III.—CAUSATION AND RECIPES

By Douglas Gasking

We sometimes speak of one thing, or of one sort of thing, causing another—of the second as being the result of or due to the former. In what circumstances do we do so ?

If we start with some typical statements of causal connection—"The train-smash was due to a buckled rail"; "Vitamin B deficiency causes beri-beri"—two things are likely to strike us. First, the effect is something that comes into being after the cause, and secondly, we suppose that anyone fully conversant with the circumstances and the relevant causal laws could, from a knowledge of the cause, predict the effect. So it is very natural to suggest, as an answer to our question : We say that A causes B whenever a person with the requisite empirical information could infer from the occurrence of A to the subsequent occurrence of B. Or we might put it : We say that A causes B whenever B regularly follows A.

But this "regular succession" notion will not do. For there are cases where we would speak of A causing B where it is not the case that from the occurrence of A we may infer the subsequent occurrence of B.

An example to illustrate this : Iron begins to glow when its temperature reaches a certain point. I do not know what that temperature is : for the sake of the illustration I will suppose it to be 1,000°C., and will assume that iron never glows except at or above this temperature. Now, if someone saw a bar of iron glowing and, being quite ignorant of the physical facts, asked : "What makes that iron glow ? What causes it to glow ?" we should answer : "It is glowing because it is at a temperature of 1,000°C. or more." The glowing, B, is caused by the high temperature, A. And here the B that is caused is not an event subsequent to the cause A. Iron reaches 1,000°C. and begins glowing at the same instant. Another example : current from a battery is flowing through a variable resistance, and we have a voltmeter connected to the two poles of the battery to measure the potential difference. Its reading is steady. We now turn the knob of our variable resistance and immediately the voltmeter shows that the potential difference has increased. If someone now asks : What caused this increase ?, we reply : "the increase of the resistance in the circuit". But here again the effect was not something subsequent to the cause, but simultaneous.

So perhaps our account should be emended so as to read: We speak of A as causing B when the occurrence of B may be inferred from the occurrence of A and the occurence of B is either subsequent to or simultaneous with the occurrence of A.

But this will not do either, For there are, first of all, cases where from the occurrence of A we may infer the subsequent occurrence of B, yet would not speak of A as causing B. And secondly there are cases where from the occurrence of A we may infer the simultaneous occurrence of B, yet would not speak of A as causing B.

Here is an example of the first case. Given (A) that at t_1 a body freely falling *in vacuo* is moving at a speed of 32 feet per second we can infer (B) that at t_2, one second later, it will be moving at 64 feet per second. We might be prepared to say that this inference was in some sense or other a causal inference. But it would be a most unnatural and 'strained' use of the word 'cause' to say that the body's movement at 64 feet per second at t_2 was caused by its moving at 32 feet per second at t_1. It would be even more unnatural, to take a famous example, to say that the day that will be here in twelve hours' time is caused by the fact that it is now night. Yet from the present fact we can certainly infer that in twelve hours' time it will be day.

An example to illustrate the second point. From the fact that a bar of iron is now glowing we can certainly infer (and it will be a causal inference) that it is now at a temperature of 1,000°C. or over. Yet we should not say that its high temperature was caused by the glowing: we say that the high temperature causes the glowing, not *vice-versa*. Another example: watching the voltmeter and battery in the electrical circuit previously described we see that the needle suddenly jumps, showing that the potential difference has suddenly increased. From this we infer that the electrical resistance of the circuit has, at that moment, increased. But we should not say that the rise in potential difference caused the increase in resistance: rather that the rise in resistance caused a rise in the potential difference. Or again, knowing the properties of a certain sort of wax, we infer from the fact that the wax has melted that, at that very moment, it reached such and such a temperature. Yet we should not say that the wax's melting caused it to reach the critical temperature: rather that its reaching that temperature caused it to melt. Why do we speak of 'cause' in some cases in which we can infer from A to B, but not in others?

The reason is not always of the same sort. Sometimes in such a case it would be nonsense to speak of A causing B, sometimes it would merely be false. Our very last example is a rather trivial instance of the first sort of reason. It is nonsense to speak of the melting of the wax causing the high temperature of the wax because "x melts" means "high temperature causes x to become liquid". So "the melting of the wax caused the high-temperature of the wax" is equivalent to the absurdity "The high temperature of the wax's causing of the wax to become liquid caused the high temperature of the wax".

But it is not for this sort of reason that we do not say that the glowing of the iron causes the high temperature of the iron. "Melting" is by definition an effect and not a cause of an increase in temperature, but the same is not true of "glowing". It is not logically absurd to say that the glowing of a piece of iron causes its high temperature; it is merely untrue. It is possible to imagine and to describe a world in which it would have been true. Here is an account of such an imaginary world.

"Our early ancestors many millennia ago discovered that you could make a large range of substances (wood, water, leaves, etc.) glow first blue, then purple, then red by a process of alternately covering them so as to exclude light, then rapidly letting light fall on them, then quickly covering them again, and so on. Wood, for instance, starts glowing after about six minutes of this treatment, and reaches the red stage in about ten minutes. If it is then left in constant daylight or in constant darkness it gradually fades through purple to blue and then ceases glowing. A number of other substances behave similarly, though the time needed to produce the glowing effect differs somewhat from substance to substance. None of the things that early man thus learnt to make glow, however, suffered any change of temperature in the process. Then, about 1000 B.C. men got hold of samples of fairly pure iron, for the first time. They tried the covering-uncovering technique on it to see if it too, like wood and water, but unlike certain sorts of rock, would glow if manipulated in this way. They found that it would, but that, unlike other substances, iron began to get hot when it started glowing, got hotter still at the purple stage, and when glowing red was very hot indeed. Precise measurements in modern times showed that on reaching the red stage the temperature of iron was 1,000°C. In other respects this imaginary world is just like our world, except that when you put a poker or other non-combustible object in a fire it does not begin to glow, however hot it gets."

Who can doubt that in this imaginary world we should have said that the glowing of the iron caused its temperature to rise, and not *vice-versa*? What, then, are the essential differences between this world and ours, which would lead us to say one thing in one world and another in another ?

Human beings can make bodily movements. They do not move their arms, fingers, mouths and so on by doing anything else ; they just move them. By making bodily movements men can manipulate things : can lift them, hold them in certain positions, squeeze them, pull them, rub them against each other, and so on. Men discovered that whenever they manipulated certain things in certain ways in certain conditions certain things happened. When you hold a stone in your hand and make certain complex movements of arm and fingers the stone sails through the air approximately in a parabola. When you manipulate two bits of wood and some dry grass for a long time in a certain way the grass catches fire. When you squeeze an egg, it breaks. When you put a stone in the fire it gets hot. Thus men found out how to produce certain effects by manipulating things in certain ways : how to make an egg break, how to make a stone hot, how to make dry grass catch fire, and so on.

We have a general manipulative technique for making anything hot : we put it on a fire. We find that when we manipulate certain things in this way, such as water in a vessel, it gets hot but does not begin to glow. But we find, too, that certain other things, such as bars of iron, when manipulated in this way do not only get hot, they also, after a while, start to glow. And we have no general manipulative technique for making things glow : the only way to make iron glow is to apply to it the general technique for making things hot. We speak of making iron glow by making it hot, *i.e.* by applying to it the usual manipulative technique for making things hot, namely, putting on a fire, which in this special case, also makes it glow. We do not speak of making iron hot by making it glow, for we have no general manipulative technique for making things glow. And we say that the high temperature causes the glowing, not *vice-versa*.

In our imaginary world there is a general manipulative technique for making things glow—namely, rapidly alternating exposure to light and shielding from light. There is no other way of making them glow. In general, things manipulated in this way glow, but do not get hot. Iron, however, glows and gets hot. In this world we speak of making iron hot by making it glow, *i.e.* by applying to it the usual manipulative technique for making things glow which, in this special case, also makes it hot. We do not speak of making iron glow by making it hot, for the general manipulative technique of putting things on fires, which makes them hot, does not, in this world, also make things glow.

And in this world, we should say that the glowing causes the high temperature, not *vice-versa.*

What this example shows is the following: When we have a general manipulative technique which results in a certain sort of event A, we speak of producing A by this technique. (Heating things by putting them on a fire.) When in certain cases application of the general technique for producing A also results in B we speak of producing B by producing A. (Making iron glow by heating it.) And in such a case we speak of A causing B, but not *vice-versa.* Thus the notion of causation is essentially connected with our manipulative techniques for producing results. Roughly speaking: " A rise in the temperature of iron causes it to glow " means " By applying to iron the general technique for making things hot you will also, in this case, make it glow ". And " The glowing of iron causes its temperature to rise " means " By applying to iron the general technique for making things glow you will also, in this case, make it hot ". This latter statement is, as it happens, false, for there is no general technique for making things glow, let alone one which, applied to iron, also makes it hot.

Thus a statement about the cause of something is very closely connected with a recipe for producing it or for preventing it. It is not exactly the same, however. One often makes a remark of the form " A causes B " with the practical aim of telling someone how to produce or prevent B, but not always. Sometimes one wishes to make a theoretical point. And one can sometimes properly say of some particular happening, A, that it caused some other particular event, B, even when no-one could have produced A, by manipulation, as a means of producing B. For example, one may say that the rise in mean sea-level at a certain geological epoch was due to the melting of the Polar ice-cap. But when one can properly say this sort of thing it is always the case that people can produce events of the first sort as a means to producing events of the second sort. For example, one can melt ice in order to raise the level of water in a certain area. We could come rather closer to the meaning of " A causes B " if we said: " Events of the B sort can be produced by means of producing events of the A sort."

This account fits in with the principle that an event, A, at time t_2 cannot be the cause of an event B at an earlier time, t_1. It is a logical truth that one cannot alter the past. One cannot, therefore, by manipulations at t_2 which produce A at t_2 also produce B retrospectively at t_1.

Let us turn now to the cases where, although from a state of affairs A we can infer a later state of affairs B, we nevertheless would not say that A causes B ; *e.g.* to the case where from the speed of a freely falling body at t_1 we can infer its speed at t_2, or infer coming darkness from present daylight. These are cases where a process is taking place whose law we know, so that we can infer from one stage in the process a later stage. Our inference presupposes that nothing happens to interfere with the process ; the falling body will not encounter an obstruction, the earth's spinning will not be stopped by, say, our sun becoming a super-nova. The difference between the earth's spinning and the body's falling is that in the latter case we can set the process going and arrange that nothing shall thereafter interfere with it for a certain time ; in the former case we cannot. It is the same sort of difference as there is between melting ice in a bucket and the water-level rising in the bucket and melting Polar ice-caps and sea-level rising. We cannot set the earth spinning, but we can set a top spinning.

Imagine a world in which there is an exact correlation between the colour and the temperature of everything. Anything at a certain low temperature is a certain shade of, say, blue. If an object becomes warmer its colour changes to purple, then red, then orange, then yellow and finally to white. Cold (or blue) objects can be made hot (or red) by putting them in a fire ; after a long time in a very big fire they become very hot (yellow). In such a world we should very probably not have had two sets of words : " cold ", " warm ", " hot ", " very hot " and also " blue ", " purple ", " red ", " yellow "—but only one set—say the words " blue ", " purple ", " red ", and so on. We should have spoken of things " looking purple ", or " being purple to the eyes " and of their " feeling purple " or " being purple to the touch ". (In our actual world we talk of things being round or square whether we apprehend their shapes by the eye or by the touch : we do not have a special word meaning " round to the eye " and another quite different word meaning " round to the touch ", since there is a correlation between these.)

In such a world we should speak of making purple things red by putting them on a fire, but should not normally speak of making something " red to the eye " (*i.e.* what we mean by " red ") by putting it on a fire ; nor of making something " red to the touch " (*i.e.* what we mean by " hot ") by this method. Still less should we speak of making something " red to the eye " by making it " red to the touch ", or of making it " red to the touch " by making it " red to the eye ". (In our actual world we do not speak of making things " visibly round " by making them "tangibly round", nor *vice versa.*) When a single manipulation on our part invariably produces two effects A and B, we do not speak of producing one by producing the other, nor do we speak of one as a cause of the other. (The visible roundness is neither cause nor effect of the tangible roundness of a penny.) It is only when we have a technique for producing A which in some circumstances but not in all also produces B that we speak of producing B by producing A, and speak of A as causing B.

When we set a process going—drop a stone from a tower, set a top spinning—we set the stage, see that nothing shall interfere (for a certain time at least) with the process we are about to start, and then set things going. After that, things take their own course without further intervention on our part—the stone gathers speed, the top loses it. There are successive stages in the process. At stage A at t_1 the stone is moving fairly fast, at a later stage B at t_2 the stone is going very fast. But, on the presupposition that the process continues undisturbed, the very same initial stage-setting and send-off, C, which will produce fairly fast motion at t_1 (A), will always produce very fast motion at t_2 (B), and the initial stage-setting and send-off C which will produce very fast motion at t_2 (B) will always produce fairly fast motion at t_1 (A). That is, the process being undisturbed, an initial send-off C will always produce both A and B: there is not a general technique for producing A which in some circumstances also produces B. Hence we do not speak of producing B by producing A. There is not a general technique for bringing it about that, one second after the start, a stone is falling at 32 feet per second, which in some circumstances can also be used to bring it about that two seconds after the start it is falling at 64 feet per second. Hence we do not speak of achieving the latter by means of the former, and do not speak of the former as causing the latter.

Of course one could, by attaching a rocket to the falling body, which fires one second after the start, secure that a body which is moving at 32 feet per second one second after departure is one second later travelling much faster then 64 feet per second. But this would contradict our presupposition that the process, after being started, was left uninterfered with. It is on this presupposition only that C always produces both A and B.

I have made two points:

First: that one says "A causes B" in cases where one could produce an event or state of the A sort as a means to producing one of the B sort. I have, that is, explained the "cause-effect" relation in terms of the "producing-by-means-of" relation.

Second : I have tried to give a general account of the producing-by-means-of relation itself : what it is to produce B by producing A. We learn by experience that whenever in certain conditions we manipulate objects in a certain way a certain change, A, occurs. Performing this manipulation is then called : " producing A ". We learn also that in certain special cases, or when certain additional conditions are also present, the manipulation in question also results in another sort of change, B. In these cases the manipulation is also called " producing B ", and, since it is in general the manipulation of producing A, in this case it is called " producing B by producing A ". For example, one makes iron glow by heating it. And I discussed two sorts of case where one does not speak of " producing B by producing A ". (1) Where the manipulation for producing A is the general technique for producing B, so that one cannot speak of " producing B by producing A " but only *vice-versa*. (2) Where the given manipulation invariably produces both A and B, so that the manipulation for producing B is not a special case only of that for producing A.

The notion of " cause " here elucidated is the fundamental or primitive one. It is not the property of scientists ; except for those whose work most directly bears on such things as engineering, agriculture or medicine, and who are naturally interested in helping their practical colleagues, scientists hardly ever make use of the notion. A statement about causes in the sense here outlined comes very near to being a recipe for producing or preventing certain effects. It is not simply an inference-licence. Professional scientists, when they are carefully stating their findings, mostly express themselves in functional laws, which are pure inference-licences, with nothing of the recipe about them (explicitly at least). Thus the formula $1 = \frac{E}{R}$ tells you how to infer the current in a given circuit, knowing the electro-motive force and the resistance ; it tells you how to infer the electro-motive force, knowing the resistance and current ; and how to infer the resistance from current and electro-motive force. All these three things it tells you ; and no one of them any more specially than any other—it works all ways, as an inference-licence. But while one might say a current of 3 amps. was caused by an e.m.f. of 6 volts across a resistance of 2 ohms, one would hardly say that a resistance of 2 ohms in the circuit was caused by an e.m.f. of 6 volts and a current of 3 amps. Why not ? Given an e.m.f. of 6 volts one could make 3 amps. flow by making the resistance equal to 2 ohms. But one could not, given an e.m.f. of 6 volts, make the resistance of the circuit equal to 2 ohms by making a current of 3 amps. flow.

From one point of view the progress of natural science can be viewed as resulting from the substitution of pure inference-licences for recipes.

There is, however, what might be called a "popular science" use of "cause" which may not exactly fit the account given—a use of the word by laymen who know some science and by some scientists in their less strictly professional moments. I have in mind such a locution as "Gravity causes unsupported bodies to fall". Such a statement is not quite on a par, logically, with "Great heat causes steel to melt". It would be fair to say, I think, that the use of the word "cause" here is a sophisticated extension from its more primitive and fundamental meaning. It is the root notion that I have been concerned with.

In accounts of causation given by philosophers in the past a specially fundamental role was often played by the motion of bodies. Every kind of change and every kind of natural law was often supposed to be "ultimately reducible to" or to be explicable in terms of it. In this account, too, though in a rather different way, the motion of bodies occupies a special position. Central to this account is the notion of a manipulation to produce A and thereby to produce B. When we manipulate things we control the motion of bodies, *e.g.* by rubbing sticks together (motion of bodies) men made them hot and thereby caused them to ignite. At least all those causal chains that are initiated by human beings go back to manipulations, that is, to matter in motion.

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