S.J.B

A. M. D. G.

BULLETIN

of the

American Association of Jesuit Scientists

(Eastern Section)

For Private Circulation

LOYOLA COLLEGE
BALTIMORE, MARYLAND

VOL. XII MARCH, 1935 NO. 3

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CONTENTS

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EASTERN STATES DIVISION

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SCIENCE AND PHILOSOPHY

MATTER AND FORM

Rev. Anthony C. Cotter, S.J.

GENERAL ARGUMENT

A substantial change supposes that both the initial and the resulting bodies are composed of incomplete substances. Moreover, if there is no limit to substantial changes, one of these substances is prime matter; and if the material body is an *unum per se*, the other substance is the substantial form as understood by Scholastics.

Now all bodies are subject to substantial changes. Moreover, there seems to be no limit to these, and every natural body is an *unum per se* form as understood by Scholastics.

MAJOR

1. The first part of the major scarcely requires proof, if the notion of *change*, as distinct from creation and annihilation, is steadily kept

in view. Still, a few words may not be out of place.

a. Let us consider an *accidental* change, which is understood more readily.

Take the water in the tea kettle that changes from cold to warm and hot. Before the kettle is put on the stove, there is the water (a substance) plus cold (an accident); after the change, we have the same water (the substance) plus heat (an accident).

Note: We are not interested now in what cold and heat are; there certainly was a change, and that change did not affect the substance as such. Nor are we interested in the change as such, but only in the initial and final stage.

b. In a *substantial* change, on the contrary, there must be a change of substance. That is, the initial stage of the change will be a body which consists of a substance plus another substance, and the final stage will again consist of the same substance plus another substance. Both bodies then, the initial and the final, are composed of **two** substances.

Now these two substances, though united to form one body, yet are not identical, but *really distinct;* for they can be separated from each other.

Secondly, there is an *essential difference* between the two. One substance always remains the same, though with every substantial change it becomes, through union with the other substance, something entirely different. It is this second substance evidently which makes it this or that body, determines it (as Sholastics say).

Thirdly, both substances must of themselves be incomplete, so that neither could exist by itself, just as water cannot exist without temperature nor temperature without water.

Note: This must not be misunderstood. First, the *human* soul can also exist without the body. Secondly, matter can exist without this form or that, but not without *some* form.

2. If there is *no limit* to the changeability of bodies into one another, ultimately the substance which migrates from body to body, is *entirely* undetermined. It may become part of any body, but only because of itself it is nothing specific.

Now prime matter is defined by Scholastics as *potentia pura,* i. e. determinability without any actual determination (specification) whatever.

Therefore if there is no limit to substantial changes, one of the two substances making up a body is prime matter.

3. If both the initial and the resulting bodies of a substantial change are *natural units, una per se,* there is only one other determining substance in each body. To postulate more than one, would run counter to the principle: "Entia non sunt multiplicanda sine necessitate".

Now substantial form is precisely defined by Scholastics as "actus primus materiae'', i. e. the very first determination of prime matter. The actus secundus is an accident.

Therefore, if the natural body (as opposed to the artificial and the mathematical) is an *unum per se*, the second substance which is part of every body, is the substantial form as understood by Scholastics.

MINOR

1. *All bodies* are subject to substantial changes.

a. Take the every-day processes common to all *living* beings: Metabolism and death.

Evidently in these processes, *non-living* matter becomes *living* and vice versa; death means that the whole being passes from the living to the non-living. Now if there ever is a substantial change, these are fair samples.

Note: Non-living matter which serves as food or drink, may be strictly non-living (as air, carbon, water, iron), or it may be organic (as beef, fish, apple); ultimately even these are built up from non-living matter, as biochemistry shows.

Now let us look at the same processes from the standpoint of philosophy. Philosophy proves that a living body is alive because of its *soul*. Yet it is not the soul alone that lives, but also the matter with which it is united. This is certain against Descartes. Therefore non-living matter, when used as food and drink, becomes truly living; it is not merely tied to something living. Certainly this is an essential or substantial change.

Note: It is not necessary (nor would it be true) to say that everything we take in as food or drink, becomes part of our living matter; the argument refers only to what is really *assimilated* by the organism.

b. So far we have only proved that some bodies undergo some substantial changes, viz. those bodies which serve as food and drink, and those changes which are comprised under metabolism and death. But we can go further.

c. There seems to be a *perfect analogy* between the non-living substances which we know can be assimilated by some living organism, and any other non-living matter. Therefore we are justifed in saying that all bodies may undergo like changes.

b. It is highly probable that all non-living substances (elements or compounds) undergo chemical changes, viz. so that entirely new substances result. Now such changes are substantial. Therefore *all* non-living bodies may undergo substantial changes.

2. There seems to be *no limit* to such chemical changes. Theoretically of course, there is none, neither from the first principles of philosophy nor from modern physical theories; in fact, the latter suppose it. Practically, modern industry, utilizing the findings of chemistry, takes

it almost for granted; war-time emergencies have shown that possibilities in this field are much wider than even scientists had suspected.

Therefore we are justified in saying that all bodies may undergo *all kinds* of substantial changes.

Note: There are limits, but of another kind. Chemical changes, whether in the living body or outside of it, take place according to a definite *sequence*, in which no step may be skipped or altered. The albumen of an egg will not be assimilated if injected directly into the blood stream of the human body; it must first be digested by the stomach.

3. Every natural body is an *unum per se*. That is to say, its parts do not exist or function primarily for themselves, but for the whole. The whole is first, the parts exist only on its account.

This is particularly evident in *living beings*. The finality apparent in every one of its parts and functions, the mutual dependence and natural helpfulness, the uneasiness of the whole which follows the intrusion of foreign elements: all these go to prove the *natural unity* of living bodies.

The case is less clear with regard to non-living bodies. But even there *molecules* seem to be natural units. Molecules can exist by themselves; larger masses are not necessary; smaller masses (ions, protons, electrons, etc.) seem to be restive until they find their natural partners with which they can combine to form natural units.

ESSENTIAL AND ACCIDENTAL DIFFERENCES

REV. JOSEPH T. O'CALLAHAN, S.J.

(A comment on the Article Written by Father Lynch in the March, 1934 Bulletin.)

The first part of Father Lynch's article: "What are essential and accidental differences?", treats of the differences between various colors and between various sounds; the second part is concerned with change of state. I have confined my remarks to the problem of change of state for I thought that the chief problem.

Fr. Lynch asks: "Are we to call the differences between the three states of matter essential or accidental," (p. 133): and concludes, (p. 135) "With regard to change of state, I would classify the crystalline state as essentially different from the liquid state".

Now I think that we must first distinguish between the differences in the states as states, and the body which is successively in the various states. The distinction is only valuable as an aid in clarifying the problem. A state is a more or less permanent condition of existence. In itself it is an ontological accident; and states as states may be "essentially" different, and yet a body in either of two states may be essentially the same. For example we could say that the state of purgatory as a state, is essentially different from the state of beatitude, and yet the soul is essentially the same in either state. When we speak of essential differences between states as such, we are using the term 'essential' in its secondary sense, precisely because we are talking about the quidditas of an accident.

Now we are not interested in the states of matter in themselves; our problem is to determine whether a body in state A is essentially different than it is when in state B. If it is, then the state A, an ontological accident, is a logical property of that body. If it is not, then the state is both an ontological and a logical accident.

Father Lynch, then, is proposing that a body in the solid state and with crystalline structure is essentially different than it was in the liquid state; that ice is essentially different from water.

When we talk of essential differences in the strict sense, as applied to substances, the subject is necessarily an individual of some species. When we say that man is essentially different from an ape, we imply that each individual man has a nature or essence which is different from that of the ape. Even if we take a group (e.g. a large mass of ice), yet since the group has the same specific essence as the individuals, ultimately we must consider the concrete individual, i.e. the 'natural unit' the 'unum per se'.

It is well here to take exception to an illustration made by Father

Lynch. On page 134 he writes: "Let us take a parallel illustration on a larger scale. We could take equal quantities of, let us say, iron and wood, and by the employment of different quantities of force produce on the one hand an automobile and on the other hand an aeroplane........ Do these differ essentially or accidentally?........they differ essentially but perhaps not all would agree to this. If we do call an automobile essentially different from an aeroplane, then we have to say that gold is essentially different from mercury; but if we claim only an accidental difference for the former, it seems we should logically postulate the same difference for the latter".

In this paragraph the term "essentially different" is not used accurately. Predicated of gold and mercury, subjects which are 'natural units', the term has its strict philosophical significance. But the automobile as the aeroplane is an "unum per accidens", no more a natural unit than a heap of sand; and the term "essentially different' applied to automobile and aeroplane, can only be used in a non-technical sense, meaning "greatly (but accidentally) different". When the term is used philosophically in its strict sense as applied to substances, the subject is necessarily an individual, i. e. an "unum per se". So then if we say that ice is essentially different from water, we mean that an individual unit of ice (the natural unit, whatever it may be in the concrete) has changed its nature.

What is the natural unit for inorganic bodies? All agree, I think, that it is either the molecule (or something submolecular) or the unit crystal. If the molecule (e. g. H_2 O) or anything submolecular, is the natural unit, one cannot hold that change of state involves essential change, for the molecule remains unchanged. If the molecule is the natural unit, and if the molecule remains unchanged with the change of state (a legitimate assumption), then the natural unit has remained unchanged and no essential change has taken place.

So the statement of essential difference between ice and water must imply that the natural unit of the solid is not the molecule but the unit crystal. There seems no other altenative. A natural unit you must have for every concrete body and groups larger than the unit crystal are certainly only aggregates of many natural units, a group forming an "unum per accidens" just as a heap of sand.

We shall next consider unit crystals, first reviewing the argument.

Essential change strictly means a change in the nature of the individual. To hold that a crystalline solid is essentially different from its liquid, one must hold that the natural unit has changed its nature. This unit is either the molecule (or something submolecular) or the 'unit crystal'. If the molecule is the natural unit there is no essential change with change of state. So to hold this essential change must imply that the natural unit is the 'unit crystal'. And so if it can be shown that the 'unit crystal' is not the 'natural unit' of the solid body, then it must follow that the statement of the essential difference between ice and water must be false. And I think it can be shown—by showing that there is no such thing as a real unit crystal!

Of course definite unit crystals are used for the purpose of classification, yet I do not think that they can be considered 'natural units'. Suppose for example that a definite number of molecules arrange themselves in a face-centered cube (Fig 1).

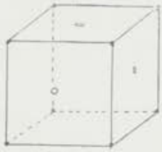


Fig. 1

At first we would be inclined to say that for the given body this cube was the natural crystal unit, having a definite number of molecules or atoms arranged in a definite pattern. But by the addition of a few more molecules, the crystal grows and we have Fig. 2.

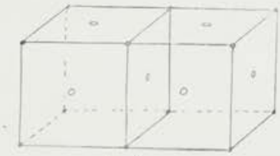


Fig. 2

How many natural units are here? Not two complete units for the contiguous atoms are common to both, and the parts of one individual unum per se cannot be simultaneously parts of another. Nor have we one complete unit and part of another, for the contiguous atoms belong no more to one group than to another. It is of course legitimate to consider the first cube as the unit for the purpose of classification but it cannot be considered a natural unit. And as indicated before, if the unit crystal is not the 'unum per se' of a solid body, then the molecule or something submolecular is; and granting that the molecule (or submolecule) remains unchanged with change of state, then the change of state does not constitute an essential change.

I conclude then that change of state does not involve essential change. But what of the arguments given by Fr. Lynch? How explain the definite crystal patterns which seem to be strict properties of the various crystalline bodies? Fr. Lynch writes (p. 133): "If we define as essential that which the nature or essence of a thing demands, we would have to say that the crystalline structure or pattern of a substance is not accidental but essential. It is of the essences of rock salt, for instance, to form crystals of a definite pattern,—it is of the nature of ice to form crystals of a different pattern, and so on".

Now even granting that crystalline structure is a strict property of a body, still it would not be a property because of the actual formation of a definite pattern, but because of the tendency so to form. If crystalline structure is really a property, would it not be quite natural to say that all the molecules of a given substance, whatever their number, have in equal degree the quality or tendency of uniting in a definite pattern under given external conditions. There must be such internal tendencies for the constancy of the definite patterns can be ultimately explained in no other way. In this case the specific property is not the actual formation of the crystal, but the tendency so to crystallize. The molecules would have this quality or tendency even in the liquid state, but its actuation is hindered by external circumstances, e. g. high temperature, too rapid molecular vibration. When the molecules move more slowly at lower temperature, these attractive forces are able to exert their effect and the crystal is formed. By mutual attractions of a definite kind (different for different molecules) they arrange themselves into definite patterns, but the individual molecules must have had that intrinsic tendency before the actual formation of the crystal, and the actuation of a tendency does not constitute an essential change.

Consequently I do not think that we can say that water is essentially different from ice; or more generally that a body in the crystalline solid state is essentially different than that body when in the liquid state. And that conclusion brings me back to the old conservative position, the substantial identity of a body in whatever state it exists—and with the big difficulty at which Fr. Lynch is hinting left untouched. I'll try to touch it now:

Summarize the problem thus: Molecules or atoms when in the solid state form a crystal of definite pattern for each substance.

The atom in turn, is formed by a definite pattern of protons and electrons, different patterns for different kinds of atoms. Now if the formation of the crystal pattern does not imply an essential difference, how can we say that the subatomic pattern is any more essential? And if this pattern is merely accidental, then gold and mercury are not essentially different; and ultimately we come to the conclusion that all inorganic bodies are specifically the same; a conclusion which many do not want to admit. Fr. Lynch avoids the conclusion by suggesting that the formation of a definite pattern always involves an essential change, even though it merely consists in a change of state.

But there is another alternative. When Father Lynch writes: "If we define as essential that which the essence or nature of a thing demands, we would have to say that the crystalline structure or pattern of a substance is not accidental but essential", he is not entirely accurate; we must hold merely that the tendency of the molecules to unite in a definite pattern is the specific property. In this way we can logically claim that substances are essentially different without being forced to hold that change of state involves an essential change. Thus: It would be a strict property of gold atoms to tend to form definite crystals (the actuation of the tendency is conditioned on external circumstances). It would be a strict property of iron atoms to tend to form crystals of a different pattern. Now since bodies specifically the same cannot have, under given external circumstances, contrary intrinsic tendencies, it follows that gold and iron are not specifically the same. And this conclusion is logical even though I deny that liquid gold is essentially different from solid crystal gold.

CHEMISTRY

RECENT ADVANCES IN CHEMISTRY

REV. RICHARD B. SCHMITT, S.J.

We wish to recall briefly the outstanding achievements of the past year in chemical research. The enormous amount of research in our educational and industrial laboratories is recorded in the literature. Most of this endeavor is theoretical and specialized, and may only be useful in the future, but nevertheless is necessary and helpful for progress in science.

The outstanding accomplishment of physical-chemical research was the production of artificial radio-activity. Irene Curie and her husband, Jean Frederic Joliot, made boron, magnesium and aluminum radio-active by bombarding these metals with alpha particles derived from radio-active substances.

At the California Institute of Technology, R. Crane, W. Harper and C. C. Lauritsen got the same results by using atoms of heavy hydrogen, deutons as projectiles against carbon. This charged carbon emitted gamma rays for an hour.

At the University of California, Edwin McMillan, E. Lawrence and M. Henderson produced artificial radio-activity in fourteen light metals, the radio-active form of sodium having remarkable properties. The fact that sodium compounds can be safely introduced into the animal system makes this accomplishment especially interesting from a medical point of view. The radio-active sodium has a half-life of about 15 hours and yields gamma rays under a potential of some 5.5 million electron volts.

At Columbia University, George R. Pegram and John R. Dunning determined the diameter of the neutron; it is estimated to be one-ten-trillionth of an inch. The weight of the neutron was determined by Gilbert N. Lewis and E. O. Lawrence at the University of California, as one-1650 billion, billion, billionths of a gram, with an atomic weight of 1.001.

Protactinium, a new element, was isolated by Aristide von Gross at the University of Chicago. It is a silvery white metal, stable at normal temperature. It produces more powerful emanations than radium, namely actinium.

Triple weight hydrogen was isolated at Princeton University, at

Carnegie Institution and in England. Under the direction of Hugh S. Taylor, the triple weight isotope of hydrogen was produced by bombarding the double weight hydrogen with deutons. This bombardment resulted in producing triple and single weight hydrogen.

Biological results of heavy water have received much attention, but few results have bêen reported thus far. Tobacco-seeds when soaked in heavy water do not thrive; when fed to a mouse, it makes him act as if intoxicated and produces a thirst. Water obtained from the tips of willow trees have been found to contain more than the average amount of heavy water.

A new x-ray tube, in which the x-radiations are produced by the impact of heavy mercury atoms on the target, instead of light hydrogen or helium atoms or electrons now used, has been developed at the University of California by Coates and Sloan. It is expected that the new tube will open an entirely new field to x-ray research, because of the differences in the radiation it produces from the customary type.

Micro-chemical methods and micro-analysis are finding more applications. About twenty-five per cent of all the analytical work performed in the Bell Telephone Laboratories is now being done with micro methods. They developed an electrolytical cell that will detect one part of metal in 100,000,000 parts of water. Some interesting results have been obtained by these micro methods in bio-chemistry, where we hope to see the greatest application of micro-analysis, that is, in medico-chemical research.

A GUIDE TO BEILSTEIN

Bernard A. Fiekers, S.J.

The only way to become facile in the use of Beilstein's Handbuch der Organischen Chemie is to practice using it. The ideal of this great organic reference work is to supply a comprehensive list and summary of the work done on all organic compounds. Since the scope of the work is so broad, the system of classification must be intensely scientific. Such it is. And the best study of the minutiae of the system can only be made after some facility in the use of the work has been acquired. The following supplies a summary of the general principles of the classification together with an outline chart.

The principles of classification that are invoked are as follows: THE PRINCIPLE OF THE "LATEST CLASSIFICATION" means that compounds falling under two subdivisions simultaneously are classified under the latest subdivision of the work. For example: $C_6H_5OCH_3$ will be classified under the aromatic compounds and NOT under the aliphatics, because the aromatics follow the aliphatics in the Beilstein scheme. This principle is rigorous even to the most detailed subdivision of the work.

FUNCTIONING & NON-FUNCTIONING SUBSTITUENTS: Functioning substituents are non-carbon groups into which other groups can be substituted. In accord with the principle of the latest classification, they are listed: OH, SH, SO_3H, NH_2, NO, NO_2, $NHNH_2$. Non functioning substituents are non-carbon groups into which other groups cannot be further substituted: F., Cl., Bh., I, NO, NO_2, etc.

The reference technique is first to look for the type of the compound in the accompanying tables making use of the principles indicated. Functioning substituents of a single type are ordered according to the following example: OH, $(OH)_2$, $(OH)_3$. These precede mixed functioning substituents.

Once a compound is located as being in any particular volume it can be definitely located by glancing at the "Inhaltsverzeichnis" or the "register". Besides, Landolt-Bornstein's tables of physical constants for organic compounds give the Beilstein system number.

TYPES	ALIPHATIC COMPOUNDS	SYS NO.	AROMATIC COMPOUNDS	SYS NO.
HYDRO- CARBONS	Olefines, Acetylenes Methane and Homol's Other Non-F'nc D'rvs	2 — 15	Cyclohezane, Cyclo- pentadiene, Benzene Napthalene, Anthra- cene, Toluene, Xy- lene & others	450 — 498
HYDROXYLS	Alcohols, Esters, Mercaptans, Glycerine, Glycols.	16 — 70	Menthol Phenol Benzyl Alcohol, Naphthol, Resor.	499 608
C—SIM- O PLE N	Formaldehyde, Acetone, Acrolein, Glyox.	71	Camphor, Benzaldehyde Phenone, Acetophen	609
Y HY- L DROX- Y	Glycoaldehyde, Aldol Monosaccharoses	— 151	Salicyl Aldehyde Benzoin, Alizarin.	890
A SIM- C PLE I	Formic, Acetic Acrylic, Oxalic	152	Benzoic, Cinnamic, Camphoric, Phthalic	891
D HY- S DROXY	Carbonic, Lactic, Tartaric, Citric	to	Salicylic, Mandelic, Gallic.	to
* KET- * ONIC	Glyoxalic Acetoacetic	322	Benzoyl Formic Phthalic Ald. Ac.	1504
S Sulf- U inic & L onic P	Methyl Sulfuric Acid	323 to	Benzene Sulfonic	1505 to
H Functn'l U De- R rivs	Sulfoacetic Isathionic	331	Phenol & Naphthol Sulfonic	1591
A Sim- M ple	Methylamine Allylamine	332	Analine, Benzidene Benzylamine	1592
I Hy- N drox- y. O	Amino ethyl alcohol Amino acetone	to	Aminophenol Aminobenzaldehyde	to
* ACIDS	Glycine Aspartic Acid	379	Anthranilic Aminosalicylic	1928
OTHER NI- TROGENS	Hydroxylamines, Azo & Diazo Cmpds.	380 -400	Phenyl Hydroxylamine Azo. & Azoxybenzene	1929 -2251
METALLO ORGANICS	Phosphine & Grignards.	401 -449	P, As, Sb, Bi, Cu, Mg, Hg, Pt, etc.	2252 -2358

HETEROCYCLIC COMPOUNDS:

2360 — 2365	with	1 0		3794 — 4008	with	3 N
2366 — 2950	with	2 0		4009 — 4187	with	4 N
2951 — 3006	with	3 0		4188 — 4483	with	O + 1 N
3007 — 3031	with	4 0		4484 — 4669	with	O#+ 2 N
3032 — 3457	with	1 N		4670 — 4791	with	O + 3 N
3458 — 3793	with	2 N				

Note: Compound of uncertain structure found in nature 4720 — 4877.

MATHEMATICS

GEOMETRICAL DUALITY

PHILIP H. MCGRATH, S.J.

In the first few pages of any treatise on projective geometry, which is the study of the properties common to a figure and its projection, we meet the principle of duality. This principle is peculiar to projective geometry and has no analogy in metric geometry. By the principle of duality in general we mean that there exists certain reciprocal relations between statements concerning geometric relations, e. g. Two points determine a line, and its reciprocal. Two lines determine a point. These statements are both valid, since in projective geometry, in contrast to Euclidean geometry, parallel lines are defined as those that meet in infinity. However, in the two statements which are made up of entirely the same words, the interchange of the words line and point give them different meanings. Throughout projective geometry, we constantly find statements, theorems and problems, which, by an interchange of words, give a statement or even a figure that is not only new but absolutely true.

This duality may exist either in a plane or in space. Let us first examine the principle of duality in a plane and then see a few examples. The principle may be stated as follows: From any theorem on the relative position of points and lines in a plane, another theorem equally valid may be obtained by interchanging with suitable connectives the words point and line.

e. g. If two lines have more than one point in common, they coincide.

If two points have more than one line in common, they coincide.

If we compare the definitions of the complete quadrangle and the complete quadrilateral, we find that they are dual figures, i. e. reciprocal to each other in a plane.

Figure I

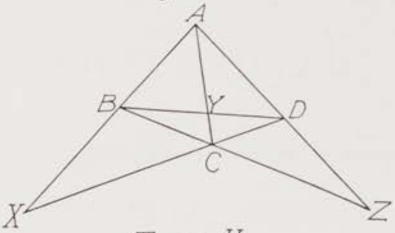
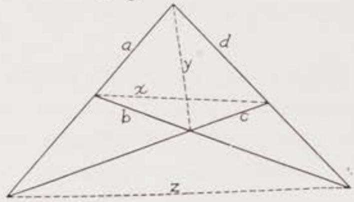


Figure II



QUADRANGLE

(Cf. Figure 1)

A complete quadrangle consists of four points A, B, C, D, and the six lines joining them, two and two. The four points are the vertices and the six lines are the sides of the complete quadrangle.

The sides fall in three pairs of so-called opposite sides, the line joining the vertices and the line joining the other two forming a pair.

The pairs of opposite sides, by their intersections, determine three additional points X, Y, Z, called diagonal points.

Thus a complete quadrangle has four vertices, six sides and three diagonal points.

QUADRILATERAL

(Cf. Figure II)

A complete quadrilateral consists of four lines a, b, c, d, and their six points of intersection, two and two. The four lines are the sides and the six points are the vertices of the complete quadrilateral.

The vertices fall into three pairs of so-called opposite vertices, the intersection of the two sides and the intersection of the other two forming a pair.

The pairs of opposite vertices determine three additional lines x, y, z, called diagonals.

Thus a complete quadrilateral has four sides, six vertices and three diagonals.

Sometimes the figures may be self-dual, i. e. reciprocal statements may give us the same figures; e. g. the figure of a line through a point and the figure of a point on a line. If we think of a triangle as formed by three non-collinear points and the lines joining them, the dual consists of three non-concurrent lines and their points of intersection, i. e. a triangle. Thus a triangle is self-dual.

In forms not confined to a single plane the reciprocal relations among the elements take on a different aspect. For example, in three-dimensional geometry, the following statements are true:

Three points not lying on the same line determine a plane.	Three planes not passing through the same line determine a point.
On any line there lie an unlimited number of points.	Through any line there pass an unlimited number of planes.

In these statements, the duality, on the one hand, is between point and plane, and between line (determined by two points) and line (determined by two planes) on the other. In the above statements if the elements point and plane are interchanged, and also line and line, the corresponding dual statement is the result.

In three-dimensional geometry then, point and plane may be considered dual or reciprocal elements; also line determined by two points and line determined by two planes are reciprocal elements.

The principle of duality in space may be stated as follows: From any theorem on the relative position of points, lines and planes in a geometric configuration in three dimensions, another theorem equally valid may be obtained by interchanging with suitable connectives, the words point and plane, line and line.

If any number of straight lines are so situated that each intersects every other, then the lines must all pass through one point or they must all lie in one plane.	If any number of straight lines are so situated that each lies in a plane with every other, then the lines must all lie in one plane or they must all pass through one point.
Two straight lines which cut one another, lie in the same plane.	Two straight lines which lie in the same plane, intersect in one point.
A straight line and a point (not lying on the line) determine a plane.	A straight line and a plane (not passing through the line) determine a point.

Applying this to regular solids of elementary geometry we find that the cube and the octahedron are dual figures.

CUBE. A cube has eight vertices, six faces, and twelve edges. The vertices lie by fours in the faces; the faces meet by threes in the vertices; the edges lie by fours in the faces and pass by threes through the vertices.	OCTAHEDRON. An octahedron has eight faces, six vertices, and twelve edges. The faces meet by fours in the vertices; the vertices lie by threes in the faces; the edges pass by fours through the vertices, and lie by threes in the faces.

The principle of duality either in a plane or in space is not in general applicable where metric relations are involved. It is only in respect to positional relations that it has significance, since in Cartesian geometry we do not recognize the infinite point, e. g. a range of points and points of a range do not form reciprocal figures in Cartesian geometry as they do in Projective geometry.

These dual theorems open up many aspects in pure geometry and give us a better understanding of many geometrical figures and the discussions with which they are concerned.

METHOD FOR POINTING OFF RESULTS IN SLIDE-RULE CALCULATIONS

BERNARD A. FIEKERS, S.J.

In the issue of this Bulletin for May, 1933, p. 204, there appeared a method for placing a decimal point in calculations performed on the "C" and "D" scales of the slide-rule. This method may be extended to the "A", "B" and "K" scales.

Scales of the "A" and "B" type are logarithmic like those of the "C" and "D" type. For the length of the "C" and "D" scale, however, there are two complete such scales, end-joined at the "A" and '"B" levels of the rule. This arrangement makes for facility at problems of involution and evolution where the second power is employed.

It means that for every reading corresponding to a given logarithmic length on the "D" scale, there is a reading on the "A" scale corresponding to double that length. The reading is fixed directly above the "D" scale and the actual length is unchanged. The same relation is true for the "B" and "C" scales.

In practice, it means that by setting the hairline at a given value on the "D" scale, the square of that value can be read off the "A" scale,—the "C" and the "B" scales being designed for the same procedure.

This is a process of logarithmic involution, where the logarithmic values do not appear, but rather the actual values, disposed at logarithmic lengths. It is the process of multiplying the logarithm by two. Now, if in this multiplication, a digit from the mantissa were carried over into the characteristic part of the logarithm, it would be indicated in slide-rule practice by our having to read the result off the right-hand half of the "A" or "B" scale. The characteristic of the product would then be twice the characteristic of the root plus unity:

$$C_p = 2\,C_r + 1 \quad .$$

If the result were to appear on the left half of the "A" or "B" scale, its characteristic would be merely twice the characteristic of the root:

$$C_p = 2\,C_r \quad .$$

The sign of the characteristic must be treated algebraically in order to gain the correct result.

If we solve these equations for C_r, we obtain a method for pointing off results in the process of square root determinations. Starting from the right hand half of the "A" or "B" scale:

$$C_r = (C_p - 1) / 2 \quad ;$$

starting from the left half:

$$C_r = C_p / 2 \quad .$$

A difficulty arises here in determining which half of the rule we should start from. Fractional characteristics are out of the question in practical work, and it is for practical work that the slide rule is designed. Test the characteristic in question by the above equations, and select that half of the rule whose equation gives an integral value for C_r,

Just as the "A" and "B" scales are designed to bear a second power relation to the "D" and "C" scales respectively, so is the "K" designed in a third power relation on the ordinary rule. By setting the hairline on a given value of the "D" scale, the cube of that value can be read directly off the "K" scale. Applying the same principles that obtained for the "A", "B", "C", and "D" scales, we can derive the following equations:

For the LEFT section of the "K" scale:

Involution:	Evolution:
$C_p = 3\,C_r$,	$C_r = C_p / 3$;

for the MIDDLE section of the "K" scale:

Involution:	Evolution:
$C_p = 3\,C_r + 1$,	$C_r = (C_p - 1) / 3$;

for the RIGHT section of the "K" scale:

Involution:	Evolution:
$C_p = 3\,C_r + 2$,	$C_r = (C_p - 2) / 3$.

Where the problem is in evolution, the test for the integral characteristic must be applied as above. Algebraic signs must likewise be carefully considered.

The writer has modified the equations and etched them on a slide-rule. The use of the "A" and "B" scales is of inestimable value in the calculations of qualitative analysis. A system based on the same principles can also be developed for the reciprocal scale: CI.

PHYSICS

PHYSICS IN THE BACHELOR OF ARTS COURSE

Rev. Thomas H. Quigley, S.J.

The place that Physics occupies in our traditional Arts Course has been described in some detail by Father Kolkmeyer in his paper: "A Prerequisite for the College Degree" (Bulletin A. A. J. S., September, 1934).

On the other hand, two recent notes (one communicated by Professor of Physics', the other by Father Delaney—cf. Bulletin A. A. J. S., December, 1934) make it quite clear that the teaching of Physics to Junior Arts students is becoming more and more difficult. This is not so surprising when we compare the present curriculum with that of some years ago. We find that at that time a course in Trigonometry and Analytic Geometry was obligatory for all Freshmen, and a course in Mechanics for all Sophomores. Then, too, the prospective Freshman of those days seems to have had a better grasp of fundamental mathematics than his successor of today. In truth, the Junior about to begin his Physics course today is seen to be at a twofold disadvantage when compared with the Junior of former years. For the Junior in our day not only lacks the scientific preparation of his predecessor, but he is generally given at least two years in which to forget whatever mathematics and science he once acquired.

It seems quite likely that much could be accomplished towards the solution of a few of our problems by transferring the Physics course from the Junior to the Freshman year. The following are some of the reasons for this opinion:

1) The student is more likely to do better work in Physics in his Freshman year. That he is sufficiently mature then for the task is clear from the startling number of very young men who are among the very best of present-day scientists.

2) Physics is becoming more and more a prerequisite for the other branches of science. This is especially true in the case of chemistry. (Cf. Fr. Kolkmeyer's paper.)

3) It would force the student, *at the very start* of his college career, to measure up to high standards of initiative and self-reliance in-

separable from such a lecture and laboratory course. (Cf. paper of 'Professor of Physics'.)

4) It would give the student a better opportunity in his Junior and Senior years to devote himself whole-heartedly to a scholarly operation for his life work, especially if he is to enter the professional or graduate schools.

The difficulty of avoiding too heavy a Freshman schedule does not seem to be an insuperable one. For instance, a course in Freshman Trigonometry does not seem to be indispensable for those students who have not had a course in Trigonometry in High School. The professor of Physics could quite easily supply the small amount of Trigonometry needed for the course in College Physics. On the other hand, it would be hard to exaggerate the importance of insisting on our prospective Freshmen having a good grasp of elementary Algebra.

The following program is suggested as a starting point for discussion and in the hope of obtaining criticisms from our professors of Physics:

I. Physics Lecture......2 hours per week.

II. Physics Laboratory..1 (two clock-hour) period every other week.

III. Physics Quiz........1 (two-clock hour) period every other week.

The assignment of home work, solution of problems, repetitions, examinations, etc., could be handled during the quiz periods. Perhaps the greatest advantage of the quiz period would be the opportunity it offers for giving the students individual attention. It would make possible a sympathetic understanding of the students' many difficulties and provide an excellent opportunity for indirectly combating their too frequent prejudice against the course. It would, moreover, leave the professor of Physics free in his lectures from the loss of time involved in laboring over points which are a difficulty to only a few of the students, etc.

The alternation of quiz periods with laboratory periods would make it possible for the laboratory instructors to conduct the quiz sections. Would it not be possible in such an arrangement for the professor of Physics, to cover the essentials of his subject by a carefully planned course of lectures, even though he had but two hours a week at his disposal?

A Suggested List of Laboratory Experiments

1) Measurement of length. The vernier and its use in linear and circular measurements.

2) Measurement of mass. The balance.

3) Measurement of vector quantities. The force table.

4) Determination of density. The pyknometer.

5) Measurement of time intervals. The pendulum and its use

in measuring time intervals; in determining the acceleration of gravity.

6) Measurements of meteorological quantities. The thermometer, barometer, hygrometer, etc.

7) Measurement of the "quantity" of heat. The calorimeter.

8) Measurement of quantities which are characteristics of wave motion. (a) The sonometer or (b) Melde's experiment.

9) Laws of reflection and refraction. Plane mirrors; index of refraction by displacement. (Cf. Laboratory Physics....D. C. Miller—1932.)

10) Formation of images by mirrors and lenses.

11) Determination of the wave length of light. Fresnel's interference method. (Cf. Miller.) (A slight modification of the apparatus at Georgetown University would be ideal for such an experiment.)

12) Measurement of electrical resistance. Wheatstone's bridge.

13) Measurement of electric current and electromotive force. Adaptation of galvanometer to use as (a) ammeter; (b) voltmeter. (Cf. Miller: experiment CXLV.)

14 Alternating current electricity. The "ideal" dynamo.

15) Measurement of the photoelectric current. Photoelectric cell of the emission type. (Cf. Miller.)

SEISMOLOGY

EARTHQUAKE IN MANILA

REV. WILLIAM C. REPETTI, S.J.

After experiencing three typhoons within a month Manila was treated to an earthquake at 8:09 P. M. on the evening of November 26th. It began to record at 8:09:35 P. M. and was perceptible for about one minute. The center was in the China Sea about 90 kilometers southwest of Manila. Practically all of the China Sea earthquakes along the west coast of Luzon originate along a line about 40 kilometers offshore thus probably indicating the existence of an active fault.

A few seconds after the shock began the Wiechert lever arms became disjoined; the pens of the Horizontal pendulums were thrown off completely; and the light spots of the Galitzins effected nothing after the beginning of the first throw. The latter was sufficient to determine the direction of the epicenter. Two of the Galitzin light systems were jolted out of alignment. The seismographs were soon put back in working order.

All of the important pendulum clocks in the Observatory were stopped by the shocks except the Synchronome, which ran wild. Its free pendulum struck the sides of the vacuum case. It did not get back to its normal amplitude until the next morning. Father Nuttall was up until nearly midnight trying to get some order into the clocks.

By six o'clock the next morning 23 aftershocks, all very small, had been recorded. In the next two days three aftershocks were perceptible to some persons on the 3rd floor of the Ateneo which oscillates very easily. It was conceded that the quake of Monday evening was the strongest felt in Manila since the earthquake of 1901 which originated in the same general area.

Some slight damage was done in the city, chiefly broken windows and crockery. The Insular Life building, about 8 stories high, had some pieces of concrete knocked off where it came in contact with the adjoining building, in its oscillations. These two buildings almost touched in the earthquake of February 14th last.

The Ateneo and Observatory community was at recreation on the azotea, 2nd story level, at the time of the quake. This azotea has a tile floor set in cement, supported by strong joists and heavy walls. The writer remained seated for some moments after the beginning and it seemed that the floor moved about three quarters of an inch. The quake came in pulses and there seemed to be a slight vertical component in the movement which gave the effect of a kneading motion. The upper floors of the Ateneo, as well as those of other buildings, developed a strong oscillation and the boys lost no time in getting out.

A radio message from Nanking, China, reported that their seismogram showed the character of a deep-focus quake.

NOTE

Rev. William C. Repetti, S.J., Chief of the Seismic and Magnetic Division of the Weather Bureau, Philippine Islands, published an article: "A VERY DEEP EARTHQUAKE IN THE PHILIPPINES." There are two charts accompanying the article: Epicentral Distance plotted against Arrival Time and Observed Arrival Times plotted against S—P Intervals.

Copies may be had from the author.

NOTE

(From the History of the Society of Jesus in the Philippines, by Father Colin, S.J., Lib. III, Cap. XVII.)

Inspired by these disasters (earthquakes of 1600-1601) Father Juan Ribera (Jesuit) suggested in a sermon that it would be well to elect a saint who would act as public advocate before God our Lord in the matter of earthquakes, just as St. Potentiana in the case of hurricanes and baguios; a saint to whom the whole community, on the annual feast day, and individuals, as often as they chose, could appeal as intercessor before God to protect us from such great trial and danger.

He first took up the matter with Father Visitor, then with externs, and finally with the civil and ecclesiastical chapters. It was suggested that a time be chosen and a place fixed at which a procession could be held and a Junta draw from an urn of saint's names, the first name thus selected to be the Patron. His mass would then be sung. The Society promised to give one of its chapels, which remained after the fall of the nave in the last earthquake, for the saint so chosen and to place there his statue and altar. This chapel would be prepared and adorned for the feast in the manner customary in our churches, and the festival would be celebrated with all solemnity and devotion.

The civil and ecclesiastical chapters agreed to the proposal of the election. On the day assigned there was a procession in the Cathedral; and before the solemn celebration of mass, the presiding officer, the Licentiate Don Gabriel de la Cruz, second Dean of Manila, drew from an urn in which there were several papers, each bearing the name of a saint. He then read aloud,

"St. Polycarp, martyr, bishop of Smyrna, on the 26th of January."

This selection was held on a day in April, 1601, about the time at which the Holy See in Rome placed that renowned martyr in the breviary with an office of nine lessons.

In conformity with this election the Society took the same saint as its patron against earthquakes and dedicated a beautiful altar to him. A bust of the saint was placed on the altar, and inscribed in letters of gold there was a distich, composed by Father Angelo Armana, which ran as follows:

"Alme senex Polycarpe, novos tutare clientes;
Sistat et auxilio terra quieta tuo."

THE WESTON COLLEGE SEISMIC STATION

Daniel Linehan, S.J.

The Weston College Seismic Station has been in operation for some few years and with a fair amount of success. But, we are entering this account of it in the "Bulletin" for the first time to inform our readers of it's brief history and present working equipment, as well as to thank publicly all those who have assisted in it's foundation and erection. Space will not permit mention of all our benefactors, and many an item, which is now history, will have to be omitted for the same reason.

In the latter part of the year 1928, Georgetown University, through the kindness of its rector, the Rev. W. Coleman Nevils, S.J., and the Director of the Seismological Observatory, the late Rev. Francis A. Tondorf, S.J., donated to Weston College a Bosch-Omori 25 kg. horizontal seismograph, both components. This instrument had served its purpose at Georgetown and had greatly assisted in strengthening our Society's reputation in the field of seismology. In the name of progress, however, it had to be supplanted by instruments of more recent development and greater sensitivity. For reasons both financial and pedagogical, Weston College was fortunate to become the recipients of these two pendula. The cost of operation was low in comparison with the modern photographic types, and the simple construction of the pendulum and registration demonstrated quite clearly the fundamentals upon which seismometry is constructed. The Rev. Edward P. Tivnan, S.J., then rector of Weston College, who had established the Fordham Seismology Observatory, and who had carried his scientific interests here, was most eager to have the station erected and operating as soon as possible. The Rev. Henry M. Brock, S.J., was appointed Faculty Director. Then began the labor of finding a suitable location and the attempt to set up the instrument.

Originally a room in the basement of the Philosophers wing had been designated as a possible site for a seismograph room. In this place the digging was begun, and at a depth of about 7 feet below floor level a sloping ledge was uncovered. However this did not appear sufficiently satisfactory for the base, due both to the insecurity which would be afforded by the steep slope, as well as the depth to which the base must be extended,—a lengthy base would take on oscillation properties itself. However, Nature came forth and settled any possible arguments as the hole began to fill rapidly with water. This water was apparently draining from the bank outside the basement. The removed dirt was quickly replaced and the floor again sealed up.

Coincidently, while these excavations were taking place, and many, including Fr. James B. Macelwane, S. J., were standing by and hoping to find the rock upon which Fr. Tondorf's one-time instruments would rest, word came that Fr. Tondorf had just passed from this life. His death came November 29, 1929. (R. I. P.)

The basement of the "Mansion" was then drilled at several points, until that portion, which the elder alumni of Weston will remember as the old refectory, was decided the best location. Rock uncovered here proved to be part of that ledge which underlies the most of the "Theologians Wing". It is a hard gabbro-diorite. With such good fortune at hand the pattern of the base was laid out and digging commenced in earnest to prepare forms for the concrete, and at the same time plans were compiled for the erection of a shelter.

The major portion of gratitude for this work must be accredited to Fr. John A. Blatchford, S. J., for the accurate and thorough manner with which this work was accomplished. His foresight and care in the erection of the base and pendulum installation have caused less adjusting and worry to the successive observers than had the original construction been otherwise. Anyone who has erected a base for pendula of this type will readily appreciate the many difficulties which Fr. Blatchford had to overcome.

In laying out the North-South line, a solar transit was employed. Fortunately, there was sufficient sunlight entering through the windows on the eastern side for an observation of the sun. Two points were determined on the floor and this line was later translated to the seismograph base. This method was chosen instead of a magnetic determination, as the many pipes and conduits in the cellar would necessarily devaluate the readings.

In July, 1930, the smoked drums were mounted for the first time and an attempt made at observation. We may easily imagine that the daily papers were eagerly scanned lest a quake had happened somewheres that this station had missed. No shocks were recorded.

In December of the same year Fr. F. W. Sohon, S. J., arrived from Georgetown to determine the constants and make the important adjustments which Weston's less experienced observers had failed to notice. During his stay here, Fr. Sohon delivered several lectures on seismology to those interested. Needless to say, his able assistance was greatly appreciated.

Once again the period of watchful waiting began, and this time with better results. January, 2, of the following year recorded Weston's first quake. From that time until June, 1934, there have been close to some 100 recorded quakes. Some of these recordings were distorted by microseisms, but the most of them are readable and possible of interpretation. Indeed, the microseisms themselves proved interesting and some little attempt has been made to study them, and this was done mostly by comparison with barographs and weather maps.

A Shortt Synchronome Clock, donated by Mrs. Thomas J. Barry, was installed in September, 1931. This was intended for the use of the seismology and physics departments. Unfortunately this clock has not performed satisfactorily since its installation, and as that company offers no service in this country, time registration has to be returned occasionally to the Springfield Master Clock of the "house system". We trust to have the satisfactory adjustments made upon the Synchronome in the near future.

Fr. T. H. Quigley, S.J., began as observer in 1929 and was succeeded by Fr. J. G. Doherty, S.J., in the summer of 1931. These men were constantly busy trying to garner as much as possible from an instrument of such low magnifying power as the Bosch-Omori 25 k. In as much as theirs was not a 'built-to-order' seismograph vault and perfectly insulated from heat and dampness, much time and labor was spent attempting to relieve these difficulties. Considering the existing conditions, the results of their zeal and application has given the Weston Station an impetus that would have otherwise taken a much longer time to realize. The present writer took over the duties of observer in the summer of 1934.

All preliminary reports of readable grams have been uninterruptedly forwarded to the Central Station of the Jesuit Seismological Association in St. Louis, as soon as possible after interpretation. From the J. S. A. bulletins received afterwards, the comparisons made with older and better equipped stations than ourselves have given us great satisfaction concerning the accuracy and adjustments of our instruments.

During the past year we were invited by Massachusetts Institute of Technology to cooperate with themselves and eight other stations in timing a blast of 250 tons of dynamite. This blast was taking place near Meridan, Conn., April 23, 1934, at approximately 2:00 P. M. (E.S.T.). The periods of the pendula were decreased as much as possible and a careful calibration of the instrument was made the day previous, with preparations for recalibration the day following. Due, no doubt, to low magnification power and comparatively long period of oscillation, our grams were bare of any disturbance during the appointed time. Later, and much to our consolation, we heard that only one of the stations invited, and that the most approximate one, recorded anything of the disturbance.

At various times the loan of grams has been requested by such stations as St. Louis, University of California, and the U. S. Coast and Geodetic Survey, for research work at these stations. Compliments were received upon the clarity of these records.

In the summer of 1934, a Wiechert 80 kg. horizontal component was installed. This instrument was purchased by Holy Cross College in

1909, when that College in cooperation with 15 other of our American Jesuit Colleges formed the First Jesuit Seismological Association founded by Fr. F. L. Odenbach, S.J. The Wiechert 80 kg. has been improved upon in a very few details during the past score of years, and so our acquisition may be considered a very happy one as far as these instruments are concerned. (Incidentally, the price has been raised some 300%).

During the latter part of August, 1934, through the kindness of the Rev. Francis J. Dolan, S.J., rector of Holy Cross College, this instrument was loaned to Weston. Immediate installation became the order for the day.

The most feasible location for the new base was determined to be a few feet further south from the Bosch-Omori instrument, where the same ledge rested less than a foot below floor level. Before laying the base proper, the area for several feet about was torn up and a blanket of sand was inserted between flooring and rock to absorb any accidental disturbances from the room. This position necessitated the building of an addition to the original seismograph room, and it was insulated entirely with "Celotex". While this construction was under way, the former quarters were renovated with the same material. Prior to this insulating the recordings of a thermograph during the autumn months showed the average daily temperature change to be in the proximity of 15° F. Afterwards, and during the same season of the year, the change proved to be less than 2° F., which is quite satisfactory for the type of instruments housed in this room. During the winter months a greater diversity in temperature change is had, but we hope to overcome this with a thermostat control. Only on one occasion, so far, has temperature affected the Wiechert instrument to such a degree that the gram was illegible. And it would have to happen during the night when a quake came in.

Likewise, this insulation has eliminated a tilting of the Bosch-Omori which was wont to accompany the turning off or on of the College heating system. The Wiechert, which would have registered this disturbance with greater magnification, actually suffers but little during the occasion.

Time registration on both instruments may be taken from either the Springfield clock or the Synchronome, which are corrected daily by radio from station DFY and GBR. Both clocks run secondary circuits to a panel board in the instrument room where a double throw switch facilitates this change. One instrument, the Wiechert, is wired for direct recordings of radio time signals, but as yet this advantage has not been adapted. We are awaiting a selective converter for station NAA which is now transmitting time signals 20 times daily on the hour.

At the suggestion of the Bureau of Standards we experimented with a sample of "Allegheny Metal", No. 40, wire, which they sent us, in suspending the damping pistons. This metal is non-corrosive and has a small coefficient of expansion, but we found it quite difficult to work with as it is not as pliable as copper or bronze. It is employed on only one component at present. At the same time, thanks to a few helpful hints from the Department of Agriculture, we have battled and more or less driven to rout those enemies of many seismologists, spiders. Many a pseudo-quake of the past could be attributed to the meanderings of these pests up and down the stylus.

The Wiechert has been in operation since the middle of September and has been performing quite satisfactorily, even though we have not had a sufficient number of tests in the form of quakes to give a definite account of its work. October and November passed by with few quakes of sufficient size. December, however, brought several of which six were possible to work with. One of these, on the 31st, was sufficiently large to displace the pendulum to the maximum amplitude allowed it during the recording of the "surface waves", even though the preliminary tremors were not too pronounced. We still feel there is plenty of adjusting to be performed before we attain the greatest efficiency of this instrument.

The detail with which the Wiechert traces a gram is excellent even in slight quakes. We are using a fine stylus and a highly glazed paper for the record. Under these conditions, the use of a lower power microscope brings to light phases that would otherwise be lost. Besides the advantages of reduced friction, this type of paper does not show surface irregularities under the microscope.

Microseismic activity has been very pronounced on occasions, and in lieu of quakes, it gives us opportunity for some speculation and study. Such tremors, though, but whet the appetite of the seismologist for more and better earthquakes.

A few years ago the equipment of our station would have classed us amongst the observatories of the first order. At present we can only trust that the day will not be too far away when we may be able to win that distinction with more modern laboratories. In the meantime, the apparatus at hand is more than sufficient to supply the necessary training and bolster the ambition of students of seismology.

In concluding, we must acknowledge our debt of gratitude to the Superiors of Weston College for their interests in our undertakings, and to the Faculty Director, Fr. Henry M. Brock, S.J., and Fr. M. J. Ahern, S.J., for their timely advice and valuable assistance.