SOME BASIC PRINCIPLES FOR TALKING STRAIGHT ABOUT QUALITY.

In the control of quality of manufactured product, it is necessary to specify the quality of a thing that is wanted and to make statements about the quality of things after they are made. The interpretation and significance of such specifications and such statements about quality depend upon two factors: a) the meaning of quality implied, and b) the knowledge of quality implied. One of the fundamental problems, therefore, at the basis of any comprehensive program of quality control is that of establishing the principles which should guide the making and interpretation of specifications and statements about quality - principles which it is necessary to take into account if specifications as well as statements about the quality of a thing are to be exact in that they say what is meant and mean what is said, as is required in quality control.

The present memorandum attempts to present such a set of principles which lie at the basis of an adequate understanding of the meaning and knowledge of the quality of a thing.

MEANING IN RELATION TO KNOWLEDGE

Specifications of the form, "The quality of a thing shall be such and such", and statements of the form, "The quality of a thing is such and such", are ambiguous unless we know definitely what is meant in each case and what degree of belief is implied. For example, when one states that the quality of a thing shall be such and such, it is tacitly assumed that the one making the specification has definitely in mind what it is that he wants and also that he has in mind how sure he wants to be when he gets the thing that it will prove to have the quality wanted. Likewise, when one makes the statement, "The quality of a thing is such and such", it is definite only to the degree that it has an operationally verifiable meaning and only to the extent that one knows the degree of belief that is implied in making the statement. Hence it is that we must consider the principles basic to an understanding of both the meaning and knowledge content of specifications of, and statements about, the quality of a thing; principles which make clear how knowledge in order to be definite must be based upon a definite meaning; principles which serve to differentiate in a

practical way what is to be understood as the difference between a thing such as a relay, condenser, or the like, and the quality of that thing in the sense that we can become aware of the quality.

QUALITY OF A THING TO ONE PERSON

Principle 1 - There are two elements in the experience of quality basic to all knowledge: a) sensuous and emotive awarenesses, and b) the a priori concept.

The awarenesses which we experience constitute the starting point of our knowledge of the quality of a thing. Out of these awarenesses we extract certain qualia such as roundness, redness, coincidence of pointer readings, and the like. Knowledge of the quality of a thing, however, does not stop with the immediate awarenesses or with the qualia extracted therefrom but instead is an interpretation of these as a sign of certain other qualia that may be experienced if one chooses to act in certain ways. Of the qualia we may say with certainty, "it looks round", "it looks crooked", "it looks (or reads) 30 ohms". In other words, round, crooked, and 30 ohms as here used are qualia. Such statements are, in other words, not subject to error. If, however, we say "it is round", "it is crooked", "it is of 30 ohms resistance", these statements represent interpretations subject to error. Thus an object may look round but upon further investigation may be found not to be round. A stick partially submerged in the water may look crooked but not be crooked. A pointer reading of 30 ohms may later be found to be partially due to errors.

The building blocks with which we start are the qualia which are immediately recognizable and which are in general considered to be universals. A quale, however, differs from a quality in that it is subject to immediate and certain recognition without error whereas quality is subject to errors and is verifiable only in the sense that if it is the quality in question, then such and such further qualia may at some future time be experienced by performing such and such a set of operations.

The interpretation of qualia as a sign of qualities depends upon our concepts, mental pictures, or constructs. Thus it is that the qualities of even such simple things as mass, length, and time depend upon our experience of certain relations of qualia and upon our thinking or, more particularly, upon the constructs and hypotheses at the basis of our thinking. One may be aware of a sensation of kaleidoscopic changes in awarenesses without at first being able to

interpret them, only to find that upon thinking, involving certain mental pictures or constructs, these awarenesses resolve themselves into qualia which become signs or indications of certain qualities.

Hence it is that although the qualia of a thing may be the same today and tomorrow, our interpretation of these qualia in terms of qualities of the thing may change. In other words, the quality of a thing to any person depends not only upon the qualia which he experiences, senses, or feels, in the presence of the thing in question but also upon the mental activity of the person. Hence there is a certain personal element in the quality of a thing. In the order of the logical arrangement of our data or of our awarenesses in a given case pertaining to the quality of a thing, principles or theories are prior to the data. On the other hand, in the order of existence the qualia of a given thing or at least our awarenesses and data pertaining to that quality, are prior to every set of principles we formulate. In other words, our knowledge of a thing is always a mixture of principles or postulates representing a priori thinking and our data consisting of pointer readings or other qualia.

Principle 2 - The experienceable quality of a thing is of two fundamental types:

1. That which makes a thing what it is independent of human interest or volition either a) by itself, or b) as a part of a whole.

2. That which makes a thing interesting or wantable.

In other words, the quality of a thing is either that which gives rise on the one hand to sensuous experience or, on the other hand, that which gives rise to emotive reaction to a thing. Hence the operational or verifiable part of the meaning of quality of a thing must be in terms of awarenesses, either sensuous or emotive. In the last analysis it is that quality of a thing which is of interest or volition that determines the wantableness of a thing or, in other words, its value to mankind. It is an unsolved and perhaps unsolvable problem to determine whether or not our emotive reaction to a thing depends upon an inherent quality of the thing other than that which can be sensed. In other words, it is an open question and one that perhaps cannot be answered as to whether or not two things which are alike in respect to quality of type 1 are alike in respect to quality of type 2. On the other hand, it is quality of type

1, in the form of pointer readings, with which the engineer most often works. In fact, it is this kind of quality which he usually tries to specify upon the assumption that if two things are alike in this respect, they are also alike in respect to their wantableness. Qualities thus specified may, however, not be necessary and, if necessary, not sufficient.

Principle 3 - The verifiable meaning of such statements as: "This is a type A relay" usually implies a large number of "If I do such and such, then I should experience such and such" constructs, pictures, or hypotheses.

In other words, the verifiable meaning of the quality of a thing is its method of verification of which they are two important kinds: 1) verifiable at will, 2) conceivably verifiable. For example, the quality of a Type A relay in respect to inductance, capacity, and the like is presumably measurable at will. Likewise, the quality in respect to tensile strength of a given kind of steel now in existence is verifiable at will. However, we may conceive of a kind of steel the like of which we have not previously experienced and which for practical reasons we may not experience, and then conceive of the tensile strength of this steel in terms of operations which we could carry out if we but had the steel. Likewise, we can conceive of means of verifying frictionless planes, perpetual motion, and the like, although for practical reasons we cannot experience them. Hence it is important to keep in mind that the operational meaning of the quality of a thing is not limited in practical everyday discussions to that which can, under conditions now existing, be verified but also includes that for which we have a conceivable method of verification.

Principle 4 - One's knowledge of the quality of a thing involves more than the meaning of that quality in that it involves the degree of belief that the given thing in each case will, if tried, be found to satisfy the set of "if ..., then ...." operational requirements that fix the definite meaning.

For example, such statements as "This is an apple", or "This is a type A relay", have the meaning set forth above and in addition ordinarily imply a degree of belief p_b that the thing in question will satisfy a given set of requirements that an apple is supposed to satisfy in one case or that a type A relay is supposed to satisfy in the other case. The significance of such a statement for practical engineering purposes lies not only in the meaning but even more in the degree of rational belief.

Principle 5 - The quality of a thing is always more than the definite or operational meaning now of this quality.

In other words, a thing is that which has certain definite qualities which we picture to ourselves and about which we know something, such, for example, as the color, taste, etc., of the apple, or the inductance, capacity, etc., of the type A relay, and some others which we do not have definitely in mind or at the moment know about. Of course, we might interpret these operationally in the sense that a thing is always something which we can find, by some operational technique, to have quality characteristics which we are not able to express now in the form of "if ..., then ...".

Principle 6 - Our picture or construct of the sensuous or emotive qualia to be experienced as fixing the operationally verifiable meaning of quality must always include certain limits representing variations which we decide beforehand to attribute to chance.

In other words, even if we confine ourselves to physical qualities such as mass, length, density, and the like, expressible in terms of pointer readings, it is necessary to allow for certain variations that we must, for practical purposes, attribute to chance. That is to say, verifiable meaning always involves a statement of such limits. Without these limits verification would be impossible except in very rare instances. The statement of operationally verifiable requirements for a given quality characteristic X involves the following five steps:

S_{X_i} =

1. Specify the method of perceiving or measuring the quality characteristic.
2. Specify the number n of repetitions to be made of the operation of perceiving or measuring under the same essential conditions.
3. Specify who is to perceive or measure.
4. Specify the method of analyzing the results of the n repetitions.
5. Specify the limits within which the observed results of the previous four operations should lie.

Principle 7 - Given any operationally definite meaning of quality of a particular kind of thing, and given any definite evidence about the quality of a thing, there exists an objectively definite degree of rational belief p'_b that the given thing has the quality meant.

One may object to this principle as stated upon the grounds that there is no definitely known method by which one may determine the degree of belief p_b', or, in other words, upon the grounds that there is no rule or philosophy which tells one how much he should believe in a given case. We are not able to fix this degree of belief either by formal logic or mathematics. Nevertheless, our attempt to justify a rational approach to any problem seems to rest upon the assumption that there is a rational approach to an objective solution of that problem. All of us have had the experience of pondering over a given set of data in its relation to some definite proposition, in this case some proposition about meaningful quality, in the hope of finding the degree of belief which we should have upon the basis of available data. In other words, it is one's tacitly implied belief in such a principle which spurs one on and on in the analysis of his data and the criticism of his own conclusions.

This principle tacitly underlies the generally accepted theory of rational probable inference and, as such, is one of the most important principles in our consideration of what constitutes knowledge of the quality of a thing.

QUALITY OF A THING TO MORE THAN ONE PERSON

We are now in a position to consider three of the principles which govern our interpretation of the common meaning of the quality of a thing to more than one person and the significance which may be attached to statements about the quality of a thing from the viewpoint of the knowledge of that quality to members of a group.

Principle 8 - The quality of a thing to you can only be inferred by me through my sensing of your reactions R to the thing under specific conditions.

For example, I do not have any means of knowing what kind of awarenesses or qualia you experience when you appear to me to be looking at a thing which I say looks red. Two people may be driving along the same highway approaching an intersection controlled by traffic lights and both may stop on red but neither one has the means of knowing what the other really experiences in the form of awarenesses except as judged indirectly from acts such as stopping and going. Likewise our awarenesses as well as our interpretations of the awarenesses in using a particular instrument or piece of manufactured product may be fundamentally different from those of another, although the discernible acts

of both of us as viewed by another may be for all practical purposes the same.

Principle 9 - One's reaction R to a given thing T depends not only upon the meaning of the quality of that thing but also upon the degree of belief p_b with which he believes that the thing in question has the quality meant.

For example, my reaction towards an apple or a type A relay depends upon the meaning which I attach to an apple or to a type A relay and upon my belief in the specific instance that the thing in question has, in one case, what I mean by the quality of a type A relay. One observing my reaction is not, however, able to judge the relative influence of these two factors.

Principle 10 - One may say that a thing has a common meaning to all members of a group of N observers $O_1, O_2, \ldots O_N$ in respect to a definite set of operations on that thing by each of the N observers under what one judges to be the same essential conditions if the corresponding sensed reactions $R_1, R_2, \ldots R_N$ differ by no more than the one making the observation judges should be left to chance.

Obviously, even though one judges the reactions of the N observers to be the same, he cannot be sure that all of the N observers have the same meaning in mind and the same degree of belief. This follows, of course, from the previous principle in that the reaction of an individual depends not only upon the meaning of quality to him but also upon his belief that the thing has the quality meant. It also follows from the preceding principle that the significance from the viewpoint of knowledge of the statement "This is an apple", or "This is a type A relay" is likely to be different on at least the three following scores for the one who makes the statement and the one to whom the statement is made: a) the meaning, b) the degree of belief, and c) the source of the degree of belief.

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