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ON DETERMINISM

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ones. And corresponding to them are possible events, something which is a third matter besides existence and non-existence.

Thus a system of Three-Valued logic was created and elaborated by me in detail last year. That system is as complete and consistent as Aristotelian logic, moreover it is superior to it by the quantity of its principles and formulas. With its introduction of the concept of objective possibility the new logic abandons the commonly accepted conception that science is based on necessity. Possible events are not effects of causes although they can be the beginning of a causal chain. An action of a creative individual can be free and yet have influence on the course of the world.

Since different logical systems can be created, it is obvious that logic cannot be restricted to a reproduction of facts but that it is the product of free action of human beings similar to an artistic creation. Logical necessity has abandoned its place of origin.

That was my work, this was my mental background and this my goal which served as a paradigm.

And now I am obliged to put aside these preoccupations and surrender to necessity, obey laws and rules, and be even their guardian. I shall not be free although I have decided to act in free will. But if I shall again feel free, I shall return to science. And then I shall stand before you or before your successors to continue the battle of the mind for freedom.

JAN ŁUKASIEWICZ

ON DETERMINISM

This article is a rewritten lecture I held at the University of Warsaw at the inauguration of the academic year 1922-1923. As it is my custom I spoke from memory and wrote the text later but I did not publish it. In the course of twenty-four years I had tried repeatedly to modify that lecture and to change its form and content. But its main idea remained unchanged and this applies especially to the critique of the arguments brought forward in support of Determinism. At the time of my lecture the facts and the theories of Atomic Physics were not known and only later were they employed in arguments against the foundations of Determinism.

I am not going to extend my article to an investigation of these new theories since I do not wish to deviate from the original text of my lecture and distort its previous form.

Dublin, October, 1946

1. In accordance with an old academic custom, the Rector commences a new academic year with an inaugural lecture. At that occasion he expresses his scientific creed and sums up his investigations.

Indeed the results of philosophical investigations should be presented in a philosophical system, in a survey about the world and life.

But I cannot do that because I believe that a philosophical system is not consistent with scientific methods. My colleagues and I belong to a presently still small group of philosophers and mathematicians who consider mathematical logic as an object and basis for their investigations. Leibniz, the great mathematician and philosopher, had created that science but his investigations in this field were then forgotten and George Boole created mathematical logic anew in the middle of the nineteenth century. In the present times G. Frege, Germany, Ch. Peirce, USA, B. Russell, England, are the most remarkable representatives of that science.

In Poland the pursuit of mathematical logic has yielded richer and more valuable results than anywhere else. In our country logical systems were created which were indeed superior to traditional logic as well as to other systems of mathematical logic as presented hitherto. Perhaps we had a better understanding of what a deductive system is and how it should be constructed. We were the first to observe that there is a connection between mathematical logic and the old systems of formal logic. Moreover, we have acquired a degree of scientific exactness which superseded previous standards.

For that reason it does not seem to be justified to ascribe to mathematics a special place for its exactness. The degree of exactness which seemingly has satisfied mathematicians is not sufficient in our science. We demanded that every branch of mathematics should be a correctly constructed, deductive system. We wanted to know what axioms and rules of inference were valid for each constructed system. We wished that proofs should be obtained in accordance with rules, that they be complete and verifiable. We were dissatisfied with the proofs ordinarily given by mathematicians, because they started in the middle, had gaps and resorted continuously to intuition. If mathematics could not pass the test when strict exactness was demanded, how could other disciplines pass the grade being so much less perfect? How could philosophy hold its ground if its fanciful speculations had so often disregarded methodical investigations?

If we investigate the great philosophical systems of Plato, Aristotle, Descartes, Spinoza, Kant or of Hegel in respect of their exactness, in comparison with mathematical logic, then these systems will fall apart like a house of cards. The basic concepts of these philosophical systems are unclear, their most important theorems not intelligible, their reasoning and proofs inexact. Moreover the logical theories which serve as

foundations for these systems are almost all erroneous. Philosophy should be rebuilt in its foundations, scientific methods should be employed by it and it should have a new logic as a foundation. This cannot be accomplished by only one individual; it must be the work of generations and of much better minds than found hitherto.

2. This is my scientific creed and although I am not able to construct a philosophical system, I shall nevertheless try to discuss in this lecture a certain philosophical problem that no philosophical theory can discard and which is closely connected with my logical investigations. I wish to say already at the start that I shall not be able to analyze that problem in all its details with the exactness I postulate. My results are very imperfect but they could be of use for somebody who might endeavor to construct with the help of these elementary investigations a more exact and more accomplished philosophical theory.

I am going to embark upon a discussion of Determinism. I believe that Determinism is not just a theory which rejects freedom of will. But at first I am going to explain with an example what I understand by "Determinism."

John met Paul at the Old Town Square in Warsaw yesterday noon. The fact of yesterday's meeting does not exist today. But yesterday's fact is not just an hallucination, it belongs to a small part of reality with which John and Paul must count. Each of them remembers yesterday's meeting. Each of them bears traces of that meeting. Each of them would swear in a court that he saw the other at the Old Town Square in Warsaw yesterday noon.

Supported by these data I shall say: At any moment today it is true that John met Paul at the Old Town Square in Warsaw yesterday noon. By that I do not mean that a *sentence* with this content is true at any moment today, since it is not necessary that such a sentence should exist at all if there is nobody who says it or thinks it, but I am using the expression: "It is true that p at the moment t " instead of the expression "There is p at the moment t " ("moment" means here a not-extended time-point, p is a sentence on facts). I do not yet know how to analyze that expression (i.e. "There is p at the moment t ").

We believe that if something already happened, then it cannot happen again: *Facta infecta fieri non possunt*. What was once true will always remain true. All truth is eternal. These sentences seem to be intuitively certain. Thus we believe: "If an object A is b at the moment t , then it is true at any moment later than t that A is b at t ." If John met Paul at the Old Town Square in Warsaw yesterday noon, then it is true at any moment later than yesterday noon that John met Paul at the Old Town Square in Warsaw.

Do we have a problem here? Was it true at any moment previous to

that of yesterday noon that John will have met Paul at the Old Town Square in Warsaw? Was it true a day before yesterday or a year ago or at the moment of John's birth and at any moment before he was born? Is everything which will occur and will become true in the future already true today and was it true since eternity? Is all truth eternal?

At this point intuition leaves us and the problem becomes controversial. A follower of Determinism will affirm the question, but he who accepts Indeterminism will reject it.

I understand by Determinism the viewpoint that if A is b at the moment t, then it was also true at any moment which is previous to t that A is b at the moment t.

If somebody holds this view then he is not able to look upon the future as being different from the past. If everything which will once happen and will become true is already true today and was true since eternity, then the future is just as determined as the past, although it has not yet become real. The follower of Determinism looks upon the facts of the world as on a film-drama which was already produced at the time when the world had been created. We are now in the middle of the show and although everybody is spectator and actor simultaneously, the end of the drama is not yet known to us. But the end of the drama is already there, it has existed from the very beginning of the show, because that drama had been already finished since eternity. Each role in the drama had been determined since the very beginning, all our adventures, our course of life, our decisions, the good and the bad deeds. And the moments of my and your deaths are already determined. We are only playing the role of marionettes in this world drama. There is nothing else left to us but to observe the scene and to wait patiently for the end.

That viewpoint is peculiar and not at all evident. But already in antiquity two convincing arguments were known and used for the defence of Determinism. One originated in Aristotle and has its foundation in the law of the Excluded Middle; the second one, known already to the Stoics, is based on the principle of Causality. I shall try to present these two arguments as clearly as possible, although they are difficult and barren.

3. We consider two sentences as contradictory if the one is a negation of the other. To give an example I shall draw on Aristotle. The sentences: "Tomorrow there will be a sea battle" and "Tomorrow there will not be a sea battle" form a contradiction. The famous principles, the law of Contradiction and the law of the Excluded Middle which go back to Aristotle, imply the existence of contradictory sentences. The law of Contradiction says that two contradictory sentences cannot both be true at the same time, that is, one of them must be false. We are not going to discuss that important principle which Aristotle and later thinkers

consider as the mainstay of our thinking. We shall investigate here only the principle of the Excluded Middle. That principle states that two contradictory sentences cannot both be false at the same time but one of them must be true. Either the sea battle will occur tomorrow or it will not occur: *Tertium non datur*, and there is nothing else between the members of the alternative, no third member that would supplant the other two. It happens sometimes that two people quarrel and that the one calls a thing white while the other calls it black; but both are mistaken and the truth is somewhere in the middle. However to call one and the same thing black and white does not constitute a contradiction. Two sentences are contradictory only if they state that one and the same thing is *white and not-white*. Here the truth is not somewhere in the middle but must be ascribed to only one of the sentences.

With these results we return to our example from everyday life: If Peter says, "John will be at home tomorrow noon" and Paul contradicts him saying, "John will not be at home tomorrow noon" then one of them says the truth. We do not yet know who of them says the truth, but we shall learn it when we visit John tomorrow noon. If we find John at home, then Peter said the truth, but if he left his home, then Paul said the truth.

Thus it is already true today that John will be at home tomorrow noon, or it is already true today that John will not be at home tomorrow noon. And not only today, but at any moment t , whenever somebody will say a sentence p and somebody else will contradict him and say $\text{not-}p$, one of them will say the truth at the moment t . Either p or $\text{not-}p$ is true. It is not relevant whether these sentences have really been propounded or whether anybody thought of them. It seems to be in the nature of the matter that either p or $\text{not-}p$ is true at the moment t . This alternation seems to be intuitively true. In applying it to our example it assumes the following form:

a). It is true at the moment t that "John will be at home tomorrow noon" or that "John will not be at home tomorrow noon."

Let a) be the first premise of the reasoning.

The second premise of our reasoning is not based on any known logical principle. One can formulate it generally by means of the following hypothetical.

"If it is true at the moment t that p , then p " and p is either an assertion or a negation. If we substitute for p the negation: "John will not be at home tomorrow noon," then we shall obtain:

b). If it is true at the moment t that John will not be at home tomorrow noon, then John will not be at home tomorrow noon.

That premise seems to be intuitively true. If it is true at any arbitrary moment, say right now, that John will not be at home tomorrow noon

(because we know that he left for a distant place) then there is no purpose in visiting John tomorrow; we certainly shall not find him at home.

We accept both premises since they are intuitively certain. The thesis on Determinism is based on them. We shall conduct the proof closely to the rules of the so-called Theory of Deduction.¹

4. Owing to mathematical logic we know that the fundamental logical system does not consist of that small fragment which represents the logic of terms, known as Aristotelian logic, but of propositional logic which is incomparably more important than Syllogistic. Aristotle had intuitively used the laws of propositional logic but it was first developed by the Stoics, chiefly by Chrysippus. In our times propositional logic has been presented almost perfectly by means of an axiom system. Charles Peirce rediscovered it independently of Frege in 1895 and supplemented it with new methods and theses. Bertrand Russell introduced his propositional calculus in 1910, as the "Theory of Deduction." He considered it to be the foundation of mathematics and logic and made it widely known in the world of learning.

The "Theory of Deduction" came to be known as fundamental arithmetic. It includes the most important methods of inference which are employed in science and life. It teaches us how to employ correctly the everyday expressions "not," "and," "or," "if-then." In the course of our argumentation we shall employ three methods of inference of the "Theory of Deduction." Let us start with the second premise:

That premise can be presented as an hypothetical of the form. If α then not β . Here α designates the sentence: "It is true at the moment t that John will not be at home tomorrow noon" and β the sentence: "John will be at home tomorrow noon." But the premise contains the negation of the sentence β , that is, the sentence "not- β ," or "John will not be at home tomorrow noon." From the premise "If α then not β " follows the conclusion: "If β then not α ." Since α has as a consequence not- β , α and β exclude each other. In accordance with this method of inference, we transform the premise b) into the sentence:

c). If John will be at home tomorrow noon then it is not true at the moment t that John will not be at home tomorrow noon.

Let us return to the first premise: the alternative γ or α , where γ designates the sentence: "It is true at the moment t that John will be at home tomorrow noon" and α designates: "it is true at the moment t that John will not be at home tomorrow noon." According to the "Theory of Deduction" the sentence: "If not- α , then γ " can be inferred from the

¹ Today we would use the term "propositional calculus."

premise: " γ or α ." An alternation is true if at least one of its members is true. If the second member is false then the first member is true. In accordance with that method of reasoning we transform the premise a) into the sentence:

d) If it is not true at the moment t that John will not be at home tomorrow noon, then it is true at the moment t that John will be at home tomorrow noon.

Let us compare the sentences c) and d). Both sentences are hypotheticals, the consequent of the hypothetical c) has the same form as the antecedent of the hypothetical d). The two sentences have the structure: If β then not α , and "if not- α then γ ." From these two sentences as premises follows, in accordance with the Theory of Deduction, the conclusion: "If β then γ ." It is true that "If the first, then the second" and "If the second then the third," therefore it is also true that: "If the first then the third." This is the principle of the hypothetical syllogism, which was already known to Aristotle. If we remember that β designates the sentence: "John will be at home tomorrow noon" and that γ designates the sentence: "It is true at the moment t that John will be at home tomorrow noon," we shall obtain as a result of the argumentation the sentence:

e) If John will be at home tomorrow noon, then it is true at any moment t that John will be at home tomorrow noon.

Since the moment t is arbitrary, then it could be the moment of tomorrow noon or any moment previous to it or finally, any moment after it. Therefore if John will be at home tomorrow noon then it is true at any arbitrary moment t that John will be at home tomorrow noon. Generally speaking, we have proved if A is b at a certain moment t then it is true for all the moments previous to t that A is b at the moment t . We proved the thesis of Determinism by accepting as a point of departure the law of the Excluded Middle.

5. The second argument for Determinism is based on the principle of Causality. It is not easy to present that argument intelligibly. Neither the term "cause" nor the expression "principle of Causality" have a definite meaning. I intend to extract their intuitive meaning by using explanations. The ringing of the electric bell that I hear presently at the door of my apartment is accepted as a fact. That John will be at home at the moment t is accepted as a fact that occurs at the moment t . Every fact happens at some place and at some time. Sentences describing individual facts include a record of space and time.

A fact F that occurs at the moment s is a cause of the fact G that occurs at the moment t , and the fact G is an effect of the fact F if the condition is satisfied that the moment s is earlier than the moment t and that the facts F and G are so connected that one can deduce an assertion

about G from an assertion about F by means of laws of nature which govern the events.²

For example a pressure on the button of the electric bell is the cause of the ringing because the moment of the pressing is earlier than the moment of the ringing, and on basis of the laws of Physics which have been applied in the construction of the bell, it is possible to deduce the assertion about the second fact from the assertion about the first fact.

According to the definition the relation of Causality is transitive. Let us assume that there are facts F , G , H , then if F is the cause of G , and G is the cause of H , it follows that the cause of H is F . According to the principle of Causality, every fact G at the moment t has the fact F as a cause, which fact occurs at the moment s previous to the moment t , whereby at any moment later than s and previous to t , there is a fact, which is simultaneously effect of F and cause of G .

In this exposition on the concept of Causality I have tried to bring to the fore the following condition for it: the fact which is considered to be a cause occurs earlier than the one being considered as effect. At first I press the button and the bell rings afterwards although it seems to me that both facts occur at the same time. If a fact is a cause of another fact then that fact will infallibly result from the former fact. If I push the button then the bell will ring. An effect can be inferred from its cause and just as a conclusion is true if the premises are true, an effect must exist if its causes exist. Nothing happens without a cause. A bell will not ring by itself, its ringing is only the result of previous facts. In the sequences of facts which follow each other and are ordered according to the relation of causality there are neither loopholes nor unexplained gaps. From the moment the bell-button was pushed, until the moment it started to ring there was a continuum of facts and they were not only effects of the pressure exerted on the bell, but at the same time the cause of its ringing. Therefore every earlier fact was the cause of a later one.

6. These explanations help to understand better the meaning of the arguments which had been used for the deduction of the thesis of Determinism from the principle of Causality. Let us assume that a certain fact F happens at the moment t . For example, John is at home at the moment t tomorrow noon. Fact F has as its cause the fact $F1$ at the moment $t1$, previous to moment t . And fact $F1$ at $t1$ has as its cause fact $F2$ at the moment $t2$, previous to $t1$. According to the principle of

² The editor of the Polish edition, Prof. Słupecki writes: "The definition of Causality given here differs distinctly from that given in the article 'Analiza i konstrukcja pojęcia przyczyny' (Analysis and Construction of the Concept of Causality) which is the first article of this book. However both formulations imply that the relation of Causality is transitive and this feature is particularly relevant in the later investigations of Łukasiewicz."

Causality each fact has as its cause a previous fact and since we can apply this law to each of the previous facts, there exists a series of retroacting facts:

... $F_n, F_{n-1}, \dots, F_2, F_1, F$. ad infinitum which are facts occurring at the moments:

$m, m-1 \dots t_2, t_1, t$.

Every fact which occurs at an earlier moment is the cause of a fact occurring at a later moment, because the causal relation is transitive. Moreover if F_n at m is a cause of F at t , then there are facts at any moment later m and before the moment t which are effects of F_n and causes of F . Since not all of them can be ordered in a series because there are infinitely many facts, we discern only some of them, for example F_{n-1}, F_n, F_1 .

So far everything seems to be understandable, but now we arrive at the most important part of the argumentation. A follower of Determinism would be inclined to argue: The continuous series of previous facts which are the causes of F is infinite, so that at any moment, *present* or past, but previous to the moment t does a fact occur which is a cause of F . If it is a fact that John will be at home tomorrow midday, then the causes for the fact exist already today because there are causes for it at any moment, previous to the moment of tomorrow noon. And since there are or were causes for that fact there are also necessarily all the effects. Therefore it is already now true that John will be at home tomorrow noon and it has been true since eternity. Generally, if A is b at the moment t then it is true at any moment *previous* to t that A is b at the moment t , since the causes for that fact were there at any moment earlier than the moment t . The thesis of Determinism seems to be proved by means of the principle of Causality.

These are the two strong arguments for the defense of Determinism. Must we accept them? Must we believe that everything in the world happens with necessity and that every free and creative action is only deception? Or should we reject not only the principle of Causality, but also the law of the Excluded Middle?

7. There are two famous labyrinths, wrote Leibniz, where our reason often gets lost, the problem of freedom and necessity of action and the problem of continuity and infinity. Leibniz did not guess that these two labyrinths form a unity and that even if there were freedom it would be hidden in a corner of infinity.

Indeed there would be no freedom if all the causes of future facts would exist at any moment. Fortunately the principle of Causality does not necessitate us to accept that consequence. Infinity and continuity are our salvation. It is not correct to use the principle of Causality to support the thesis of Determinism. It is not true that John's being at home tomorrow noon, is an effect of an infinite sequence of causes which

must necessarily include present and past facts. Indeed a sequence of causes for a fact can start later than at the present moment. That becomes clear by means of the following consideration.

Let us imagine that time can be presented by a straight line and let us ascribe the segment $(0, 1)$ of the number line to a certain time segment. Furthermore, let us assume that 0 corresponds to the present moment and that a certain future fact occurs at the moment 1 , and finally that the causes for that fact occur at moments corresponding to real numbers greater than $\frac{1}{2}$. Then the sequence of causes for that future fact is infinite and does not have a beginning, that is, a first cause. That is so because the first cause would be of necessity at a moment corresponding to the smallest rational number greater than $\frac{1}{2}$, and there is no such number. In the set of real numbers and in the set of rational numbers ordered according to their magnitude, there are no two numbers which follow each other, that is, which would be adjacent to each other. Between any two numbers there is always a third one, thus there are infinitely many numbers. In accordance with the principle of Causality every fact in the sequence has a previous fact as cause, the sequence of causes is infinite and the lower limit is the moment $t = \frac{1}{2}$, being later than the moment 0 and having its place in the future. The lower limit, the moment $\frac{1}{2}$ cannot be transgressed by the sequence of causes, and therefore the present moment $t = 0$ cannot be reached. This proof shows that there are infinitely many causal sequences which have not yet begun since they are still in the future. This viewpoint is not only logically possible but is indeed more cautious than the theory that every future fact, even the least important one, has causes since the beginning of the world. Of course, I do not doubt that there are certain future facts which have their causes already today and have had them since eternity. Astronomers predict with the greatest exactness heavenly phenomena by means of observations and laws of motion, for example, sun and moon eclipses. However nobody can foretell today that a fly which is nonexistent at the present will buzz around me at noon on September 7th next year and the theory that the future behaviour of a future fly has already today its causes and has had them since eternity, seems to be more fantastic than a judgment of the least scientific validity.

Thus an argumentation for Determinism using the law of Causality as its foundation cannot be valid. One can be deeply convinced that nothing happens without a cause and that every fact has a cause and yet not believe in Determinism. We are now going to investigate the validity of the argument using the law of the Excluded Middle as a point of departure.

8. The argumentation based on the law of the Excluded Middle, although it is independent of the former one, is only understandable if the

assumption is made that for every fact there are causes since eternity. I shall explain it with an example from everyday life. Let us assume that John will be at home tomorrow noon. If we accept that for every fact there are causes since eternity then we must also accept that there is already now a cause or causes for John's being at home tomorrow noon. Therefore it is already now true that John will be at home tomorrow noon. The sentence: "It is now true that p at the moment t " which could not be analyzed before has now for the proposition p about a future fact a perfectly understandable meaning. "It is now true that John will be at home tomorrow noon" means that there exists now a cause of John's being at home tomorrow noon and that cause contains its future effect in a similar way as premises imply a conclusion. The cause (or causes) of a future fact described by the proposition " p " and existing at the moment " t ," is the *factual counterpart of the proposition*: "It is now the case that p at the moment t ."

We could employ the same reasoning for the negation: "John will not be at home tomorrow noon." If we assume that all facts are since eternity, we must accept that there is already now a cause for John's not being at home tomorrow noon. Thus the proposition: "It is true at the present moment that John will not be at home tomorrow noon has for its factual counterpart a cause (or causes) of the future fact which exists already at the present moment. The fact that John will be at home tomorrow noon (or will not be) exists only then at the present if the assumption is made that all facts exist since eternity, and therefore also the future facts. Thus it is already now true that John will be (will not be) at home tomorrow noon. The argument which takes its point of departure from the principle of the Excluded Middle is dependent upon the validity of the principle of Causality.

9. We have shown that the second argument for Determinism is not valid. In accordance with the previous results we assume that there cannot be any causes for John's being at home tomorrow noon (or for his not being there) at the present moment. It is possible that the infinite chain of causes that John will be (will not be) at home tomorrow noon is to be placed in the future and has not started yet. Using common language, nothing is yet known about that fact. What kind of argument should we employ now?

It seems that we can say that the proposition "It is true at the present moment that John will be at home tomorrow noon," has no corresponding fact in reality since there are no causes of that fact at the moment t and nothing necessitates us to accept that proposition as true. Indeed it could happen that John will not be at home tomorrow noon. Analogously the proposition, "It is true at the present moment t that John will not be at home tomorrow noon," has no corresponding fact in

the real world because there are no causes for that fact at the moment t and nothing necessitates us to accept that proposition as true. Indeed it may be true that John will be at home tomorrow noon. We are therefore at liberty to reject both propositions as false and accept their negations. That is, "It is not true that John will be (will not be) at home tomorrow noon." Thus the hypothetical e) which was accepted in the previous argument namely: "If John will be at home tomorrow noon, then it is true at the moment t that John will be at home tomorrow noon", becomes invalid. Namely the antecedent will be true if John will be at home tomorrow noon, but the consequent will be false if a moment t is chosen which is previous to that of tomorrow noon, and there are presently not any of the causes for John's being at home tomorrow noon. And if the hypothetical e) is not valid, then the thesis of Determinism is also invalid. One can substitute such values for the variables A , b , t , occurring in the thesis of Determinism: "If A is b at the moment t , then it is true at any previous moment before the moment t , that A is b at the moment t ," that its antecedent is true and the consequent false.

Since the thesis of Determinism is not valid because no future facts exist, the proof which had the law of the Excluded Middle as its foundation must be erroneous. Indeed if we reject as false the propositions: "It is true at the moment t that John will be at home tomorrow noon" and "It is true that John will not be at home tomorrow noon" then we must also reject the alternation a) which is composed of these two propositions and was the point of departure for this argumentation, since an alternative is false if both its members are false. Also the hypothetical d) becomes false: "If it is not true at moment t that John will not be at home tomorrow noon, then it is true at the moment t that he will be at home tomorrow noon." [d) was obtained by transformation of a)] That is so because the antecedent of d) is accepted but the consequent is rejected. Thus one of the premises and a link in the proof are not valid and therefore it is not surprising that they brought about an incorrect conclusion.

We must stress the point that in rejecting the alternative a) we do not abolish the law of the Excluded Middle. The members of the alternation are not in contradiction to each other. The propositions: "John will be at home tomorrow noon" and "John will not be at home tomorrow noon" are contradictory and the alternation composed of these propositions must be true in accordance with the law of the Excluded Middle. However the propositions: "It is true that John will be at home tomorrow noon" and "It is true that John will not be at home tomorrow noon" are not contradictory, because the one is not a negation of the other and the alternation composed of them is not true. We have accepted the assumption a) on entirely intuitive grounds and not in accordance with

a logical law. But intuition can deceive and it has deceived us in this case.

10. Although this solution seems to be logically correct, it does not satisfy me entirely. It does not agree with my intuition. There is a distinction between not accepting the proposition, "It is true that John will be at home tomorrow noon" because we do not know at the present moment whether or not John will be at home tomorrow noon, and rejecting it because there is already at the present moment a cause for John's not being at home tomorrow noon. I believe that we are only in the second case justified to reject the proposition and to say: "It is not true at the present moment that John will not be at home tomorrow noon." However in the first case we can neither accept nor reject the proposition, we can only suspend it. That distinction is also applied in life and in the everyday language. If it is not known at the present moment whether John will be at home tomorrow noon, we will say: It is possible that John will not be at home tomorrow noon. But if there are causes for John's not being at home tomorrow noon and we know about them then we shall say: "It is not possible that John will be at home tomorrow noon." And if it is not already known at the present moment whether John will be at home tomorrow noon then the proposition, "It is true at the present moment that John will be at home tomorrow noon" can neither be accepted nor rejected, that is, it is neither *true* nor *false*. Consequently also the negation of that proposition, "It is not true at the present moment that John will be at home tomorrow noon" can neither be accepted nor rejected, that is, it is neither true nor false. The previous reasoning by which the first proposition was rejected and the second one accepted is not valid. In particular the hypothetical d), which was previously rejected because its antecedent was considered to be true and the consequent false, need not be now rejected since it is not the case that we accept the antecedent, but reject the consequent. And since the hypothetical d) together with the hypothetical c) (which is seemingly correct) is sufficient to establish Determinism, it would appear that the argumentation of Aristotle has retained its validity.

11. However that is not the case. Only now we have reached a solution which agrees with our intuitions and with the viewpoint of Aristotle. Although the Stagirite had presented arguments for Determinism, he only did it for the purpose of rejecting them later. In the famous chapter 9 of the *Hermeneutica*, Aristotle seems to have come to the conclusion that the alternative, "tomorrow there will be a sea battle or tomorrow there will not be a sea battle" is already true and necessary today, but that each single proposition is concerned with a contingent future event and as such is neither true nor false. That is how the Stoics understood Aristotle and why they, as followers of the deterministic view-

point, had fought him. And that is how the Epicureans understood him and why they agreed with him in their defense of Indeterminism.

Aristotle did not undermine with his argumentations the law of the Excluded Middle, but only the most fundamental law of logic, namely that every proposition is either true or false, and that it must have precisely one of two logical values: truth or falsehood (although it was he himself who at first had formulated it). I call this law the principle of Bi-Valued Logic.³

In antiquity the Stoics who knew its implications defended it vigorously, but the Epicureans were opposed to that law. Since it is a fundamental law it cannot be proved. One can only believe in it and only a person who thinks it is evident will believe in it. I myself do not think it is evident. Therefore I am free to accept or not to accept that principle and I assume that besides truth and falsehood there are other logical values, at least one more, and that is the *third* logical value.

What is that third logical value? I have no appropriate name for it⁴ but since I have already supplied some explanations it is not difficult to understand what I have in mind. I declare that there are propositions which are neither true nor false but in some way *indifferent*.

They pertain to future events about which nothing is yet known. These propositions are at the present moment not true because there is no fact which would correspond to them. If we may employ a not very clear philosophical terminology we can say that neither existence nor non-existence corresponds to them, but only *possibility*. Indifferent propositions, whose ontological object is possibility, have a third logical value.

If we employ a third logical value in logic, we alter its foundations. A Three-Valued system of logic (the first outline of which I succeeded to present in 1920⁵ differs from the Two-Valued system of logic not less than the system of Euclidean Geometry from the system of Non-Euclidean Geometries.

Nevertheless it is an equally consistent and non-contradictory system just as the system of Two-Valued Logic. But although the new logic has a new structure, the thesis of Determinism will not be accepted by it. Namely in the hypothetical, which expresses that thesis:

"If A is b at the moment t , then it is true at any moment previous to the moment t that A is b at the moment t' ", one can substitute for the variables A , b , such values that the antecedent will be true but the consequent will be an indifferent proposition, that is, it will have a third

³ Note of J. Śłupecki: Łukasiewicz mentions this law in several papers, in particular in "Philosophical Remarks on Many-Valued Systems of Propositional Calculi," pp. 144-163.

⁴ J. Śłupecki: In the paper quoted before Łukasiewicz ascribes to that third value "possibility."

⁵ J. Śłupecki: The first acknowledgment of Three-Valued Logic is earlier and it was made public in 1918 in a Farewell lecture delivered by Łukasiewicz at the University of Warsaw.

logical value. That will happen if there is no present cause for the fact that A is b at a future moment t . It is not possible to accept, that a hypothetical is true if the antecedent is true and the consequent indifferent, since from the truth can only follow a truth. The logical argument in favor of Determinism fails ultimately.

12. I am now coming to the end of my argumentation. The old arguments for Determinism cannot hold their ground against critique. But although the arguments in favour of Determinism have been rejected, one cannot conclude that Determinism is invalid. The faultiness of the arguments does not prove that the thesis itself is faulty, but, using the previous results, I would like to say that Determinism is no better proved than Indeterminism.

Therefore we are at liberty to prefer Indeterminism and need not be afraid of somebody's objection that we are being careless. We are free to assume that not all the future is predetermined. If some of the causal chains will commence only in the future then only those facts which are not too distant from the present moment, for example the happenings of tomorrow, are already determined at the present. The more distant the facts the less can they be foreseen even by an omniscient mind. Only general forms of facts are determined and *possibility* plays here a great role. The drama of the world is not a film which was finished long ago, but the greater the distance from the projection at the present the more gaps and empty places there are contained in the film. And that is of advantage, because we are able to imagine that we are not only passive onlookers but active actors in it. We can choose the more advantageous possibilities for the future and avoid the bad ones. We can form the future of the world in accordance with our intentions. I do not know how it is possible, but I believe that it is.

But also the past cannot be treated differently from the future. If only that part of the future is real which is causally determined by the present facts, and if the causal chains which will start in the future belong to the sphere of possibility, then it is also the case that only that part of the past is real which has effects in the present. If a past fact has no effects then not even an omniscient mind could infer it from the present events and it belongs to the sphere of possibility. One cannot say it had existed, but only that it was possible. And that is satisfactory. In the life of everyone of us there are difficult moments of guilt. We would be glad to erase them and not only from our memory but also from reality. We are at liberty to believe that if all the effects of those disastrous moments will disappear, even if it would happen only after our death, then the disastrous moments themselves will also disappear from the real world and will pass into the world of possibility. Time heals our sufferings and brings us forgiveness.