from the ranks to the proud distinction of President of the Royal Society, once spoke to those assembled as follows:—"The *grandest, as well as the most correct views*, are those that have been gained by minute observation, *and by the application of all the more precise and accurate methods of science.*"

I have complimented Mr. Craig upon the diligence he has shown, but I am sceptical as to the existence of some of his tri-unities. My own view of the tri-unity in nature is the trinity of matter, force, mind. These exist pre-eminently in man in every form of animal life and are incorporated in every physical object by virtue of the *laws* which govern phenomena. Law is scientific thought *in operation*; therefore, matter, though dissociated from life, exhibits the impress of mind, and reveals the trinity.

With regard to Mr. Craig's treatment of the question of creation, I entirely differ from him, and in as few words as possible I will explain myself, and hope that some of the younger members

will in conclusion be led into a course of reading that would afford pleasure as well as instruction.

Copernicus, by study of Greek literature and reflection, accepted the Pythagorean system of the universe, and declared his belief that the sun (not the earth) was the centre of the solar system. Galileo demonstrated the correctness of these views. Newton revealed the laws governing the planetary phenomena, and established the truth that the planets are to the sun what children physically are to their parents. Laplace's genius gave to the world the splendid conception that the members of this family derived their being from a common source; that sun, planets, and satellites were originally a homogenous mass of molten matter, which, though once amorphous, gradually acquired form and motion; that the form was approximately that of a disc; and the motion that of revolution. By degrees—through long ages—the periphery of this revolving disc cooled, and became separated from its main body, and by attraction and accretion formed a planet, the *outermost* of the system. So successively with the other planets, thus creation began from without - not from the centre. We are not the third, as Mr. Craig had inferred, but the sixth in order of creation, excluding the orbit of the asteroids. It might be said, "If Laplace's theory of creation were true, the earth, at the beginning of its life as a planet, must have been an incandescent mass, just as the sun is now? It must also, one would think, have possessed then precisely the same elements that the sun possesses?" Exactly so, and in beautiful confirmation of the theory, the geologist has revealed the fact that, at one time, the earth's inner layer of crust (its igneous rocks) was in a *fluid* state, and the astronomer, by the aid of the prism or spectroscope, is now able to affirm without the slightest fear of contradiction, that the sun and planets are built of the same material elements, and that all are subject to combustion and decay; and, in conclusion,

> "Stars shall fade away, the sun himself
> Grow dim with age, and Nature sink in years;
> *We* shall still flourish in immortal youth,
> Unhurt amid the war of elements,
> The wreck of matter, and the crash of worlds!"

MR. HAWTHORN'S REMARKS.

I should not like to go away to-night without expressing the extreme satisfaction and pleasure that I have derived from listening to the very instructive paper read by Mr. Craig. I am sure we must all coincide in one view, and that is the amount of trouble and labour entailed in getting such matter put together. I am perfectly sure that the self-imposed task has been a very pains-

taking one, and Mr. Craig has admirably succeeded in showing our Junior members what a broad expansive field there is for scientific research. I think that the paper we have listened to may be called perhaps a dissertation on science, and now that we have had the lead given us we may go on quoting indefinitely "Scientific Tri-unities," and without going outside the Marine Engine Room. We have 1st, the three ways in which heat may be conveyed, viz., Radiation, Conduction, and Convection; 2nd, Ebullition, Evaporation, and Condensation. Also the three strains, viz., Tension, Bending, and Shearing. The three motions that we as Engineers are most conversant with, namely, Reciprocating, Rotary, and Vibratory (or Oscillating), in fact there is no end to the ideas that Mr. Craig's paper gives birth to; and as this paper was written more for our juniors members than any one else, I am pleased to see so many present, and I am sure they must cordiallly thank him, and if they have received a little knowledge, and if Mr. Craig can only set them thinking in the right direction I am sure he will feel amply repaid. I am very pleased I managed to get here to-night.

MR. JAS. ADAMSON'S REMARKS.

In the Paper read by Mr Craig we have the result of much labour and burning of the midnight oil; our thanks are due to the writer for what he has brought forth for the benefit of the junior section of our membership.

I regret that we have not heard the voices of some of the younger members and graduates who are present, as the facts have been collated chiefly for them to think over and push their enquiries further than the threshold of one or other of the subjects to which attention has been invited.

While examining and re-arranging some old papers one evening recently, it was my lot to meet with an Essay on "External Perception," written some years ago; in that Paper the line of reasoning led me to the conclusion that the knowledge gained by the eye was the most unreliable, and in order to gain reliable knowledge it was necessary to look below the surface of things, ponder over and study them in all their bearings, I have been furnished by Mr. Craig, unwittingly, this evening with a good illustration of this.

In the early part of the evening we were led to believe that a glance of the eye would reveal to us certain objects which we could unhesitatingly name. A small model piston was held up to view and indicated as a "Characteristic of the Handiwork" of one of our Members:—a "Buckley" Piston. The Junk Ring being now

removed, you will see at once that the piston is fitted with a "Common Packing Ring and Springs," and is, therefore, not a "Buckley" Piston. It may be useful to bear the lesson of this illustration in mind, although it is a pleasantry, there is many a true word spoken in jest. Be not content to obtain a superficial knowledge of things visible or invisible either, but go to the root of the matter, think for yourselves, and examine below the surface, taking nothing for granted, prove all things, and only hold fast that which is good.

I have much pleasure in moving that a hearty vote of thanks be accorded to Mr. Craig for his paper.

THE CHAIRMAN'S REMARKS.

(Mr. F. W. Wymer.)

I would like to follow up the remarks made by Mr. Adamson when proposing a vote of thanks, and give a few words of counsel to the junior members - both those who are present and those who, though absent, may be privileged to read the paper given to the Institute by Mr. Craig—entreating them not to be in too great a hurry to run away to sea, but to stick to the workshop for a year or two after they have served their apprenticeship and get a more thorough and practical knowledge of the marine engine in all its phases. It is a mistake to allow a young man just out of his time to go to sea, it is bad for him and bad for the valuable machinery, and I would advise them all to read Mr. Craig's paper carefully, as it will tend to engender a desire in them to go more thoroughly into the scientific part of their business as well as the practical.

MR. CRAIG'S REPLY.

It would be absurd for me to indicate that I am a votary of all the Sciences stepped over to-night, but I have been a most assiduous student of their elementary and general principles for the last month or two, aided considerably by the exceptional opportunities of reference afforded by the Public Libraries of this great City of London, and some of their learned and courteous officials, to whose kind assistance I am indebted and whom I thank.

Referring to the discussion I must say that the kindly criticism of the Paper leaves me very little to say in reply. Mr. Rowe spoke of Laplace's theory of creation as differing from that in the Paper; this is only a general exception, and not a particular one, as I distinctly indicated that my reference to the genesis of creation was taken as recorded in the Book of Genesis itself, in which I found the Divisions referred to, the finding of these anywhere being all I have to do with at present, and I thank my friend for the suggestion of Laplace's theory, as a possible hunting ground for more illustrations of Tri-unity.

Mr. Prior has not dealt quite so leniently with me, as he takes particular exception to the astronomical fact of the "earth's position in the planetary system as third in distance from the Sun," and I see by his assenting nod that I would be in order in referring to that point of his remarks. Knowing little or nothing of this particular science personally, I find on referring to the text of the Paper that I used the word "all," meaning that all the authorities I searched agreed on this particular point, and my own reference works (which I regret not having at hand here) are "Oliver's Astronomy" published so recently as 1888, where it is often stated, and specially tabulated as holding this rank among the eight major planets at page 119. "Natural Philosophy" also, by Quackenbos, an American Work, published in 1866, and (page 375) confirmed by a reference to all the standard authorities at my command; I can scarcely step in where astronomers seem to differ, and I should have liked if Mr. Prior had been able to quote or remember his authority, when the Institute might have settled the matter off-hand at this discussion. I would like to have this information when convenient, for sake of notes on the point and further inquiry.

The remarks on the Paper by Mr. Hawthorn, I think, indicate approval of the general object of the paper, also that its matter seems to improve by distance from the platform, with both of which I am very pleased indeed, and would only add that Mr. Hawthorn has caught the idea I held to be of considerable importance, viz.:—to shew there is great scope for thought and its resulting literature, which should engage the consideration of our young friends somewhere between the elementary principles—mainly dealt with to-night—and the latest engineering triumphs, on which high-class Papers are looked for from the Seniors, and we trust the Juniors will endeavour to cultivate their own special province in the wide field which lies between these.

I am not sure that there is any other point for me to refer to specially in reply. I may just say generally that I would like it to be quite understood that I am not responsible in any way for the theories, expositions or systems indicated or quoted in this Paper, nor do, I put them forward preferably or for discussion. I simply quoted them because they illustrated Tri-unities, and any standard or generally accepted theory, if supported by plain common-sense, is good enough for this object—not for the purpose of setting up a theory, but of simply calling attention to a wonderful peculiarity. Some of you might consider the subject of Tri-unities sufficiently interesting to work them out to a greater extent than I have done in this Paper, and in the doing of it you

might come across important essential matters. At first sight the Tri-unities may not seem obvious, and in case it might appear that I shirked such as these to night, I will give you an instance. The "senses," though they do not illustrate Tri-unity numerically, yet otherwise they do so in a very marked manner, by their first principles, which I have all along made the test-guage of efficiency for Tri-unity. The knowledge of the external world, which the "five senses" are specially designed to convey to us, is due to the faculty of distinguishing objects and the methods by which this is accomplished by them, are of *three* different kinds:—the "Sense of touch" with its organ "the skin"; the "Sense of taste" with its organ "the mouth," both acquiring the information *by contact;* the "Sense of hearing" with its organ "the ear", the "Sense of seeing" with its organ "the eye," both acquiring their information *without contact;* while the "Sense of smell" can better assist all the other senses by its peculiar compound faculty of acquiring its information *by either or both ways.* It would be a serious omission were I to close this Paper on "Characteristics of Handiwork" without a reference to the noblest of all created work—*Man* himself. The *races* of man are classified into three great groups, the "White," the "Black," and the "Red," or copper coloured, and there is also a powerful illustration of Tri-unity exhibited in the three distinct separate natures of *man, woman,* and *child.*

Regarding the quotation from the Astronomer Royal "That all science consists of *observation and measurement,*" Mr. Prior remarked (almost with regret, I think) that it did not support the idea of *Tri-unity.* It is very fortunate that his usual lucidity did not forsake him in the matter of the illustration of the "infant scientist on the chair." In my opinion that infant is not only not a *scientist,* but is not safe on that chair until he not only *observes and calculates,* but in addition completes the Tri-unity by carefully "*exercising his judgment*" afterwards. By virtue of three distinct operations, which are alike indispensible to his safety on the chair, and his claim to the title of an "infant scientist," the theory of Tri-unity is fully maintained and confirmed, while I am sure it will be as pleasing to Mr. Prior as to myself, that the illustration remains as serviceable as ever for his purpose of demonstrating the deductions of the Astronomer Royal in the cases of other than "*scientific infants.*"

On further reference to Mr. Rowe's general remarks on the theory of Laplace, I found in my explorations among the Histories of Science, very few *obvious* illustrations of Tri-unity, such as I

specially desired, and in the theory of Laplace, I was of opinion that they were too remote or obscure for the initial stage of the Paper, and that the sources of reference also were rather inaccessible to juniors; Mr. Rowe has entirely dispelled this idea, by his admirable way of touching on it at the discussion stage, when we are better able to understand it. The reference to the Creation occurs early in the Paper, and though I was unable to press the theory of Laplace into service for my special purpose, I have now my reward in being able to appreciate it, from recent study of the whole subject. Mr Rowe in advancing the theory, or hypothesis of Laplace, invited the attention of our younger members to it as a subject for their study and resulting benefit, remarking that it far transcends any other theory that has been put forward to explain the origin of our earth, but it is only hypothesis after all like that of the ancient writer of Genesis, unless the latter was only responsible to the extent of recording "*legendary lore*," and which, perhaps, may be imperfectly interpreted by the sense of our translation. I understand Laplace himself put his theory forward with much diffidence, but it unites so many apparently unconnected facts by a few simple and general laws, well-known to be in action, that it has every mark of probability to recommend it. It involves no invention of a new agency, and no assumption for the occasion of special laws to to suit the case, the only hypothetical part consists in the assumption of a certain condition of things at a remote unknown period as Mr. Rowe has indicated, the theory harmonises with what would equally apply to the other planets as well as ours, and with the identity of similar chemical elements to that of our earth, as has been demonstrated by modern observations in the science of "Celestial Physics." It was the work of Newton to discover the great "Laws of Gravitation," yet it was Laplace who has pointed out that these same Laws assure the eternal stability of the Solar System, notwithstanding the threatening perturbations which occasionally affect the planetary orbits, and which he demonstrated to be in reality only slight oscillations about a mean position, as he himself graphically puts it, "Immense pendulums of eternity which beat centuries as our pendulums beat seconds." And as Laplace found these laws to be efficient in the preservation of the system, so he conceived they might also have operated in its formation. The theory advanced by Laplace is thus only a probable hypothesis, and before accepting it, or indeed any other, we must not forget what Mr. Rowe was careful to inculcate as to being honestly sceptical generally. There is another point I am honestly sceptical about, and that is where Mr. Rowe interprets me as saying that the earth was *third* in the order of creation. I said

that "the earth was created on the third day, or period of time," and added that "three operations preceeded this, so making it fourth," while Laplace places it sixth. Granting it to be so, 6 bears such a suspicious relation to 3 that I may allow it to stand over for further investigation. Coming to the radiant tribute to the principle of Tri-unity, which Mr. Rowe reserved for the closing tableau of his remarks, where he lifted the curtain to the musical strains of thrilling Addisonian verse, revealing the Spirit of Tri-unity—triumphant; and disclosing its muse, who has forestalled us in recording its praises in his own immortal stanzas—and now, amid the after-glow of such thrilling effects, I would—before relapsing into the silent oblivion of conclusion—express the hope that those constituting the portentious "We," in those verses (the human race tri-unity of *Men*, *Women*, *and Children)* may include all those whose welfare we desire, and who, when the (second) Tri-unity of *Stars*, *Sun*, and *Nature* are no more, shall still flourish in immortal youth amid the (third) calamitous Tri-unity—*elemental warfare*, *wreck of matter*, and *crash of worlds*.

ADDENDA, &c.

* The undernoted are the Rules referred to at Page 23, illustrating the peculiar property and power of the numeral 9, when used as a test of accuracy in calculations.

ADDITION.

156	3
6425	8
789	6
7370	8

RULE.—Cast out nines from each of the Addenda (cross-wise), writing the "*remainders*" only, to the right of the vertical line, as above, then add these "*remainders*" vertically, and cast out nines from same, also add (cross-wise) the "*answer*" of the sum, cast out its nines, these remainders will agree if the summation is correct (leaving 8 as above).

SUBTRACTION.

68597	8
5646	3
62951	5

RULE.—Cast out nines from each of the Addenda (cross-wise), writing the "*remainders*" only to the right of the vertical line, as above, then subtract the lower from the upper (if the upper is "*less*" than the lower, add 9 to the upper), the remainder should agree with that resulting from the cross-addition of the "*answer*" with the nines cast out, as 5 in above example, if the working is correct.

MULTIPLICATION.

32645	7	
8	2	8
261160	7	

RULE.—Cast out nines from the (cross addition of) multiplier and multiplicand, and write the results (8 and 2) in the spaces right and left of a cross, as above, multiply the results (16) cast out nines, placing the remainder (7) in the upper space of the cross, as above—lastly, cast up nines from the cross-addition of the "answer" placing remainder in the lower space of the cross.—The figures in these upper and lower spaces will agree if the working is correct.

Wilson and Whitworth, Steam Printers, Broadway, Stratford.

PREFACE.

THE LANGTHORNE ROOMS,
17 BROADWAY,
STRATFORD, 27*th September* 1889.

A meeting of the Institute was held this evening, when the discussion on Mr Bruce's Paper on "Radial Valve-Gear," read the 24th September, was continued.

The meeting on each occasion was presided over by Mr Macfarlane Gray.

The following pages contain a report of the proceedings and illustrations reduced from those exhibited on both evenings.

The subject brought forward in this paper is not only of considerable importance from a mechanical point of view, whether considered by engineers in their own interests, as responsible for introducing or working this or any gear out of the common run, or in the interest of steamship owners in addition, as responsible for recommending the adoption of any gear in view of giving more cargo carrying capacity, when first cost economy at the sacrifice of efficiency and sustained economy may be the result.

The subject is also of importance from an educational point of view, as giving opportunities to the younger members of studying principles as well as results.

It is probable, therefore, that another paper on Radial Valve-Gear may be given in the course of the current session.

JAS. ADAMSON,
Hon. Secretary.