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SCIENTIFIC SESSION ON HYDROLOGY AND ON REGULATION OF WATER COURSES(RUNOFF)

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PREFACE.

The great importance of waters in the development of the national economy in our country had been already recognized at the earliest times. Yet, in the past the waters were exploited to a limited degree, and the water economy as well as the enterprise of water constructions developed slowly.

Before 9 September 1944, the power of all hydro-electric centers amounted to about 60,000 kilowatts, and the improved areas measured about 740,000 decars(74,000 hectars) of which 350,000 are drained and situated chiefly along the side of the Duna River and at the Black Sea, and 386 000 are irrigated, situated in the basin of the rivers Marica, Tundzha, Struma and Mesta -- in Southern and Southwestern Bulgaria. The improvement of the rivers was very slight and unsystematic so that the effect of the improvement works was insignificant. This state of water economy and this condition of the water-construction enterprise had its repercussion also upon the status and development of hydrology in the country. Until recently, we had not have a united single good logical and scientifically based hydrometrical network; the observations on the water stands and the measurements of the water volumes in the water sources were not done regularly and systematically so that their data were uncertain.

Radically different are the conditions after 9 September 1944 when the rule went over into the hands of the Nation, with the Bulgarian Communist Party(BCP) at the head. By learning from the rich experiences of the U.S.S.R., the National Republic of Bulgaria started with deliberation upon the road of socialism, and in a short time it was transformed from a lagging-behind agrarian land into an industrial -agrarian country, with collective treatment of the land and strongly increased productive forces. With the development of productive forces, the requirements in relation to the water resources were also enlarged. The need of water for irrigation, for gaining power and for watering has grown incredibly much. On the other hand, with the nacionalization of the industry and with the creation of the Work Cooperative Agrarian Economy("TKZS") the obstacles which in the past were pressing the water economy have been removed, and wide possibilities opened for its development. In a comparatively short time, a multitude of water electric centers were investigated, planned and constructed, as well as irrigational and (P.4) drainage systems and hydrotechnical equipments for them such as dams, tunnels, bridge-canals(aqueducts)etc., of which no one would even dare to dream in the past. Let us recall some of them only: -- the dams "Vasil Kolarov", "Aleksandr Stambolijski", "Georgi Dimitrov", "Studena" (Cold), and the "Stalin"; - the water electric centrals "Asenica I", "Asenica II", "Tyzha"(Sorrow), "Rosica", "Batoshevo", "Petrokhan", "Klisura"(Gorge), "Georgi Dimitrov", "St.Zagora", "Pasarel", "Kokaljane", "Batak", and others; -- the irrigation systems "Stalin" (The Brushljansk and the Sandrovsk lowlands), "Pyrvomaj", "Pirinska Bistrica", "Cherven Brjag"(Red Coast), "Rosica", "St.Zagora" and others. There were constructed about 600 small dams and reservoirs and more than 1000 sounding wells by which the local waters are used for irrigation and for other water economical needs.

The Second Five-Year National Economical Plan(1953-1957 years) provides for the doubling of production of electric energy in relation to the year 1952 and for the enlargement of the irrigational areas to 5 million decars, or to a size from 13 to 15 times more than that in the year 1944.

With the expansion of water economy, and with the use of the water resources of the country for energy, irrigational, watering and other purposes, the requirements for hydrological investigations have also increased and changed, investigations which give strong impetus to the development of hydrology and call to life also the need for the development of the hydrological science. In the year 1946, in the State Polytechnical Institute, a special chair was created for hydrology and hydraulics. In the year 1951, the Service for Hydrology, which formerly used to belong to the Ministry of Electrification and Improvement, was united with the Service for Meteorology into a single service when, parallel with it, the services for engineer hydrology were created in the planning organizations. In the very same time, from 1945 until today, the Scientific Research Institute for Hydrology and Meteorology and the Branch for Hydrology in the Technical Institute of the Bulgarian Academy of Sciences were created. Important achievemnts of practical and theoretical nature have been noted. Yet, together with the achievements of the people, there are also a series of weaknesses the more substantial of which are: - the still existing lack of an unified scientifically grounded hydrological network; the lapse into formalism at the study of the regime of the water sources; the neglecting of certain fields important in the management of waters such as the hydrological forecasts, etc. All this urges the necessity of a basic survey of the condition of hydrology and of the hydrological science in our country and the need to outline, as much as this is possible, the trends and the tempos of their future development.

p.5) In its desire to satisfy these needs, the Technical Institute of the Bulgarian Academy of Sciences takes the initiative for the organization, jointly with the Scientific Research Institute for Hydrology and Meteorology, of a united scientific conference.

The regime of our rivers, however, is such that the correct and purposeful use of their waters is possible only through an artificial regulation of the water courses and through their adaptation to the needs of the society of people. With reference to this, in the agenda of the conference, reports are also included on the regulation of water courses, and the sphere of organizers of the conference was widened -- with the participation of the VTO(Departmental Technical Organization)"Hydroenergy Project".

The conference was held on 27 and 28 February 1956, with the following agenda:

1) Opening, with a brief address by Academician L. CHAKALOV, Secretary of the Class for mathematica, physical and technical sciences of the Bulgarian Academy of Sciences.

2) "Development of hydrology and of the hydrological science in the National Republic of Bulgaria"-- re-port of Engineer Professor B. MARCHINKOV, member of the Scientific Council of the Technical Institute at the Bulgarian Academy of Sciences.

3) "New trends in the development of hydrology"-- report of Engineer R. PAPAZOV, junior scientific coworker in the Technical Institute of the Bulgarian Academy of Sciences.

4) "Scientific foundation of the hydrological network in the National Republic of Bulgaria"-- report of Engineer IVAN MARINOV, Director of the Scientific-Research Institute for Hydrology and Meteorology.

5) "About the hydrological forecasts"-- report of Engineer R. MINCHEV, junior scientific coworker in the Scientific Research Institute for Hydrology and Meteorology.

6) "Methods for regulation of water courses and their application in our country"-- report of Engineer SHELI BENATOVA and Engineer R. RAJKOV, Departmental

Technical Organization "Hydroenergy Project".

7) "Reflections on the hydrological characteristics at the regulation of water courses"-- report by Engineer R. RAJKOV and Engineer SHELI BENATOVA, Departmental Technical Organization "Hydroenergy Project".

8) Discussion of the delivered reports.

9) Closing of the deliberation with an address by Corresponding Member, Engineer Prof. D. VELEV, Director of the Technical Institute at the Bulgarian Academy of Sciences.

The interest in the conference was great-- more than 150 engineers of the production, and scientific workers have attended. After the reports, lively discussions were arranged in which 35 people took part. (P. 6) A proposal was also submitted which was unanimously accepted, to have the materials of the conference -- the reports and the statements-- printed in a separate publication so that it could become the property of a wider circle of specialists.

The present work appears as an answer to this proposal; it contains the reports, some of the most essential discussions and the conclusions and recommendations made at the conference. We remark with regret that for technical reasons it was impossible to insert all discussions, although many (almost all) contained valuable thoughts and recommendations. For those who are interested in the omitted parts also, the stenograms of the conference stand at disposal.

Sofia, May 1957.

Corresponding Member DIMO VELEV.

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p.7) PROF. engineer B. MARCHINKOV.

DEVELOPMENT OF HYDROLOGY AND THE HYDROLOGICAL SCIENCE IN OUR COUNTRY.

Introduction.

The water has always played a great role in the economy of all countries. Unlike other treasures of Nature such as coal, oil, mineral ores, the water resources are constantly renewed, and, thanks to the circulation of the waters of the Earth globe, they represent one ever lasting source. Man has been always striving, with reference to the technical development in the corresponding era, to exploit the waters for satisfying his needs and for improving his mode of life. While in the past times this was achieved with comparatively primitive means, more recently, with the advancements of technics, an aspiration has been alive after much greater utilization of the water sources. Today, with the high level upon which the hydrotechnical construction works stand, the waters are utilized much more purposefully and systematically for irrigation, for water supply, for obtaining the electric energy, for water transportation, and so on.

In certain cases however, the waters turn out harmful effects, too: -- with an unfavorable situation of the waters on and under the land surface, swamp formation or high stand of the ground waters is provoked by which the health and hygienic conditions of the affected regions are deteriorated, or the regular growth of the agricultural plantations is impeded. On the other hand, with floods due to the swelling of the rivers, bridges, dams and similar other equipments, flooded valuable cultivable areas and populated places may become damaged or destroyed, while not infrequently even human victims are taken.

And in both instances, appropriate measures are taken which in the first instances have the purpose of utilizing the waters in the given direction, and in the other instances, of removing or minimizing their harmful effects.

The measures by which the utilization of the water resources is realized in a given direction are called "water economical" or "hydrotechnical". The water economical measures presuppose the construction of a series of equipments.

To have built a given water economical measure with the greatest economical effect, it is necessary to draw up basically the so-called "water economical studies" (p.8) -- plans which show the main stages of the planning. But while with the plan-

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ning of other engineering constructions knowledge about the regime of a utilizable water source is not required, or this holds good partially only for certain engineer constructions, with the water structures the basic recognition of the regimes of the water sources to be utilized represents the absolutely necessary initial step. Without basically recognizing the regime of the water sources, it is impossible to expect either an accurate planning of the water economical measures, or a purposeful exploitation of the same.

The non-recognition of regimes of the water sources may lead either to the construction of large and expensive equipments with overestimation of the water currents, or to an irrational use of the water currents with an underestimation of the same. Similarly with an overestimation of the high waters, it may come to a complete compromising of the equipment and to human victims. That is why a fundamental duty of any hydrological service today is to study the regime of the water sources.

In the studying of the water sources, a special science, hydrology is engaged which represents one of the geoophysical disciplines. As a part of geophysics,--the general science which studies the physical and other processes that arise on our planet,--hydrology is also in contact with the other geophysical disciplines, --such as meteorology with which they join in the studies of rainfalls, of the evaporations and of the other climatic elements, and geology (which studies the entrails of the Earth) with which it joins in the general study of the problems about the drifts and the subterranean waters. Hydrology has a close contact with geography, too. We cannot present the hydrological features by tearing them out of the environment in which they appear.

At today's stage of the development of hydrology, those sections are in order which have differentiated into separate disciplines-- hydrometry, hydrogeology, oceanology. This does not seem however any reason for their losing connection between themselves. On the contrary, with their shaping as independent disciplines, they acquire a wider basis and their connections with other disciplines are better realized, with which they have common points of contact. Thus, for instance, limnology includes not only the studies which are related to the balance of the water sources, but also those related to the balance of the materials and of the energies. In the science about swamps, in addition to the questions about the water courses, the questions of morphology, genesis, physico-chemistry and geography of the swamp formations are also considered.

It will be also in regard to another important question for which there is no regular understanding and knowledge in our country.

While in the past it was thought that hydrology in general was a scientific branch which had for its goal to serve the hydrotechnical construction industry and it was even mistreated as a section of hydrotechnics, today, thanks to the high level on which hydrology is kept in the U.S.S.R., the understanding for these problems has radically changed. As the experience has shown in this first socialistic country in the world in which hydrology holds the first place all over the world, the famous Soviet hydrologists -- Prof. M.A. VELIKANOV, Prof. I.I.(p.S) CHEBOTAREV, Prof. D. SOKOLOVSKI and others -- think that the great development of hydrology and the pre-eminent role of this science in the U.S.S.R. are due to the opportune separation of hydrology into an independent discipline which gives service not only to the hydrotechnical construction industry but also to the other branches of the national economy, including also the defense of the country. It is however in radical contradiction with the staging of hydrology in the other countries. Even up to the present day, in many countries hydrology is a supplement of the hydrotechnical disciplines. In his work "Hydrology of the land", 1948, Prof. M.A. VELIKANOV states:" Hydrology as a science is a child of the Great Octrobist Revolution". In the same work he further announces:" We think that hydrology as a science about the activity of the waters of the Earth and hydrology as a science about the hydrotechnical construction industry, as an engineering technical discipline, ought to be strictly distinguished from each other. Every science grows out of the needs of life and in front of the practice it justifies its existence by useful results, together with this, however, it also has its own proper logics. The science always represemts a system".

S.N. NIKITIN in "Principles of River Hydrology"(1952) states:" From a subsidiary science of hydrotechnics, the Soviet hydrology grew up to become an independent geophysical science which developed and branched off into a series of separate disciplines."

A.N. CHEBOTAREV in "Hydrology of the Land and River Confluence", 1950, states: " Primarily, hydrology has developed in close connection with hydrotechnics and physical geography which is the main reason that hydrotechnics and geographies have pretended to include it in the sphere of their own jurisdiction, having no consideration for the role and for the importance of hydrology as an independent outgrowth of scientific knowledge. Two-three decades have hardly passed since hydrology presented itself as an independent discipline and the results are evident at hand."

As we see, hydrology is a young science and it conquered its place as an independent discipline in the Soviet Union. Inspite of the fact that even in other countries it has acquired a well-known development, it would be daring to say that what had been achieved in certain countries in the course of one century and a half it came about a little quicker in the U.S.S.R. in the last 2-3 decades.

This lagging behind of the other countries is due to the inaccurate understanding that hydrology would be directly subordinated to the hydrotechnics and that the hydrological studies must be directed only in reference to the hydrotechnical constructive industry. As an example of this wrong development of hydrology we must put in evidence the unilateral evolution of the same in the various countries. Thus, in France, Austria, and Hungary, hydrology chiefly developed in connection with the fight against inundations, in Bavaria, in Switzerland, Sweden and South France -- in connection with the use of the water energy, in the U.S. and in Italy -- in connection with the improvements and in Germany -- in connection with the development of the water ways. The same was observed in Russia, too, before the revolution when hydrology has developed chiefly in connection with water transportation and with the improvements. (P. 10). Basic results in connection with it are not achieved, and for this reason the water sources and the technical regime are not studied at all.

Especially in the U.S.S.R. this situation had been put to a re-evaluation, and already in 1919, in relation with the electrificational plan, the question was put for the creation of an independent State Hydrological Institute which would be charged with the task of organizing the whole-sale study of regimes of the water sources in the U.S.S.R. There is nothing to stop us in the development of hydrology of the subsequent decades, in the methods of work and in the achievement, but we shall only remember that the building of such structures as are the Great Constructions of communism is possible only with hydrological studies which stand upon a very high level. But to lead up to this high level of hydrological studies it was also necessary to solve the question of the personnel staff. This was also solved in a radical way in the U.S.S.R. Special hydro-meteorological institutes were there created which prepare specialist hydrologists (engineer hydrologists). From these facts it is evident that the successes in the U.S.S.R. in the field of hydrology are due to the timely separation of hydrology into the science and the practice and to its development into an independent discipline.

I. Development of hydrology in our country.

Immediately after the Liberation there was no type of hydrological construc-tionindustry.

Activity in this direction was manifested in the administration of the ir-rigationin the Marishka Valley which was accomplished by primitive methods inherit-ed from the Turks for which hydrological or hydrometrical studies were not required. This is the main reason that even an embryo form of hydrological investigations is lacking.

Gradually, with an arrangement of the affairs of the waters by means of reg-ulations in regard to gicing right for the utilization of the waters by private people and in regard to administering the irrigation, during 1910 the question arose about constituting a few water reading stations on the Marica River for the purpose of studying the regime of the water level and of helping the Waters Administration with the distribution of the water in the various irrigation districts. Yet, this did not go into effect, and no stations were opened on the chief irrigation canals which would service the irrigation, especially on the canal "Pashaark", on the canal "Njakhrikebir", on the canal "Eniark", etc.

With this , the f i r s t p e r i o d starts in the development of hy-drology. For this time, with the purpose of getting water readings on the Marica River at the city of Pazardzhik, at the city of Plovdin, at the village of Papaz-Lij, to get water stands at the river Topolnica in the village of Kaluger and at a few other points, by the initiative of the management of the Waters Service, brig-ades were established in which the engineers P. ABADZHIEV, V. VASILEV and others had participated. They prepared water-reading scales from wood, with metal membranes pas-ted onto them that represented the lining of the scales. These water-reading scales were distributed to their local designations, and fastened onto the bridge pillars of the corresponding points. (P. 11). Thereafter the levelling of the null points of the water readings(: bench marking) was made, which is found by the contemporary "Reports of the Water Stands", as the informations were called which the observers promulgated to the administrators of the water services. The observations themselves were made according to special instructions and verbal advising of the observers. It should be recorded that, beside such water readings established at these places and the registration of the water stands, which could not be used even for the assumed purpose for which they were organized(the administration and the distribution of the waters),nothing else was accomplished. But even such a beginning from which something more could develop faded away.

With the entry into the Balkan War in 1912, the account giving on the water stands at these few posts was discontinued.After the end of the Balkan War a few water readings were still made of the rivers in Northern Bulgaria,and these were supplemented in Southern Bulgaria ,but the observations for these readings did not differ at all from the one practiced at the originally established stations.

In the period from 1913 to 1915, nothing more was consequently achieved neither in the understanding about the organization of the water reading stations, not in its purpose either. The impression is even gained that the water stands were observed,without being used for any concrete purpose:- simple registration without concrete utilization of the collected data.

The European War which came in 1914 had an influence upon this beginning (during the time of the war the observation of the water stands was abandoned at most places for the second time). Thus the works have also continued after the conclusion of the European War-- before 1920, and with this the first period in the development of the hydrological studies comes to an end. In common features, it is characterized by a lack of clarity in the goals of the original works themselves, and by an almost complete unusability of the collected data. The measurements of the water quantity are almost missing, which would however explain,at least to a certain degree,the regime of the rivers at the posts at which the water reading stations have been established.In general, before 1920 the observations have been carried out in 48 stations.

The second period begins in 1920. Stimulus for it was given by the coming into force of the Law about water syndicates and about the State program for the waters. In the same Law for water syndocates and the State program for the waters, the river basins are pointed out which have to be built up, and the places where the dams will be constructed.The other hydrotechnical measures were also pointed out. In general and as a principle, the waters affairs, and the relations between the State, the private users of water and the cooperative associations -- the water syndicates were organized. In a special paragraph the importance of the hydrological(so-called hydrographical) studies was accounted for, as the studies were enumerated which had to be completed -- observations of the water stands, measurement of the water amounts, of the directions, of the evaporation, photographs of the river basins, etc. According to the Law for water syndicates provision was made that the Waters Service should have four departments of which the Department of Hydrography would administer the water usage and would also carry out the hydrometrical and hydrological studies. For this speaks also the circumstance that the setting of the water reading stations was chiefly started at the sites of the future hydrotechnical objects, without abandoning, of course, even the setting of water readings for the general characterization of the regime conditions in the other rivers.

It should be considered that the beginning of the hydrometrical network was thereby established in our country, however imperfect it might have been and however on its basis the chief principles might have not corresponded with the standards of hydrology in the other countries of those days. Almost the entire country was covered by a network of water reading stations the density of which was not large and it hardly counted about 80 stations as it represented mainly the chief rivers:- Marica, Iskyr, Tundzha, Chaya, Vycha, Elidere, Osym, Yantra and others. All this makes again the impression that the high mountanous areas were not represented, in spite of the fact that a few of the dams in the State Waters Program were foreseen at these places. It must be also noted that no serious steps were made to start the measurement of the water quantities at the water reading stations, and thereby to have any, though just orienting data received on the regimes of the rivers whereby the observation of the water stands would be rationalized.

Exactly at this time, Volume I of the Archives of the Ministry of Agriculture with the title "The Water Forces in Bulgaria" was published by engineer Iv. MAVROV in which work, beside pointing out the water sources for utilization in the country, the h y d r o l o g i c a l s t u d i e s o f s o m e o f t h e r i v e r s are also given at which rivers the constructions of hydrotechnical objects were planned:- the rivers Vycha, Topolnica, Osym, Chaya, and others. The lack of whatever may be a hydrological basis in the country before this moment(as we shall also see thereafter for quite a while)

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thereafter for quite a while) becomes evident from the circumstance that in this work the regime of the rivers is put into an extremely unsatisfactory light. This shows that in our country complete vagueness was then been in existence concerning the relation of the hydrological regime of the rivers which vagueness led to the condition that engineers of good preparation, which type might have been also engineer Iv. MAVROV, were given an estimate on the water passage of the river Topolnica at the village of Lesichevo at an average of 640 million m^3. On the other hand, the correlation of the water passage of the rivers Topolnica and Vycha is such that the Topolnica river was stated as having more passage of water than the Vycha river whose water passage is still far from what it has in reality. The 2½ times overestimation of the water passage of the Topolnica river however(and it is the same with the other rivers) is characteristic for a lack of perfect orientation about the relation of conditions of the water passages of the rivers in our country.

In the period from 1920 until now, the observation of the water stands was carried out more accurately. The same is true also for the instruction of the observers of the water readin stations. In 1923, the first instruction for the observation at the water reading stations was published, as it gave the basic elements how to do the observations. In the instructions the ordinary waters are differentiated from the extraordinary rises of waters(waves, tides), and for the latter the times of observation are given in general. There exist a series of regulations which allow to make the conclusion that, unlike the first period of the hydrographic service, light was thrown upon the methodology of making (p.13) the observations of the water stands and upon the aim that was pursued by these observations. Something more than the service for water, in the city of Pazardzhik they organized the taking of samples for sedimentation from the river Topolica to determine its turbidity. The method by which the samples were taken was a primitive one, and the handling itself of the samples themselves was a still more primitive one. All this again shows the progress and that the aims which were pursued in the taking of these samples were clear for the organizers of the service. But not only this happened;-- in the subsequent years, after collections of material, they came to publishing the data for the water stands for the period from 1924 to 1926 inclusively. In this publication

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The water stands are given for the observed water reading stations on maps and on graphs of the movement lines of the water stands. Besides, in the Yearbook for 1925 an analysis was given of the flood of the Marica River at the town of Pazardzhik, and also the key curve of the water reading No.4 of the same river. Estimate was given on the flood of the Marica river in 1911, and valuable conclusions were made. The area flooded by the river Marica, in the district from Pazardzhik to Plovdiv was represented on themap. It may be said that these are the first informations in the literature which, although in a scanty form, give a few plausible characteristics on our rivers.

If the period from 1920 to 1926 was poor concerning the measuremnts of the water amounts by means of hydrometrical screw, such measurements started in 1926 and were continued until now. The start coincides with the entry of engineer Iv. GANEV into the hydrographical service upon whom was put the task to organise the works of hydrometry. From that year on, measurements of the water quantities were started at some rivers in the country such as the rivers Vycha, Topolica, Elidere, Chaya, Osym, Mytivir, Kamchaya, Vit, Tundzha, and others, by means of a hydrometric screw. A new instruction was worked out for the observation of the water stands, and similarly such for the methodology of measuring the water amounts and of the computation of the water amounts themselves. A model was also composed by which the equalisation and the key curves of the water amounts could be obtained by a method of the least squares. These are the first key curves for our rivers which, although even just approximative, already give an idea about the conditions of the water passage at some posts of the country. Moreover, in 1928 in the hydrographic service overflows were projected and such have been constructed (for instance) at the river Mytivir in the village of Sersemkale, in the land of the village of Mukhov, and the ice of the river Topolica was stabilized with a threshold at the village of Lesichev, in the Pazardzhik district. This stabilization plays a positive role for some time. However, the constructed overflow of the river Mytivir was not able to fulfill its purpose, because the river is very rich in alluvial drag, and in a short time the tract behind the overflow was obstructed so that it could not further function as an overflow. As we shall see, such mistake was also admitted more recently at the overflow of the river Vidima, and at other places. In the same year, a hydrometric bridgelet was constructed on the river Iskyr at Km 35 plus 900 by the highway to the town of Samokov(near the place of the construction of the Stalin dam). There was not sufficient leaway provided (p.14) for it in height, and it was demolished at the time of a high water stand. Yet, it accomplished its function for a while until it was carried away; a series of measurements were made by it which measurements are characteristic for the regime of the river Iskyr.

Everything that was said as far about this period speaks for a greater competence -- even for a specialization in this matter. However, the organizators of that time in the service have looked much narrower upon the task of the hydrological investigations, and they were contented with doing partial investigations of the water passages at a few posts only. The reason for this must not be sought in them so much as in the material basis which was very weak. But even this partial activity was interrupted in the year 1930 when engineer Iv. Ganev left the service. Therewith came the end of these investigations and actually of this period, too.

In the years from 1930 to 1934 almost nothing had been done beside the observation of the water stands. The publication of the year books was also stopped. The water stands have been observed, but they were left to the observers themselves, and were hardly controlled by anyone. The obtained reports in the Water Service were distributed into the files and there they remained. Things went on this way until the year 1934. Only a few revisions of the precipitations were accomplished which were made by the then chief of the Water Department, engineer Ya. Zelkov; however, this was his personal activity. In all the same time we established, jointly with engineer Zelkov, the hydrological year for Bulgaria to run from November the first until October the thirtyfirst.

The t h i r d p e r i o d started in 1935. In this year in the budget of the Water Department -- which had four subunit inspectorates: studying, hydrography, structure, and water syndicate -- the Inspectorate for Hydrography was provided with a special hydrometrical service with two engineers, three technicians, and two notaries(scribes). It must be noted that until that time the Inspectorate for Hydrography had its own list of functionaries who were engaged only in the administration of the usage of water. The provided new functions were exclusively for hydrological and hydrometrical studies. Into this newly constituted service came at this time the engineers Sapunov and Marchinkov. The difficulties which they had to cope with were extremely large. Above all, trained people were lacking who could assume the works and who could carry out the works successfully. In the same Water Department a part of the management personnel had a negative attitude towards the newly created service, which has been considered as unnecessary. The new service could exist and advance only with the support of management personnel of the Water Department which support was not given. The same preparation of the two engineers who entered the service was itself unsatisfactory for them to cope with the tasks assigned to them, since until then no systematical hydrological studies had been carried out and no experience was available. The circumstance that a new service was created, indeed a special service, compelled it to be correctly organized.

The first and fundamental problem which arises in connection with the organisation of the new service would be then the reorganization of the preexistent hydrometrical(p.15) network which was not in correspondence with the contemporary requirements without changes. The network itself was constructed in an elementary manner. The water reading stations were spread chiefly in the middle and the lower runs of the rivers. With foreseeing the great difficulties which would come if the network were reorganized when large numbers of the existing water readings should have been replaced, it was decided to work with this network for a certain time while it was being reorganized and filled out gradually. To this resolution the circumstance also contributed that at the moment when the hydrometrical activity started we did not have any idea of the water passage conditions in the country. To basically reorganize a network, it means that the water passage conditions of the rivers in the country are known at least partially. That is why the work is continued with the existing network. There were six sets of hydrometrical propellers supplied four of which were sent to the provinces and two remained at the central service. It has to be remarked that at this time the waters were administered by seven regions and five districts. Some of these services had old hydrometrical screws most of which were not in use and were put into activity. The next task of the newly constituted service was to compile instructions for the observation of the water stands. Such instructions were worked out in all provincial services. Later, instruction was also compiled for the measuring

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of water amounts. As a basis for this instruction served the already in 1929 printed work of engineer Iv.Ganev entitled "Directions for measuring with the Veltman screw".The new instruction in form of a circular was elaborated for the provincial services to serve as a guide in the carrying out of the hydrometrical measurements. At the beginning of the autumn of 1935, two sets of hydrometrical propellers were inspected and two brigades were constituted each composed of three people -- an engineer, a technician and a scribe-- one of the teams for Northern Bulgaria and another for Southern Bulgaria, which teams had to do the measurement of the water amounts-- more specifically of the low autumnal waters along about 20 posts in the two parts of Bulgaria.This first envelopment of the network with a purpose of measuring the waters had great significance,since at the same place we became acquainted with a certain number of points of the network and with the observers themselves. It was established that the observers up to that moment were left alone to themselves and that almost no kind of control was exercised above their work,neither were they in the knowledge until that time how to act in certain specific cases(observation of high waters, measurement of the temperatures of the water, noting of the appearance of ice,etc.).After the brigades were completed, a detailed instruction was worked out for the observation of the high waters,which had to be turned over to the property of the observers through the corresponding regional and district engineers. Moreover, it was determined that to perform the measurement of the water amounts an average of three-four days were necessary for one measurement.It was the decision of the central hydrometrical service to do measurements twice annually-- in the months of April and May, and September and October since by the regions and the districts still 3 to 4 measurements are to be done. It is a pity that it is impossible to realize these measurements thoroughly since not each service was provided with hydrometrical(p.16) propellers. Then it was ordered to a few of the regions and districts which owned propellers to perform the measurements in the neighboring regions and districts which did not have such propellers,which was not well accepted.Inspite of this,such measurements have been performed.It should be considered that with 5-6 measurements annually the key curve could be compiled for each water reading(the annual) which follows, and for 2-3 years we had already an idea,though not a very precise one, about the water passage conditions in our country.Many misleading facts and mistakes were disseminated

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about the relations of the water passage in our country.

This number of 4.5 measurements yearly was also very small according to our opinion, but there was no way to increase their number. It was considered to have the measurements made upon the high waters in the regions and the districts, and they(the regions and districts) were instructed to do such measurements. Here, however, we were not able to get help which we had expected from the regions and the districts because of the unhappy attitude of the management toward(against) the hydrological investigations. There had been, however, cases at which the regional and the district engineers showed a special interest and love toward the hydrological investigations, which is the case with the regional engineers of the regions of Starozagor, Pazardzhi, Tdrnov, Kyustendil, and Shumen. With a special accuracy were performed the works in the Starozagor region.

In the meantime, in the service the problems about subterranean waters were put to consideration, also the problems of the measurement of the sedimentations, of the evaporations, etc. Beside a few investigations of organized character, it was not possible to accomplish almost anything in this area because of the weak material support. Accomplished was the experience(The experience was gained) that a set of sounds was supplied, but the people who were put in charge of the set were unable to fulfill their obligation. Two sedimentation apparatuses were ordered in Germany together with a series of sieves which were delivered very late-- one at the end of the year 1943, and because of the evacuation of the service, they could not be put to use.

After 9 September 1944, the perspectives for the development of the hydrological service had considerably grown. It must be remarked that, always in connection with the outlined development, the perspective widened for the utilization of the waters in the country and for the reorganization and enlargement of the service. The Soviet hydrologists who are present in the capital(of the service of the Soviet Army) had paid visits to the service and had given valuable recommendations. In this way, a contact was established with the hydrologists Kochetkov, Dzhegamya, B. Kazancev, Mishchenko, S. Zamokhvalov. It was asked by the Waters Director that they should give from their point of view a written opinion concerning the condition of the Service. After one week's study, Kochetkov on his part came out with a written declaration to the Directorate of Waters in which he said that the service was correctly oriented, but it was too small in comparison with the size of the tasks which have to

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be fulfilled, that the network must be widened (both the hydrological as well as the meteorological, and this chiefly at the mountainous districts -- the highland sectors), ; that the studies should be also started into other elements--evaporation, precipitation and underground waters, and there should be a start made for the prediction of the water passages. He stated that among all the Balkan states we got to the first place in hydrological investigations. (p. 17) There are countries-- Greece where such a service does not exist in general. These recommendations had been fulfilled about undertaking of a few small reorganizational measures, since it was still not possible at all to undertake large measures, on account of budget reasons.

The subsequent years after September 9, 1944, do not emerge as a new period since no measures were yet undertaken which would create a new setting of work in the hydrological service. The personnel of the service was enlarged, but the structure of the service completely remained the same. This way it went on until 1949 when the service, which by 1947 went already over to the Ministry of Electrification, at the suggestion of the Soviet specialist engineer Mojseev, was reorganized.

The period from 1935 until 1949 may be considered as such in which we had a hydrometrical service which was organized, though small. Systematic measurements were accomplished, though not in that range in which such measurements should have been made, for which the conditions were lacking. The service established itself and made efforts and achieved indisputable results. The workers in the service had to surmount exceptional difficulties at the performance of their jobs and they had to protect the service until 9 September 1944. It may be said that the achievements were obtained thanks to individual workers who have worked in the service without total cooperation of the management of the Waters Service. In this relation there is an essential difference in the understanding before and after 9 September 1944. Though still unorganized, after 9 September 1944 a radical change came into the attitude toward the service.

In this period it had been possible to collect hydrological data which will be used by the planners as well as by the service itself for an outline of the hydrological regime of the country. Let us consider only in what position we would be if in this period these investigations would not have been done which even up to now are being utilized for the characterization of the water passages. In such a case our entire hydrotechnical construction enterprise after 9 September 1944 would have been laid upon a sandy basis.

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In this period were also published the year books for the hydrological observations in the country from 1934 until 1940. The first two year books-- for 1934 and for 1935-- contain in a systematic form the water stands at the observed water readings of the rivers(including the river Duna) and of the Black Sea, and also the water stands of the wells for the underground waters in the Karaboaz and the Vidin lowlands. There were also the water-collective regions given of the water-reading points and the benchmarks of the water-reading posts. To each yearbook annexes were attached-- charts for the yearly rainfalls with projected water readings and the pluviometric stations, and charts for the distribution of wells in the Vidin and the Karaboaz lowlands.

In the same period, an experimental hydrological section was created on the Kýtina river, at the village of Kurilo, jointly with the Forest Service. At this small water-collecting region five pluviometric stations and a constructed overflow were placed. The water-collective region was outlined and the investigations(the studies) (p.18) of the water amounts and of the rainfalls were started(through measuring the remainder behind the barrage). For unknown reasons, however, immediately after 1944, the rainfall measurements were not communicated to the people(they were taken by some service and placed(posted) elsewhere), and this undertaking which should have thrown light upon the precipitation and the water passage regime of a small river could not be realized. In this period the first computation of the curve was worked out by a method of mathematical statistics. It was done on the Topolica river, at the village of Lesichevo, as the water amount of 1858 was inquired into.

The f o u r t h p e r i o d starts with the year 1949. The service for hydrology was organized. With the new organization, local central water quarters were organized which were put under the direct administration and action of special persons-- water-overseers who controlled the work of a group of observers of water readings. The central administration was reorganized, changes were also accomplished in the network. Invited was also the Soviet specialist hydrologue engineer P. ELISEEV who introduced valuable improvements into the network and into the methodology of the work of the service. By his recommendations, a scientific council was organized which started to be engaged in the actual problems in connection with the new staging of the workers. The new service started to publish in 1950 the review organ entitled "Hydrologia". The Scientific Council was convoked frequently and problems

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were placed about the district divisioning of the country in hydrological relation, about the hydrological terminology, about the account giving of the irrigational waters between two water-reading stations, etc. To the service two consultants were also nominated to the Scientific Department-- professors. The instrumental support was also improved as well as the instructing of observers. There was also created a "tarage"(repair)(?) station with a circuit basin at the Army Camp. The service is independent, though it is under the Ministry of Electrification.

The reorganized service comprises two sectors-- a hydrological and a meteorological. In the meteorological sector there is nothing to stop us except in the cases where the work of the two sectors is interwoven. This combination, done at the suggestion of the Soviet specialists, is logically the result of the connection which exists between the hydrological and the meteorological elements. The hydrological sector in the service is shaped with the following four subdivisions: a) a hydrological scientific department which treats the methodical and scientific problems; b) a department "Networks" which administers the hydrological network, receives and controls the performed observations, gives instructions for the performance of the observations, and similar others; c) a department "Hydrological work-up"-- carries out the working-up, the treatment of the data obtained from the observations and measurements, it compiles the key curves and it determines the primary hydrological characteristics and d) a department "Water Cadastre"(Register) which is engaged in works for systematizing and arranging of the received hydrological characteristics into a single system, with regard to their convenient usage by planners and other interested people. This department performs also the physico-geographical description and arrangement of the climatical elements in the corresponding water-collective regions.

(p.19) In this period the widening of the network was accomplished inasmuch as the mountainous regions were much more represented, i.e., water readings were arranged which controlled the water passages of the small water-collecting areas. At the start of the year 1950 there were 228 stations, 8 posts and 20 wells. The question of opening and also of closing some stations will be considered in a special report. Here we only give the results of the reorganization of the network in relation to the number of stations as in 1950 there were 265 stations observed.

The water reading stations, found in the following years, i.e., after the union of the hydrological service with the Meteorological Institute, show the following courses:

1951:	276 stations and	14 posts
1952:	281 "	14 "
1953:	276 "	9 "
1954:	275 "	10 "

Special attention must be paid to the fact that, in distinction from the past(actually before the year 1940 Dobrudzha was not at all under our government) we have such stations also in the Dobrudzha, with regard to the study of the complicated hydrological regime in this region.

Depending upon the elements which are observed, the stations are grouped in four sets. At the hydrological investigations, attention is also paid to the regime during the winter.

For the accomplishment of the work by the network,-- observing the water stands and measuring the water amounts, the territory is divided into 4 regions (formerly into 7 regions) so that each region has an engineer, a technician and other administrative and assisting personnel. For the more operative performance of the control on the observation of the water readings and on the work of the stations, the country is generally subdivided into 60 districts, each of which is administering and checking a group of water readings. The managers of these districts have gone over qualifying courses of two months' duration and they are familiar with every work that is to be done at the water readings.

Even up to the present time, the system of observation of the water stands did not change-- the observations are made by the ordinary water-reading scale. Self-registering water readers are not in use. The earlier introduced minimum and maximum water readers had not given results, yet nothing was undertaken for their improvement. Considerably increased is, however, the number of measurements which are between 15-20 and 35-40 a year. The measurement of water amounts is done with the hydrometric screw. Provisionally, measurement had been also made with a floater, but this was abandoned. As a method for the measurement of water amounts they introduced the chemical method or a method of matching, which is carried out at great turbidity. After the information received from the service, the same method gives good results. The measurements of the water amounts are made by determined schemes-- the speed is measured at 0.2 N (from the surface), at 0.6 N, and at 0.8 N, and the average speed is calculated by an adequate formula. Actually, this is an abbreviated method for

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doing the measurements, and the Service must further examine this scheme, or generally the application of another scheme, it gives good results. In this respect it must be considered that the Service has made haste with (p.20) the application of the abbreviated methods, without checking them. Regretfully, even up to the present time, the measurement of the high water amounts, respectively of the high tides, has not definitely improved. Thus, water amounts are not measured at different water stands of high tides. When the importance of the form of the high water is considered for the planning and for the genetic estimation of the water passage as well as the more precise estimation of the water passage itself, it must be thought that this is a serious omission in the Service, the more so because, with the present day's setting of so strongly emphasized centralization, the facilities are present.

The measurement of the drift is at 104 points. Question arises only about the muddiness since the question on the trailing drifts in general is in the stage of research with reference to both the organizations and the methods of the work at taking samples and elaborating the results. It must be noted however that even the samples taken for muddiness do not characterize the same since on one hand the muddiness of high tides is not studied, and on the other hand individual samples are taken during a certain interval of time. This explains the marked underestimation of muddiness at points at which a considerably greater muddiness is expected. In general, in this field there are seriousomissions and the service should take steps for the rapid solution of this problem.

One of the problems which have not been even attempted to be solved until now is the one about the underground waters which has a great economic importance for our country. That which has been done is due to the initiatives of a few among the planning organizations to which the problem is of special interest, but this is only partial – it concerns a specific region, and the investigations will last a certain time until the data which are necessary in reference to the planning have been collected. This problem remains open in front of the Service, and it is waiting for its solution. (*FOOTNOTE: By a Decree of the Ministerial Council, urged in the HMS, a subdivision was organized which will organize the studies of underground waters).

II. ACHIEVEMENTS.

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II. ACHIEVEMENTS.

In the Service, the subject-matter scientific plan has been regularly placed and tied together with the most actual hydrological problems, in connection with the building-up of the water engineering construction enterprise, and the servicing of other sectors of the Economy. Thus, priority is taken by the problems about the water passage(course) in the separate river basins, problems on the drifts(methodology), on the coefficients of the ruggedness of the rivers which, in addition to the hydraulical, also have a great hydrological interest, the problem about hydrological predictions, etc.

It must be expected that the scientific workers of the Hydrological Section will go to their scientific sessions with finished achievements of their own elaboration.

After its union with the Central Meteorological Institute in the year 1952, the Service started to publish the review "Hydrology and Meteorology"(p.21) which to a certain degree is the continuation of the review entitled "Hydrology". The review journal is well compiled, and therein are contained reflections as well as achievements of our hydrology and meteorology, even the achievements in the U.S.S.R. Certain original studies are also published, but less in number. It seems also that this review will rise to the place which it should have and that it will reflect the meteorological and the hydrological ideas in the country. In the review journal place is also given to problems which have greater practical significance.

The Service and the Scientific Research Institute(Its Hydrological Section) have not come out until now with publications of substantial importance which would help in practice. Yearbooks were published about the water stands for 1941 and for 1942 which is actually a continuation of the publication of the yearbooks of 1940. In this yearbook the old structure has been retained. Yearbooks were also published for 1936 and 1937 which contain the water amounts in a tabulated form. The yearbooks before 1940 were put into press.

A chart was compiled by the engineer R. HUSEV with iso-lines of the modulus of water passages so that the data on the water passages from 1935 to 1955 have been used. By the same author a chart was also compiled on the water-passage coefficients in the country for the same period. The two charts were also examined by the Scientific Council, and the recommendation was given to print them with a few corrections, but until the present time this was not done. We think that these charts which represent the first approximation of these values for the entire country should get a publicity. With the shown occasional deficiencies their subsequent revision will deal.

In the current year the Service was again reorganized-- the Scientific Institute was constituted. Therewith, the Service itself is getting detached, together with its operative work also, from the purely scientific work in the fields of meteorology and hydrology. It must be remarked that, with the constitution of a scientific institute and with a proper selection of the personnel, greater achievements will be obtained. Such are also expected for the operative services which at the moment are working after instructions.

The problem of the personnel (the cadres) in the Hydrological Service is a very acute one. Above all, a consideration must be made that the Hydrological Section does not have the facilities for specialization such as had been available for the people to become meteorologues. In spite of this, the hydrological cadres which work in the HMS (Hydrological Meteorological Service) have increased their qualifications considerably.

The problem of the lower cadre has not been solved well. I think that the district workers must be entrusted to technicians and that the regional workers must be increased in number. The engineers cadre in the provinces is very small. Greater number of subdivisions must be created-- a form must be found how they are called, and occupied by engineers. We cannot be satisfied with 4 regions and with the regional director not having the chance to test and still less to take part in the works which are done in his region. With smaller subdivisions and with more in number which will be occupied by engineer-hydrologists the director will have to personally perform a series of studies and investigations of physico-geographical and of meteorologo-climatological in nature. This way, the decentralization will bring results which now, with the weak competence which the responsible functionaries now possess in the districts, cannot be achieved. (p. 22)

Generally, about the late period, i.e., the period after the unification of the Hydrological Service with the Meteorological Institute the following may be said:- thanks to the cares of the Party and the Government, great attention has been paid also to hydrology and to the hydrological studies, and for the provision of the Service considerable means have been granted. Of this care, the governmental documents also give evidence by which the problem of its future development is solved. Such trend of development was unthinkable before 9 Sept. 1944, and its main reason is the radical difference in the attitude of the National Government toward the building up of our water engineering construction enterprise which before this date had been in an embryonal and incomplete form of existence. The results which have been achieved until now must be confirmed and enlarged.

XII. SUBJECTS FOR THE YEAR 1956.

Hydrological Prediction.

"SHORT TERM PREDICTIONS FOR THE DUNA RIVER". The topic is timely and necessary in connection with the navigation on the Duna River. With the data of the year 1955 an attempt is being made at improving the data obtained until the present time by the accepted methods.

a) To the problem: "Regime of the river run-off".

We obtained and established the dependences and relations between the distribution of the run-off and the weather, the altitude above sea level, the geographical latitude, the Mediterranean and the continental influences and others on the basis of which an attempt is being made to determine the seasonal distribution of the run-off and the beginning of the hydrological year.

b) Regime of the run-off of the Arda River.- By the balancing method, the relations of the run-off of waters to the physico-geographical and climatical factors were obtained. On account of the unqualified nature of the data there are certain difficulties.

c) Regime of the run-off of the Vycha River.- The regime of the Vycha River was established, including the chemism and the drift regime. The empirical (deductions) relationships about the influence of distribution within the year, which is a gradient of the water collecting region, have been concluded.

ENGINEERING HYDROLOGY.

In the planning organisations of "Water Project" and Energy Hydroproject", special sections were created for the needs of planning which have the purpose of elaborating the hydrological data required for planning the water economy measures. In connection with this, a number of hydrological problems arise which are of decisive importance, and on their correct estimation depends the stability of the euqipment as well as the economical interest(aspect) of the measure in general. (P.23) In the engineering hydrology of the two planning organizations the following more important problems are developed:

1. The problem of the standard of run-off, assurance and distribution.

2. The problem of high waters and waves:- assurance and form of the high water.

3. The problems of alluvial floating and drifting.

4. The problem of evaporation.

5. Problems in reference to the rainfalls. The intensity of rainfalls represents here a special interest since a question arises about the measurable water volumes at the equipments which are not observed.

6. The question about the lengthening of the hydrological series(theories?) also stands out sharply, since these sets of numbers are very short to give the characteristics and to be used with the balancing method for equalization of the run-offs.

In connection with these chief problems on the part of the specific organizations, a number of requests are submitted to hydrology, resp. to the Hydrological Meteorological Service which must be answered by the service.

IV. HYDROLOGY IN INSTRUCTION.

Before 9 September 1944, in view of the fact that there had been no special hydro-engineering profile at the State Polytechnicum, neither was there a special chair for hydrology. A part of the material of hydrology was read under the title "Hydrography" at the Chair for Water Construction to the students of the Construction Department. Immediately after 9 September 1944, parallel with raising the question about opening a cultural engineering department, the probelm also arose to create a Chair for Hydrology. Such was provided as the Chair for Hydrology and Hydraulics, and it was opened on 1 March 1946. The following subjects were read by the Chair: a) to the students of the Construction Department:- hydrology 3 hours weekly in one semester, when general hydrological questions were considered in connection with the practice of construction engineering; b) to the students of the Cultural Engineering Department, 6 hours of lectures were read on hydrology(2 semesters, each 3-3 hours), and in addition to this, 2 hours of lectures on meteorology, 2 hours water engineering, and one hour water cadastre. In consequence, after the Water Engineering Faculty opened, the Chair for Hydrology and Hydraulics was divided into two chairs-- a) for hydrology and meteorology, and b) for hydraulics. Therewith it was intended to get larger specialization of the members of the two chairs, in regard to the heterogeneity of the disciplines. With this division, the subject of water engineering went to the Chair of Water Supply and Canalization. At the Chair of Hydrology, lectures have been also read to the students of the Construction Faculty-- for hydrology and hydraulics as well as to the students of the Mining Geological Institute-- for hydrology and hydrometrics. In view of the fact that in our country we do not have a special hydrological profile which would create the specialists required for the practice, the Water Engineering Faculty has been charged with reading hydrology in a widened type.(P.24). It must be kept in consideration that this also applies as to the condition of hydrological researches in our country which are not at a high level and almost each water engineer must be occupied with working out complex hydrological problems which require a greater competence in the hydrological relations than in those countries where the hydrological foundation is better guaranteed. In the U.S.S.R., specialized top-level scholarly institutions are available where engineer hydrologues are prepared who carry an adequate part of those studies into practice and are relieving the water engineers themselves. In our country, too, the opening of this specialty has been considered, but it was determined that about 5-6 persons would be needed every year, and because of this it had not come to an opening. The role of hydrology has not been sufficiently appraised, and consequently in the State Polytechnicum it came to the suspension of the subject of "Water Cadaster", and afterwards the subject of meteorology has been also discarded; and it was at this moment when in the U.S.S.R. the problem about the new trends in hydrology was submitted to discussion where the genetic method stands at the first echelon. At the present time, hydrology is read to the specialist water engineers in two semesters in 3 hours weekly(for the specialists of the Water-Improvements Construction and the Hydro-Electrical Construction), while the specialty of Water Supply and Canalizationis attending one course in one semester with 4 hours weekly.At present, lectures on hydrology are also read to the students of the Mining Geological Faculty-- speciality of Hydro-geology--, 2 hours weekly, while exercises are also additionally done in one hour weekly. To the students of the specialties of Industrial and Civilian Construction, and of Roads and Railroads, lectures on hydrology and hydraulics are read in 3 hours weekly. Moreover, lectures are also read to the students of the State University-- specialty of Geophysics and Meteorology,-- in 2 semesters in 2 hours weekly.

In a main course that is read to the students for the specialty of Hydrological Meteorological Service and Hydrol-Electrical Service, the following materials are entered:

1) Introduction; 2) hydrography of rivers; 3) hydrometrics; 4) climatological factors of the run-off of waters; 5) application of mathematical statistics to hydrology; 6) underground waters-- hydrological problems; 7) water run-offs and methods for their investigation; 8) extreme conditions of the run-off; 9) alluvia; 10) hydrological prediction; 11) methods for performing water-economical studies (regulation of the run-off); 12) water cadaster; 13) dynamics of the small river currents).

The five hours provided in the program are extremely insufficient for the consideration of all these questions the more so since the course of hydrology also includes meteorology(in view of the climatic factors and the water cadaster).

The underestimation of hydrology as a scientific discipline,which has a profound significance for our national economy and especially for the building up of the water resources, is brought to the point that the Chair for Hydrology and Meteorology also includes the subjects belonging to another chair-- for the utilization of water energy. Therewith hydrology is deprived from the chance to develop as an indeoendent discipline. Hydrology, which originates by the Great Octobrist Revolution and is one of the geophysical disciplines which have their own (P.25) methods and must have their own independent way of development, is reduced to stay as a supplement of one of the practical water engineering disciplines. I believe that this shall be well understood and that the Chair will be restored, the more so since the preparation of the staff of the merged two chairs is heterogenous,and

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there is no benefit from this merger as their year old co-existence indicates.

Lectures on hydrology are also read in the Geographical Faculty-- for general hydrology, hydrometrics and hydrology of the land. In this relation I think that the specialists of this profile may be considered as auxiliaries for the hydrologues in practice at the elaboration of the physico-geographical side of the hydrological problems.

V. PUBLICATIONS.

In general, in the field of hydrology we do not have many publications which would comprehend the various hydrological problems. The reason for this is that the hydrological personnel in our country has been formed in a comparatively short period of time, and at the moment an exact hydrological basis which would serve as basis for hydrological research is completely missing. Until now the following publications have been made:

1. On the hydrography of Bulgaria-- Prof. A. ISHIRKOV, 1901.
2. Yearbooks for the hydrographic observations in Bulgaria, 1924, 1925, 1926.
3. Yearbooks for the hydrographic observations in Bulgaria 1934 - 1940.
4. Yearbook for the hydrographic observations in Bulgaria, 1941.
5. Yearbook for the water amounts of the rivers in Bulgaria in 1936 and in 1937.
6. Yearbook of the Duna Measurement Service with the Direction of Water Reports, vol. 1, 1937-1940.
7. The swamps in Bulgaria-- Prof. G. BONCHEV.
8. Floods in Bulgaria-- Engineer B. ANGELOV, 1943.
9. The catastrophal flood of the Rosica River in 1939.
10. The runoff relations of the rivers Tundzha and Topolica-- Engin. YA. ZELKOV.
11. Application of mathematical statistics to hydrology-- Engin. IV. MAVROV, in the Isv. BIA, 1941.
12. Rev. "Hydrology." 1950; Rev. "Hydrology and Meteorology", 1952, 1953, 1954, 1955. Its publication is continued.

VI. HYDROLOGY IN THE BULGARIAN ACADEMY OF SCIENCES--

The TECHNICAL INSTITUTE,B.A.S.

In the Bulgarian Academy of Sciences(B.A.S.),hydrological problems are elaborated at the Section for Water Economy in the Technical Institute. Here are worked up the problems:-- on the regime of runoff of a few of our rivers, hydrology of the River Beli and Levi Iskyr, the problems of heavy raindfalls, the problems on the statistical computations in hydrology, abbreviated methods for measurement and investigation of the "progressive hydrological series".It should be noted that the lack of a special list of hydrological employees does not give a possibility for complete development of the hydrological work. A special section must be created for hydrology at the Technical Institute which section would take up the elaboration of the most acute problems in the fields of hydrology:- water balance, the alluvia (sedimentation), the hydrological forecasts,etc.

CONCLUSIONS.

In its development,hydrology in Bulgaria has not made such achievements which would completely satisfy the requirements of the water engineering construction enterprise.Before 1935, the work had been done in an extremely unsystematic way, and only in 1935 did the period start which gave results that were used in practice. This was however still wholly unsatisfactory.The present needs urge the Hydro-Meteorological Service, the Technical Institute at the Bulgarian Academy of Sciences, the services for engineering hydrology,etc.,to have a more purposeful recourse to a larger,greater,all-enveloping investigation of the hydrological problems,while complete coordination is established between the works of the institutes and chairs and services and the Bulgarian Academy of Sciences.In connection with this,the following problems arise:

1. The Hydro-Meteorological Service (HMS) must reorganize its supported hydrological network,and must put it upon a completely scientific foundation.

2. The HMS will elaborate a scientific methodology for the investigation of hydrological phenomena,as it conforms with the achievements in the U.S.S.R.

3. With reference to the practice, the HMS must give the primary data in a form that will permit the use of these data without resorting to additional elaborations, before making the data more precise, as the corresponding services for engineering hydrology revise them in regard to their goals.

4. The services for engineering hydrology at the planning organisations, with regard to their specific engineering hydrological problems, must also organ-

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ize their own operative network. The composition of these services as well as their material basis should be widened.

5. At the hydrological researches, especially of the HMS and of the services for engineering hydrology, one should apply the genetical method for the possibility of which the necessary data are there, since in regard to this the HMS is reorganizing its network and its researches.

6. To use three basic methods in hydrology:- standard, reconnaissance, and laboratory methods.

7. To open experimental hydrological districts, balancing stations, and hydrological experimental quarters. To pay attention to the non-investigated elements:- underground waters, evaporation, and alluvial drifts.

8. To restore an independent Char For Hydrology and Meteorology at the Engineering Construction Institute.

9. The Hydro-Meteorological Service should regularly print its hydrological yearbooks and publications.

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(next article starts on next page)

(P.27) ENGINEER: RADOI PAPAZOV:

NEW TRENDS IN THE DEVELOPMENT OF HYDROLOGY.

Before the start of this century,hydrology has not been a separate science. Certain knowledge on the hydrological phenomena was taught in the courses for water communications, irrigation,etc. The existing institute and establishments had been measuring only the water stages and water amounts of the rivers and of the sea in connection with water transportation, and primitive irrigation and the utilization of the water energy.

Later,with the growth of the needs for the engineering sciences and with the developmentof the science on natural reservoirs and on the action of water on the land surface, hydrology began to assume a shape as a separate science with its own methods of research.

Complete contents of hydrology as a doctrine on the total action of water upon the surface of the Earth , according to M.A.VELIKANOV , had been given the first time by the Soviet Union in the twenties of this century. He believes that hydrology as a unified and total science became differentiated after the Great Octobrist Revolution which brought to life the many-sided and total exploitation of the water resources of the country, and therewith chances were also opened for the development of hydrology.

The hydrological science has grown out form the needs of the practie of water engineering and,by satisfying the needs of the latter, it rightfully demands its independent development.

Any science and any branch of knowledge which has for its final goal to support Man in his efforts at subjugating Nature, to give him the chance to study Nature, also to enable him to rule Nature, is a useful science.and its existence is justified.

The existing features of hydrology as a science are included in the following: 1) its object is the water regime of the land on the whole, and not only its separate element-- the runoff; 2) it studies the origin and development of water regime ,and its elements for the purpose of regulating them; 3) it is closely related with the practice of the socialistic construction enterprise, and it is a basic discipline,when planning the water engineering structures; 4) its task is to disclose the regularities of water regime.

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At the present time, the development of water economy puts such a task upon hydrology which to solve correctly will require its full development as a separate science, and as such to also elaborate the very small hydrological problems which as separate links are participating in the solution of a number of huge practical tasks.

(P. 28) The socialistic economical system lends a plan-like character to hydrological researches. It sets up the problem on the complicated utilization of the river basin for the purposes of water transportation, of energetics, of water supply, and of irrigation. Such combined usage of the water resources puts the modern engineering hydrology upon new foundations and requires from it a new solution of the existing water-economical tasks.

In the field of engineering hydrology, the Soviet research hydrologues have achieved great successes. They successfully combine the genetic research of the phenomena of runoff with the mathematical elaboration of the results obtained from the observations, when they are widely using the physico-geographical means and the profound mathematical analysis.

The high standard of Soviet hydrological science, compared with the investigations of the bourgeois research hydrologues, deserves special attention. Nothing would we learn from it by applying it mechanically in our country, since our rivers and reservoirs have their special conditions.

In the directives of the Sixth Congress of the Bulgarian Communist Party and the Decree of the Government and of the Party about the further raising of the rural economy, etc., a number of tasks were stated for the assimilation and the irrigation of 8 million decares (1/10th of a hectare) of agricultural areas, for the improvement of 5 million decares of high-mountain pastures, for the construction of a number of energy sources, dams, etc. The correct solution of these tasks requires the full exploration of the water resources in our country.

To correctly and adequately develop the water resources in the country, complete and reliable hydrological data are needed. We cannot construct water engineering structures, irrigational and drainage systems, without studying in advance the hydrology of the given water source, without improved and deepened water-economical research.

By the complicated investigation of the elements of the runoff and of the factors conditioning it, the prerequisite is created for planning and construction of the hydrological structures upon a solid basis, and therewith also for the solution of the tasks charged by the Party and the Government to our water economy.

In reference to such stated tasks it is essential to clarify the methods and the formulas by means of which the regime of the riparial runoff is determined.

1. EXISTING METHODS AND FORMULAS FOR THE STUDY AND COMPUTATION OF RIVER RUNOFF.

As it is well known, to define the regime of a water source it is necessary to determine: 1) the normal runoff; 2) the size of runoff and its variation; 3) the annual distribution of the runoff; 4) the characteristic high and low waters.

For the definition of these elements of river runoff, a number of methods (analytical and graphical) and formulas are in existence.

At the determination of the normal runoff or of the average annual runoff for a sufficiently long period(about 35 years) one must(p.29) start out from the data of the hydrometrical observations and must determine the relation to the equation of the balance of waters. The normal runoff and the annual and intraannual distribution of it are some of the most important characteristics of the rivers, and they serve as basic values of departure in water economical investigations and plannings of water engineering structures.

Another extremely important problem is represented by the investigation and determination of the maximum waters-- the catastrophic flood wave. They have a rather different character, since they contain an element of chance, and they determine the destructive capability of the river. They must be approached by another method, since they start out from the physico-geographical peculiarity of the drainage area and the probable occurrence of a torrential rain of very great intensity or an intensive melt of the snow covers.

The minimum waters in the summer period are relatively more steady values. They depend upon the precipitations occurring in the summer months and upon the accumulation of the ground water of the vernal and winter periods, and they demand the smallest economical (demand) effort for their regulation and control, with regard to the needs of irrigation. The within the year distribution of runoff greatly depends upon the physico-geographical characteristics of the drainage basin and upon climatological conditions.

At the determination of the normal of runoff as well as at the determination of the maximum and minimum waters, three cases may happen at the present time: 1) where we have a sufficient number of observations and measurements on the regime of the river for a longer period(35 years); 2) where we have a shorter period of observations and measurements (5-10 years); and 3) where no kind of observation and measurement is available on the regime of the rivers. In the first case, the arithmetical average value of a number of measurements is used so that, by means of the method of mathematical statistics, the error of deviation of the observations from the standard (σ_a)(i.e., the standard error) is determined, which we add to , or deduct from, the arithmetical average "y^0"

$$y = y^0 \pm \sigma_a \quad \sigma_a = \pm\frac{\sigma}{\sqrt{N}} \qquad \text{and} \qquad \sigma = \pm\sqrt{\frac{\sum(y_i - y_0)^2}{N - 1}}$$

In the second case, the method of analogy is used for extrapolating the series, and then we deal with a problem as in the first case; in the absence of any kind of observation we are using the large number of empirical formulas, graphs, etc.

The existing empirical formulas include different factors such as the drainage basin and a number of other factors which depend upon the climate and the physico-geographical characteristics of the drainage area, without investigating these factors, however. Different authors have given different interpretations to the coefficients. They received different results because of the fact that they elaborated elements for different basins.

Here we may mention the empirical formulas for the determination of the normal runoff by M.A.VELIKANOV, D.L.SOKOLOVSKI, B.V.POLYAKOV, and by P.S.KUZIN, and the one for the normal of the maximum rate of runoff by KLESTLIN, NIKOLAI, by ZBRO-ZHEK and PROTODYAKONOV.

(p.30) According to M.A.VELIKANOV and D.L.SOKOLOVSKI, the normal runoff is given by the equation $h_0 = \alpha x_0$, depending upon the normal rainfalls and the annual average loss of moisture from the air of the drainage basin.

The normal runoff, according to B.V.POLYAKOV and P.S. KUZIN, is given by the same equation, however, for the α coefficient of runoff these authors give a different value and structure of expression. Similarly, S.N.KRICKI and M.F.MENKEL are expressing the coefficient of runoff in the loss of moisture.

The best conformity with the observations is obtained by the formula of B.V.POLYAKOV

$$\eta = \frac{9}{d_0^3 + 9}$$

In case of an insufficient number of observations, the normal runoff is determined by means of a comparison related to the neighboring adjacent river analogue.

The river runoff is chiefly a product of the climatic elements--precipitation and evaporation--, which, depending upon the various physico-geographical peculiarities of the drainage area, will give one or another kind of runoff. Therefore, more accurate is the method which uses the equation of the balance of waters,

$$y = x - z \pm u$$

where $\underline{x}$ is the average precipitation for many years, which has occurred in the drainage area, $\underline{z}$ is the average evaporation in many years, $\underline{u}$ is the fluctuation of the underground water storage, and $\underline{y}$ is the runoff.

We will consider this method in greater detail since at this time it is the only one which gives good conformity between the river runoff and its conditioning factors.

At an investigation of river runoff by the method of water balance, a series of difficulties are met with:-- the determination of the evaporation, of the transpiration from the vegetal cover, and mostly the fluctuation of the stored underground waters in the innermost parts of the drainage area. In support of the latter investigations, the works of F.A.MAKARENKO and B.I.KUBELIN are coming into account which also open favorable perspectives for the genetical quantitative determination of the underground supply of the rivers.

The equation of the balance of waters is composed of two parts: a) an income part into which enter:-- precipitations falling on the surface of the earth, condensed water vapor from the atmosphere, water from underground tributary which comes over from the adjacent drainage area; b) a part of expenditure which consists of:- surface runoff, evaporation from the ground, and from the water surfaces, and transpiration from the vegetal cover, underground runoff flowing into foreign drainage areas.

Or, the equation of the balance of waters consists chiefly of precipitation, runoff, and evaporation $x = y + z \pm \Delta u$, and a part of Δu that represents the storage of reserve moisture in the drainage area.

A number of Soviet hydrologists have investigated the latter element. Thus, for instance, G.P.KALININ and D.D.LIKHOLETOV propose the following relation between the annual runoff and the rainfall of the Upper Volga:

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p.31) $y = x - 331 \pm 0.7D\, x_0$ where $Du = 0.74\, D\, x$

This computation of Du is made on the basis of the fact that the evaporation is taken for constant thru the years, and on the basis of the relation of Du to the difference of the precipitations during the summer period (June-Sept.) of two subsequent years.

According to D.L.SOKOLOVSKI ("River Flow"- 1952), this assumption is corresponding to the reality though in an incomplete way, but it refers to the Volga basin which is in the zone of a surplus humidification.

This value of Du namely gives a variable character to the runoff, and it expresses its annual variation, while it leaves out of sight the fluctuation of the rainfalls.

With the supposition that the reserve of the underground waters is balanced in a longer period, this equation could be admitted in a simpler form: $x_0 = y_0 + z_0$, which represents the ration between the average pluriannual value of the precipitations, the runoff and the evaporation.

The method of water balance stays on the basis of the genetical method and it creates a connection between the elements which are conditioning the river runoff.

At investigating the variations of the annual runoff in the hydrometrical data, the method of mathematical statistics is used. By the curve of assurance, calculated by its three parameters, Q_0, C_v and C_s, the assurance of the average annual runoff is determined, or that of the maximum and minimum waters for a given period.

The calculation of the curve of assurance is done by the tabulations of S.N.RIBKIN in which are given the relative deviations from the average ordinate of the binomial curve of assurance at $C_v = 1$, and the different percentages of assurance.

After the construction of the empirical curve of assurance by means of the formula

$$p = \frac{m - 0.5}{n} 100\% , \qquad \text{or } p = \frac{m}{n+1} 100\%$$

for the corresponding assurance the observed values—the modulated coefficients, are put down. Thi way a check is made how far these points are dispersed on the theoretical curve.

For the calculation of the normal as well as for the extreme values of the annual averages— maximum and minimum values— or the runoff, the formal statistical method is used which is discussed at present.

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This is the method of the mathematical statistics about which more will be said somewhat later.

Another method, which has lately arisen, is the genetical method (analysis) of the phenomena and of the river runoff. Only in the last decades, by using the dialectical method for analysing and explaning the hydrological phenomena, did the Soviet hydrologists start the studies of those factors on which the formation of the river runoff and its genesis depends.

In recent years, the elements of runoff, the normal of runoff, the maximum and minimum of waters, were placed upon the genetical basis as a mutual relationship is sought between the factors which condition the river runoff and the runoff itself.

(p.32) We will briefly stay at the various theories of the formation of the maximum and minimum waters and of the normal runoff which may be grouped in a) empirical formulas, b) formulas which are determined from the regime, and c) hydromechanical theories of the runoff, d) voluminous formulas which account for the entire form of the flood waters and not only for the phase of the maximum (D.L. SOKOLOVSKI...River Flow, 1952).

One of the theories on the formation of maximum waters is that of Prof. V.F. SRIBIN. He has independently worked out the theory of runoff in 1937-40, when he outlined the drainage basin and the curves of the sub-supply of runoffs, which according to him could have three forms of increase -- rectangle, triangle, and parabole. By taking into consideration the intensity of the precipitation and the curve of the supply, Prof. SBIRIN obtained the formula,

$$Q_m \cong 16.7\, \alpha \psi \varphi\, F,$$

and later, after a number of revisions, he came up with the formula,

$$Q_m \cong C\ P\ H\ M\ F \quad m^3/sec.$$

Other theories of runoff are also available as that of Prof. DUBERIRA, of Prof. ROSTOMOV and Cand. Techn. sciences L.D. KJURDUMOV who all are proposing different outlines, particularly the last mentioned, by starting out from the river network.

But all these formulas, though they include a few physico-geographical, climatological, and other factors, remain entirely empirical formulas in which the relationship between the factors of the runoff and the runoff itself is expressed.

On account of the nature of the formation of maximum waters, the formation of maximum waters on one hand from the snow-melt, and on the other hand from the heavy rains must be separately considered.

Along with the method of V.F.SRIBIN, methods and formulas are in existence by Prof.A.V.OGIEVSKI, Corresponding Member Prof.M.A.VELIKANOV, Pof.D.L.SOKOLOVSKI, and others who propose different schemes and formulas.

Prof.A.V.OGIEVSKI proposes the following formula for the territory of Ukraina S.S.R. and more particularly for the Dnepyr River:

$$Q_m = \frac{0.023\ AF\ m}{\frac{L}{\alpha(10^3 J + 30)} + t}\ \beta \varphi \tau \lambda\ m^3/sec.$$

which contains a number of parameters that express the influence of the different climatological and physico-geographical factors.

Thus, e.g., it expresses the influence of the drainage area upon the runoff, the duration of the running-off and of snow-melt, the slope of the river and the declivities, the hydrographic length of the river, and a number of other parameters which reflect the forest coverage and the swampiness of the drainage area, the coefficient of regularity and the coefficient of repeatability.

Prof.A.V.OGIEVSKI also gives a number of formulas for the maximum waters at torrential rain in which the influence of the various factors of the river runoff is expressed.

(p.33) Corresp.Member Prof.M.A.VELIKANOV, as he starts from the dynamics of the surface runoff, is dividing the drainage area by lines which unite the spots with identical time of flowing, called i s o c h r o n e s.

At this scheme of the drainage area, M.A.VELIKANOV notes three cases for the time of flowing:- 1) when we survey the runoff for a short period of time during which the underground runoff does not succeed in reaching the river; in such a case in the equation of the balances of waters the underground runoff is taken as a loss. In such a case it is characteristic that M.A.VELIKANOV, aside from the dynamics of the surface runoff, also starts from the equation of the balance of waters.-2) When in the drainage area we also have sloping parts on which the surface runoff is almost absent and all the fallen rain soaked into the soil.- 3) When in the drainage area we also have a steep terrain where the entire fallen precipitation is running off, without feeding an underground runoff.

While he is using the equation of the balance of waters, and including the influence of the separate factors of runoff, M.A.VELIKANOV arrives at a differential equation which he then puts into the following formula:

$$Q_m = \alpha \beta \gamma \delta \Theta \Omega \ m^3/sec.$$

M.A.VELIKANOV points out that the maximum waters of the sno-melt represent an extremely complicated set of phenomena which may be divided into three main processes:- 1) melting of the snow, 2) inclined flowing off of the melted waters, 3) movements of the waters which were formed from the melting of snow, downwards to the rivers and reinforcement by the water masses coming from the side. When he divides this complicated set of phenomena into separate processes, Prof.M.A.VELIKANOV approaches the genetic analysis of the phenomena of the river runoff.

When he considered how the maximum waters are formed from heavy rain, M.A. VELIKANOV thinks that the following matters represent relatively rare phenomena(i.e., falling of rain with great intensity and duration over a large drainage area is rare). That is why the runoff of a storm represents a practical interest only in reference to a very small drainage area which is fed entirely by rains. According to him, the maximum waters of a heavy rain must depend upon the size of the area affected by the rainfall, upon its duration and intensity. The maximum waters, the form and their size depend upon: 1) size and the configuration of the drainage area; 2) the direction of the moisture-laden winds; 3) the width of the rain-bearing clouds, and 4) the position of the cloud in relation to the point of survey as it is seen, with a number of meteorological peculiarities.

When he proposes the method of the isochrones, M.A.VELIKANOV obtains a basic equation for the storm runoff. This equation and the formula for the runoff of snow-melt is successfully used in the Central Institute for the forecasting to a number of small drainage areas.

(p.34) D.L.SOKOLOVSKI in 1937 came out with the formula,

$$Q_m = A_p F^{0.75} \ m^3/sec.$$

and more recently $Q_m \cong A_p F^{0.75}\ b\ b'\ m^3/sec.$

which has acquired a wide use. In exchange of this, it has been simplified and it gives account of certain physico-geographical peculiarities which make it approach the formula of genetic analysis. D.L.SOKOLOVSKI lately has new investigations and formulas on the formation of the runoff:

$$Q_m = \frac{1000\ H\alpha F}{3600\ t_n}\ f \cong \frac{0.28\ H\alpha F}{t_n}\ f\ m^3/sec.$$

In 1951, A.D.SAVARENSKI published a new method for the study of the river runoff which he constructed upon a genetic basis.

For the examination and calculation of the river runoff, A.D.SAVARENSKI proposed the following groups of data as basic and initial:-1) characteristics of the weather and the climatic conditions of the drainage area(prediction for the flow of the rains, temperature, moisture, etc.), or the probably possible typical characteristics of the weather; 2) characteristics of the drainage area(relief, soil, vegetal cover, forest cover, hydrological conditions, and their changes in the period of investigation); 3) investigation of the conditions of the drainage area at the beginning of the period of measuring; 4) existing and newly established regulations and methods of computing the process of advancement of the air moisture, evaporation, runoff at the slopes, and the icing of the river, accumulation and formation of moisture, infiltration of rainfalls into the lower strata and their getting to the surface of the ground in the forms of springs; 5) actual data on the runoff.

On the basis of the specified data, a number of preparatory works must be done, and they are:

1. FOR THE CHARACTERIZATION OF THE DRAINAGE BASIN: a) elaboration of the models of the runoff of the drainage basin(defining the area of supply, the ways and the time of runoff of the water particles and the areas of their outflowing); b) composition of schemes for calculation of the drainage area(their division into basically generalizing types, slope, and determination of the percentual composition of these types in regard to the various parts of the drainage area); c) division of the area into types, ravins, hydrological zones, and d) finally, division of the rivers into sections.

2. FOR THE CHARACTERIZATION OF THE CLIMATIC CONDITIONS: a) establishment of the general type of course of the coming of the precipitation upon the surface of the drainage area and the probability of this line of course; b) and an outline of dividing the investigational period into separate sections of time,

On the basis of some new studies of the laws and methods by which the movement of water is followed by the slopes and the soil, the following methods are available: a) simplified methods for determination of the volume of the accumulated moisture, of the seepage and of the runoff at parts of various types of the drainage areas, for the different main storages of moisture, of the intensity of (p.35) of arrival of water and tributary from the side; and b) reference tables for the quick calculation of runoff at concrete conditions of types of slopes, ravins and other parts of the river network for a given year's time.

According to A. D. SAVARENSKI, the ratio must be established which expresses the process of runoff in dependence upon the elements of water balance at different types of conditions, or

$$M \equiv \varphi(X, M^{0}, v^{0}, S_b) \quad ; \quad S_n \equiv \psi(X, M', v^{0}, S_b) \text{ and } V'' \equiv \xi(X, M', V', S_b)$$

where the value of the runoff is $\underline{M}$. The underground waters (S_n) and the storage of humidity at the end of the observation period (V'') are determined as the function of the complex of the local conditions (X), of the value of the tributary which comes from the drainage area (M'), of the main storage of humidity in the drainage area for the observation period, and of the humidity arriving from the atmosphere (S_b) — precipitation, etc.

The calculation of the runoff consists in the following solution of the equation of the balance of waters of the form,

$$M = M' + S_b - S_n + (V' - V'').$$

With the aid of the above relation the water balance is determined for the entire drainage area — for its surface and underground portions and the dynamics of movement of the water masses is traced at a given time by the coverage of the entire drainage area.

When the determination of runoff is summed up this way and the time of calculating the surface and underground runoff is counted together, the runoff curve of the waters coming from different parts of the drainage area is constructed.

The scheme of A.D.SAVARENSKI for the calculation of the runoff,in spite of its complsity and the few deficiencies which could be avoided at a more detailed
fore
elaboration, represents a step forward at the investigation of the river runoff on the basis of a genetic analysis of the phenomena which are shaping it.

From what was said above about the different methods for the calculation of river runoff,it is clear that two trends are basically in existence:- the first -- the formal statistical method of investigation, and the second-- calculation and investigation of the river runoff by the genetic method and analysis of the phen- omena of the factors which are shaping it.

2. ESSENCE OF THE FORMAL STATISTICAL METHOD AND BASIC METHODICAL SHORTCOMINGS.

The employment of mathematical statistics and of the theory of probability at the investigation of the variations of hydrological phenomena consists therein that the curve of distribution is determined for the statistical values which re- present the chance phenomena to find the coefficient of variance and of asymmetry of the number of observations, and thereafter,on the basis of the parameters Q_0, C_v,C_s, to construct the curve of assurance which is the integral form of the curve of distribution. By means of the method of mathematical statistics, in a day's time not only the variations of the water runoff are determined(p.36) but also a few extreme values of the normal runoff, of the maximum and minimum of waters, by in- troducing the assurance.

The method of mathematical statistics has found application the first time in 1914 by the American hydrologist Allen HAZEN in an article:"Determination of the regulability of water reservoir for municipal water supply".

In 1930 it was imported into the Soviet Union by D.L.SOKOLOVSKI,and it was elaborated by S.N.KRICKI and M.F.MENKEL. Characteristic is for it that the investig- ations are resting directly on the direct measurements of the river runoff.

"By setting out on the road of empirical investigation of the laws"-- assert C.N.KRICKI and M.F.MENKEL--"we are compelled to reduce them to a system of situa- tions and to work out hypotheses justified only in such a case in which they in themselves are corroboration of the observed material".

These hypotheses include the following situations:

1) The Law of the annual cycle of the runoff appearing as a reflection of the shift of seasons throughout the year.

2) The hypothesis about the subordination of the annual fluctuation of phasic homogeneous values of runoff to the Law of Large Numbers.

3) The postulate of the invariability of the average normal and the Law of variation of natural river runoffs unaltered by human action during this period (of not a great length) in which the effect of the engineer structures is not substantial.

Such are the prerequisites from which S.N.KRICKI and M.F.MENKEL started out with the theory of the regulation of the river runoff with which they introduce the assurance of the latter.The curve of assurance reflects a number of properties of the statistical combination.But what is a statistical combination. It is a combination of objects or phenomena which,by the determined signs, do not represent anything congenerous and homogenous.

At an investigation of the hydrological phenomena we can never suppose that anyone of them by their signs is homogenous and congenerous.

Neither should we forget that even the most complete statistical description cannot give the completeness of the studied phenomena since at its description the phenomenon is examined out of its normal relations with the surrounding medium.But there is something else:- the characteristics of statistics do not offer a possibility and they cannot directly establish the existing relations between the phenomena and their causative agents.

The employed values of mathematical statistics may take different significance so that the occurrence of each of the significances will correspond with a definite probability.Such values represent the chance event.The juxtaposition of the significances to the chance values and the corresponding significances of the probability of their occurrence represent the Law of the distribution of probability of a given event.

(p.37) These are the initial elements of mathematical statistics at determining the river runoff.Now we must male ourselves acquainted with the natural phenomena and with the factors that are shaping them.

In hydrology we may consider two kinds of phenomena:

a) complicated events, which represent mass combination of the elements or of the simple physical phenomena, and b) complexes (syndromes) of events or of phenomena, which consist of mass combination of complicated events. The river runoff and its shaping represents a complex phenomenon. An element of chance may be collected in the elemental simple phenomena, in their regular structure which represents elements of hydrological events. These elements in every investigated phenomenon represent such a heterogenous combination, and their chance character has a more or less influence upon the phenomena.

M.A.VELIKANOV(see his Hydrology of Land, 1948) thinks that for the different categories of phenomena a corresponding approach of statistical analysis should be found and that for the determination of the curve of distribution one must start with the regular dependence of the elementary physical events.

The complex events represent a definite combination of the heterogenous events which are theoretically unrepeatable(non-repetitive). Each one of the events may happen only once. In two different rivers, the same high waters cannot be observed, but even in one and the same river two phenomena of the same high waters cannot be repeated either qualitatively or quantitatively. The gathering of statistical materials in respect of such complex events as the high waters from a heavy rainfall, from melting of the snow, the deformation of the river bed and many others, will anyhow be insufficient for the determination of the probability of their repetition in a quatitative relation.

M.A.VELIKANOV thinks that the complex events must be dismembered into a limited number of simpler events for a few of which the curve of distribution, deduced directly from the observed data, may be obtained approximately better.

Thus, for instance, M.A.VELIKANOV thinks that we have no possibility to construct the curve of distribution of the maximum waters of the spring high waters at a given section of the river when the observations have been only conducted for a few decades, which is too short a period to have the curve of distribution simplified. However, if we genetically divide a given complex phenomenon into simpler ones, when we study separately the curve of distribution for the temperature increase in the investigated period and district, it is possible, it is even thought that better results will be accomplished. And this is even more possible since in these elements the factor of chance may be amassed to a considerable degree. Also in both cases we are limited by a given drainage area of the river, and we may conduct observations of different parts of a physico-geographical district, and thereafter the so obtained curves of distribution(reflecting the chance element in each phenomenon) are combined with the method of hydromechanical(p.38) analysis of the process of runoff of the melting waters on the slope and in the bed of the river. And in this way, by taking into consideration the physico-geographical factors, we shall determine the runoff of the river.

Not all hydrological events should be considered as by chance. The formation of high waters by heavy rainfall has a chance character in a considerable degree, and especially so in small drainage areas, as the chance character is presented by the chancy falling of the heavy rainm however the average annual runoff and the minimum runoff are of a rather different character. Even the high water resulting from the snow-melt does not represent an event which would be qualitatively and quantitatively identical with the high waters after a heavy rain. The high waters of snow-melt are conditioned by the intensity of melting of the snow and the run of the temperature.

For the possible utilization of the statistical methods when anyone of the hydrological phenomena is studied these events must be genetically homogeneous, i.e. of an equal origin. When the conditions of homogeneity are not observed, this will lead in no matter which may be the case to inevitable mistakes, occasionally to rather significant ones.

At the present moment, the deviation of the annual runoff from its normal, the determination of the minimum and maximum waters is done by the method of mathematical statistics, by basing it upon the curve of the Pearson III Type, yet without taking into account the fact that its employment is wholly formal.

We shall spend some time on a few peculiarities of the method of mathematical statistics which show how it is formal and inconvenient for the determination of the different characteristics of the runoff.

When we investigate the characteristics of the two parameters C_s and C_v, we must understand what accuracy they are calculated with. The value of the probable error is theoretically given only by assuming that the normal distribution, as in general it can be confirmed by cases, decreases with the quadrate root of the number of observations.

The American hydrologist FOSTER has computed the probable errors for C_v and C_s with the supposition that the data of observations on the runoff follow the theoretical curve. These data are given in the following tabulation from which it is evident that with 100 years of observation the error at the determination of C_s is from 8% to 11%. In our country commonly we compute the curve of assurance by the observations of 10-15 or of 20-25-yearly periods, at which according to FOSTER the error for C_s reaches the order of 29-30% so that when we are talking about rivers with observation periods of 5-10 years the error will reach 70-80%.

LEGEND of rubrics of TABLE on p.38: 1) number of years; 2) Error at C_v in percentage; 3) error at C_s in percentage.

(p.39) We could also determine such an error at the calculation of C_v and C_s by the observations of our rivers, by the studies of Prof. Boris MARCHINKOV, by means of the advancing series where for the given series the coefficient of variation C_v varies within great extremes in the advancing period into which different years enter.

From this it is evident that at the calculation of the ordinates of the curve of assurance the coeffieient C_s is used, computed with error that may reach up to 30% with 20-years' observations, but, at smaller number of observations, it may reach up to 50-80%. This circumstance will not make us confident in the accuracy of the determination of these parameters.

The American hydrologist Allen HAZEN has computed the value for 50 American rivers with observations for 25-28 years, and he has established the ratio of

$$C_s/C_v \neq 2.$$

This ratio takes on values from 1.03 to 1.70 which values are less than the value which Pearson gives as obligatory.

This is still a defect of the method of mathematical statistics.

On the basis of the data from 31 points with observation years of 33 to 38, D.L. SOKOLOVSKI arrived at the conclusion that, for the computation of maximum waters of the ordinary rivers in the plains, the correlation $C_s \cong 3\ C_v$ could be accepted, and for the mountain rivers $C_s \cong 4\ C_v$. These correlations are however determined on the basis that the value of C_s, as well as the curve of assurance, will in the best way corresoond with the empirical material.

From all what has been said as far,it is evident that the methods of mathematical statistics used for the computation of the curve of assurance and the latter are subject to doubt,and they do not have the necessary scientific proof at the investigation of the river runoff.They are however used as approximations in the practice.

At the study of the physico-geographical factors and in result of the hydrological analysis of these factors we shall further obtain good results if we determine the relations between the water runoff and the factors which are shaping it.

Here is what B.V.POLYAKOV(in his book:Hydrological Analysis and Computation, Hydrometizdat Publ.,1945) is saying about the method of mathematical statistics and about its formalism:" Furthermore we remark that among some of our hydrologists there is enthusiasm for the theory of probability and for mathematical statistics.Such an extreme statistical trend gives a lopsided development to science, and it harmfully reflects upon hydrological studies.A few hydrologists are spending their whole time and activity in the false conviction that the chief thing in hydrological researches is exhausted in the determination of C_v and C_s".

From the analysis of the method of mathematical statistics which we have made we may arrive at the conclusion that it is formal and that in hydrology(p.40) the main thing is not the computation of C_v and C_s,and particularly of the curve of assurance.

S.F.AVERYANOV(in his book: About the Soviet Hydrological Science,Izvest. USSR,Dept.Techn.Sc.,No.6,1952) point out the following basically erroneous positions in the formal statistical method at the study of the river runoff,which we ourselves have also found on the basis of the above exposed statements:

1) The formal statistical method,when it is using the theory of probabilities on one hand and when it is accepting observations by chance and mechanically without their explanations on the other hand,is denying the individual scientific method of knowledge--the dialectical method,according to which the chance events are such events which result by necessity in a chancy ,indeed,because of not simultaneous,operation of the factors that are conditioning them.This method starts from the chancy fluctuation of water runoff,without especially elucidating what this fluctuation is due to.

Instead of disclosing the basic relations and the opposites in the water runoff and the elements that are shaping it,-- which requires the dialectical

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method at examining the events of Nature--,by thinking that the runoff is a complex combined physical phenomenon,the formal statistical method is taking into consideration one sign only, the magnitude of the runoff,when it is expecting that the events will be arranged by chance, and it is remaining in dark without knowing how to advance.This element,taken as a number torn out of any kind of physical sense is elaborated by mathematical statistics after which the empirical curve of distribution is extrapolated to which curve the observations are approximately subjected,and by the curve of assurance the probable repetition of a given magnitude of runoff is sought for.

Really,isn't it evident that if we only use the runoff as an observed number,without taking into consideration all the physico-geographical,geological,and climatological factors,we would get entirely wrong results?? Thus,for instance,at the determination of the runoff in the karst-type localities,below which the water reading is made, we had not have a true idea about the runoff,its magnitude, and its distribution. This is also true at the diversion of a portion of the runoff into channels for mills,fulling mills,etc. Observation of the runoff by reading the water below(beyond) these equipments had not given a true picture,and the formal statistical method did not reach the actual course of the runoff.

The neglect of these circumstances will lead up to the erroneous idea on the entire runoff of the river,--not only in respect to its normal,but also in regard to its variation.

2. At the investigation of the water regime of the rivers,the formal statistical method takes for its subject the magnitude of the runoff as a NUMBER when it tears off the quantitative half of the process form its qualitative half.

For the illustration of this,let us stop at the formation of high waters from heavy rainfall and from snow-melt. These are two different phenomena which the mathematical statistics assumes as identical(p.41) when it takes the quantitative side of the phenomenon only. It is not taken into consideration that the quantitative phenomena are caused by wholly different qualitative phenomena.

Finally,the runoff of water,represented as a number,only gives the quantitative characteristics,without letting us have an idea about its qualitative side.

And furthermore,is it possible that the formal statistical method could answer the problem of what may cause one or the other runoff of a river in one or more years when it starts out from the hydrometrical observations only? In our opinion--- NO.

(p.41)All these ways of investigating the runoff have a more or less metaphysical character;they are non-scientific,and their use by the progressive hydrological science must be restricted.

3) The formal statistical method essentially denies the idea of the change of the river runoff.S.N.KRICKI and M.F.MENKEL,in their work of regulating the river runoff,start out from the postulate of the invariability of the average normal and of thevariation of the natural river runoff,and they arrive at the invariability of the latter,which denies the idea of development and change of the runoff.

Bot not only this. At examining the river runoff,by starting out from the observations for separate years,the values of thr runoff are torn away from each other when it is thought that they are obtained by chance,without an interrelation between themselves. It is known however that a relationship exists between two years,or a number of years,at the determination of the average annual and the annual runoff.For each year,an equilibrium exists between the elements of the water balance.The annual runoff,considered as an element of the water balance together with the underground and surface runoff,obtains a characteristic strictly in relatâon to dynamic laws of a number of climatical and physico-geographical factors. Their interrupted changing and movement is also conditioning the persistent changing and fluctuation of the runoff.

4) The formal statistical method does not follow the interrelation of the river runoff with the general water regime,since under water regime not only the river runoff is understood but also the underground runoff,the moistures,the evaporation,etc.

5) The formal statistical method cannot satisfactorily solve the question of regulating the water regime of a given river;it does not give the prediction of the runoff,since it starts out from the prediction of the factors which are shaoing it.

We must more precisely define the concept of the formal statistical method.Under this we understand a method which,at the investigation of the river runoff,uses the hydrometric observations only,without looking for any correlation or reason of them in the remaining other factors of the runoff.

A distinction must be made between the magnitude of the runoff,-- the normal,the maximum and minimum water quantities.

The steering of the processes of Nature(including the river runoffs also) is only possible when the required relations are known which are conditioning the processes. Only at such a case(p.42) is a scientific provision possible. This is where our forces must be directed to and this is the kind of method which must be used in the research of Nature's phenomena.

3. THE ESSENCE OF GENETIC ANALYSIS, METHODICAL BASIS AND DEVELOPMENT OF THE GENETIC METHOD FOR THE INVESTIGATION OF THE RIVER RUNOFF.

What is the essence of the genetic method of investigation?

Under the concept of genetic method one must understand the method which takes the task of studying and utilizing in its investigations the existing relations between the formative factors and the phenomena of runoffs and the task of detecting the laws, the origin and the development of the water regime.

The genetic method, contrary to the formal statistical method, is surveying Nature not as a chance-wise accumulated mass of objects and phenomena, torn out of connection with each other, but as phenomena which are associated, which depend upon each other and are in continuous change.

By this position, the river runoff cannot be considered as an isolated phenomenon, torn away from the factors which are influencing its shaping directly or indirectly.

The factors which take part in the formation of the runoff may be divided into two groups:- into constantly acting and slowly chaning such as the physico-geographical, pedological, geological, etc. conditions,-- and variable factors such as are the climatic factors. The latter factors to which belong the precipitations, temperature, and evaporation are unstable; they quickly change and also cyclically. They are the main factors of the runoff. the remaining physico-geograohical factors are only interrupting, one way or another, the main factors. By using the meteorological and hydrological predictions, science may disclose the relationship and may establish the correlation between the separate simpler phenomena. The meteorological phenomena, however variable they may be, are all again subordinated to some laws, and they do not run indiscriminately in Nature. However, these phenomena must be studied, and the relationship must be established between them and the runoff. Thus, the dialectic materialism is surveying things, and, by being guided by it, the genetic method must consider the phenomena at the investigation of the river runoff by the same method.

It should be remarked that at the hydrological investigations of runoff the various characteristics of a future runoff are of no interest. In other words, we must provide for the runoff of a given river, but not through the assurance according to my opinion.

How and by what method would this become possible? What data and what type of relations are we using in this investigation?

The data of the observations on the runoff, the rainfalls, the temperature, and so on, do not give a possible basis that, by means of the existing dependences and relationships between them, we could start out from the past for the provision for future phenomena. They do not make it possible that we could calculate the average monthly and the average yearly values, the variation of the annual (p.43) runoff, its dynamics or, transferred upon graphs, to track down its changes in the course of a given period. The elements of the runoff are originated in different ways and by different factors.

The computation of maximum waters should have been based upon the basis of their (technical) genesis since all those factors are used which condition them. Here, the qualitative aspect of the phenomena has an influence upon the quantitative side. It is not indifferent in what way and how the maximum waters originate, which the formalistic statistical method is unable to detect or solve.

Nature and the river runoff cannot be considered as a status of rest and immobility, of standstill and invariability; they must be regarded as the status of direct movement and change (STALIN). The method and the staging cannot be correct when some natural phenomena are assumed to happen by chance. The river runoff is formed by definite factors. It depends not only upon the precipitation fallen in the year but also upon the amount and volume (size) of the underground runoff and upon a number of still other factors.

The attempts at making the examination of the river runoff from the equation of the balance of waters are correct and the only successful method, since the the water balance includes the whole cycle of phenomena which comprise the processes of forming the river runoff.

Thus, according to V.P.VALESYAN, on the basis of the regularity (under analysis) of the distribution of the components of the water balance in general and of

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their factors in particular, it was determined that almost all factors which influence the runoff, and especially the amount of precipitations, the temperature of the air, the strength and the direction of the wind, the atmospheric pressure, the solar radiation and others, and even the human water economical actions, are related to the altitude above sea-level of the place. The disposition of the main mountain peaks, crests and the remaining forms of the relief and their direction, the absolute and relative altitude above sealevel of the separate riparial drainage areas influence in a definite way the distribution of precipitations and evaporation, and thereby also the runoff.

What relations exist between the different factors and elements and how do they influence the river runoff?

Here, we will discuss some of them. Thus, e.g., there is a relation between the temperature and the altitude above sea-level, between the altitude above sea-level and the precipitations. There exists a relationship between the temperature and the deficit of humidity, and hence also the evaporation.

On the precipitation--rain or snow--the temperature has an influence where the rain or the snow, fallen upon a terrain, makes the amount of runoff different or slows down its formation. The influence of the temperature on precipitation turns out to be also an influence upon the runoff. The direction and strength of the wind exercises an influence upon the formation of precipitations, upon the evaporation, &c.

The brusque change in the conditions of the runoff also comes when there is change in the temperature of the air and of the ground at its transition through freezing degrees in the fall and in the spring, and also in winter time at the freezing of the rivers, freezing of the ground, etc.

(p.44) With rivers of the mountain type which are fed from glaciers or from large snow covers, the course of temperature has great influence upon the formation of the runoff. Our high-mountainous rivers have different course lines in comparison with those of the plains. Their maximum significance is seen in the summer months.

One of the components of the equation of the balance of waters is the summary evaporation. The evaporation of a given territory depends upon many factors.

Especially important factor which influences the process of runoff is the deficit of humidity which determines the evaporation, and itself is dependent upon the temperature.

That is why the basic climatic factors which influence runoff are the precipitations, the temperature, and the evaporation.

These as well as a number of other correlations between the climatological elements and the runoff are in strict regularity and cyclicity(periodicity) and they must be kept in view at the investigation of the runoff.

As an example we may give the researches of A.V. OGIEVSKI who gives a number of graphs on the relationship of runoff, precipitation, and evaporation when he uses the equation of the balance of waters. He(in his book: Hydrology of the Land, 1951, Sel'khozgiz) gives three basic characteristics between these events:

1) Direct ratio between runoff and precipitation and the almost constant small change in the value of evaporation.

2) Markedly expressed relation between evaporation and precipitation, with a small dependence upon precipitation for the runoff(River Oka)

3) Rather sharply expressed relationship between precipitations and both runoff and evaporation(River Elba).

A basic relationship and regularity between the climatic elements and is also the relation between the runoff and a number of physico-geographical factors.

The size, the form, and the direction of the drainage area exercise a considerably large influence upon the volume of runoff and its distribution; especially large is this influence upon the formation of flood wave.

However, the larger the surface area of the drainage region is, the smaller is the likelihood to have precipitations falling all over the entire region, or to have an occurrence of simultaneous melting of the snows. Otherwise the snow melting is possible since it is in relation with the temperature and the altitude above sea-level, and in altitudinally homogenous drainage areas it is more probable to have a large front fo snow-melt. These influences reflect upon the formation of high waters which are causing catastrophes. With the heavy rains for high waters, the intensity of precipitation is of importance; at the melting of the snow covers -- the temperature and the hot currents of air are decisive.

The relief of the terrain has also in influence upon the dynamics of the dynamics of the runoff.The steeper is the drainage area and the greater is the slope of the river bed,the higher is the speed of the flow-off and the smaller is (the shorter is) the time of the runoff.Influence is also exercised by the ground and the plant cover.

(p.45)The relief however also has another significance.It influences the distribution of precipitations since the peaks are driving the air masses to rise to different directions.

The forestation,which represents a surface of great roughness,retains the water,reduces the passage of the surface runoff,enlarges the seepage and therewith it reduces the time of the flow-off.The forestation(if it consists of tall trees) also influences the microclimate.It causes ascendant air currents;it retains the moisture-carrying currents,and it helps the falling of the precipitations.

The plant cover,in the process of its vegetative life, is consuming much water from the ground,and at the same time it exhales as much water into the atmosphere.

The ground and the plant cover influence the distribution of the runoff, of the surface and the underground runoffs which again in their turn will influence the correlation between the high waters in the spring and the average summer runoff of the rivers. The forestation reduces the average annual runoff to a considerable degree.

In this way,the influence of forestation is also different:- some factors which have influence upon the feeding of the rivers have a positive,and others a negative effect.Forestation also exercises an influence upon snow melting,and hence also upon the surface runoff.The runoff is also influenced by lakes, swamps and glaciers.

The subterranean feeding of the rivers is in close relationship with the density of the river network.It is in dependence upon the relief,the precipitations, the ground,and the forestation.The larger a portion of the precipitations reaches the river bed through the underground runoff;the smaller are the surface water runs &c.

MAN with his action at changing Nature is also changing the surface area of the drainage regions,and hence the course and the flow-off of the runoff.He acts upon the natural runoff in the bed of the river when he constructs a number of structures,dams,and other measures to regulate the runoff.He changes the plant cover,the area of forestation,and the swamps, the composition of the ground,the character of the surface runoff,as well as the direction and way of the runoff. Hence,the significance which the action of MAN has as a factor conditioning the river runoff is evident.

Until now,we pointed out those complicate settings and the complexity of the phenomena at the formation of the river runoff,the diversity of the factors, their action and the existing relations between them.Only with complex surveying of these actions in toto would we have a complete,scientifically grounded research of the runoff.

In its researches,the genetic method starts out from the circumstantially basic study and elaboration of the regularities existing between the phenomena of Nature.But these regularities must be studied in detail.The actions of the basic factors must be studied between which the regularities exist.This is the direction in which the eyes of the hydrologists must be turned when they are studying the phenomena of the runoff with the aid of the genetic method.

In support of the method of genetic analysis,the opinion of a number of Soviet hydrologists should be cited such as: D.L.SOKOLOVSKI,(p.46) who maintains that " the fluctuation of both the maximum and minimum annual runoffs in accordance with the weather may be considered as by chance, i.e., as a basis of the operating factors which are so much changing with the weather(whose law of fluctuation with the weather is not accurately known at this moment) that their combined action and obtained regularities can be studied by the method of probability at a given phase of the development of hydrological science.However,these values,as well as the values of the maximum and minimum waters to some extent, do not appear chancy since they are strictly based upon complex physico-geographical conditions. The mutual relation and the mutual reason of the latter must be studied by the genetical method,and the apparatus of mathematical statistics must be used to such extent as it is necessary to use in the elaboration of the observed data."

" This way,the methods of probability and the statistical methods are as auxiliary methods in studying the change of the runoff in accordance with the weather.The basic method for the research of the runoff as a magnitude,however,

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in strict dependence upon the elements of the geographical landscape, is the dialectical method of learning the mutual relationship and the mutual dependence between the phenomena"(River Flo,p.116,1952).

And furthermore:"The simplicity and the standard character of the methods of statistical calculations-- sufficient for all engineering-- will in many specialists create the false impression of the supremacy of these methods,the false idea that they are independent methods of research, and hence also their fetishisation and the giving an imperfect account of the substance of the phenomena." * (FOOTNOTE:D.L.SOKOLOVSKI: On the genetical and statistical methods in hydrology. Izv.AN.SSSR, Sect.Techn.Sc., No.5,1952).

A.V.OGIEVSKI thinks:" ..that the method of mathematical statistics must undoubtedly serve as one of the means in the procedure of hydrological investigations,but the substance of the problem on river runoff must be investigated upon a genetical basis".**(FOOTNOTE: A.V.OGIEVSKI: On the application of the statistical and genetical methods in Hydrology.Ibid., No.1, 1952).

And indeed, If the genetic analysis is not confirmed by the corresponding elaboration of the actual data,it may become scholastic,but the statistical elaboration,finished without a genetical analysis, may become formal and is such a one.

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In the discussion that occurred at the Technical Department of the Academy of Sciences in the USSR on the distribution and the development of Soviet hydrology,the scheme of A.D.SAVARENSKI was put to scrutiny. It represents,as we had also mentioned earlier, a study of the river runoff on the basis of the equation of the balance of waters, by dividing the drainage regions into zones with determination of the underground,surface--ravine and river runoff, and also it thus examines the (p.47) supply feeding of the runoff,the transient and underground flowing waters of the surface level. This scheme investigates the process of runoff so as it is formed and as it comes to life. N.A.KOSOLAMOVA thinks that this scheme investigates in a most general case the study of the runoff,but it is not deprived of a methodical basis and that in Nature one also meets with a great variety of different types of drainage regions.

In hydrological respect, the proficiency of the drainage areas is different.

There are well-investigated drainage areas where the genetical analysis may be used, but there are also such which are not studied in any direction. N.A.KOSOLAMOVA PRO- poses that a number of typical schemes should be elaborated by the genetical meth- od which may serve as instructions in further investigation carried out on the phe- nomena, etc. Each of the drainage areas consists of slopes, and she thinks that the slope represents the combination of different characteristics for the homogeneous conditions of the microclimate in the valley.

This way the so determined conditions for the slopes may be united in groups and the investigation may be completed on their basis.

Others of the participants of the discussions, as S.N. KRICKI and M.F.MEN- KEL think that the scheme of A.D.SAVARENSKI is practically unfeasibile, when they write:" How could be practically determined the relationship and the elements of the water balance of a given drainage area? How could be measured and computed the entry and the division of the water into surface and underground pathways, the evap- oration from the ground, the transpiration from the vegetation, etc.? How could these tasks be solved at partition of the drainage area not by the water divide but by arbitrary lines limiting "landscape zones" and "typical slopes"? How will be estab- lished the distribution of the underground level of water? how will be broken up the drainage area into vertical zones? and how will be determined the exchange of moisture between them?"

In the discussion, opinions were pronounced about the coexistence of the statistical method and the genetic method, and about the impossibility of their op- position. A number of participants, however, as A.V.OGIEVSKI, D.L.SOKOLOVSKI, V.P. VALESYAN, N.F.AVERYANOV, A.D.SAVARENSKI, N.A.KOSOLAMOVA, spoke against the possibil- ity of such a coexistence.

In conclusion, on the basis of the above exposed facts, we can say that there are essential differences at hand between the two methods, and that on this account it is not even possible to think of their joint utilization. Another matter is the problem of using mathematical statistics at the elaboration of the data of the ge- netic method. This is possible and urgent, and in this sense a number of hydrologists have spoken.

It must be also added that hitherto the formal statistical method has acqui- red large spread in the practice due to the fact that it only uses the data of the phenomena concerning the runoff of the past and that therefore the required data are not available in reference to the factors which influence the formation of the runoff, the genetical method which (p. 48) requires the elaboration of a number of relationships and dependences between the factors that condition the runoff is more difficult to use in practice.

Our rivers and river basins have not been sufficiently studied. Beside the known data on the water stand and the water amounts of the hydrometrical net of our rivers and the precipitations, we do not have at our disposal almost no other additionally elaborated data of the elements of runoff. In our studies we widely use the formulas and the methods of the Soviet scientific hydrologists. These formulas, however, are in reference to the Soviet Union, and they must be tested with the data of our conditions.

In the planning organizations, the method of mathematical statistics is used for the drainage areas and hydrometric stations where we have observations for at least a slightly more protracted period of time as the observations are subjected to critical estimation of their certainty. Observations on the water stands and water amounts of our rivers are in existence for periods of 15-20 years.

Along with the method of mathematical statistics, the planning organizations also use the balance method ("Energo-hydro-Project), for which longer observations are necessary. It gives a certain consistency and characteristic of runoff, when it uses the course graph and total graph of the course graphs for a longer period, but it also has quite a number of defects.

At the investigation of runoff for small rivers and river basins which have not been studied, and on which sufficient number of observations on the runoff are not available, our planning organizations use the Soviet formulas, without verifying a number of coefficients in the formulas whose values may be different under our conditions. In such a case, in our planning organizations a number of dependences are looked for, without being able to elaborate them in detail, since we do not have a series of observations on the different factors of the runoff.

At the study of the regime of our rivers for planning of structures where the observations are of 5-10 years' period, our research departments are endeavouring, through prolongation of the number of observations, through analogy and correlation, to use the method of mathematical statistics.

The genetical method has slight application in our country for the reason that the factors between which relation exists have not been studied or not sufficiently well studied, and that the problem of studying of the physico-geographical, climatical, geological, and other factors has not been put upon the required level and with the required seriousness before the scientific research institutions.

In the Hydro-Meteorological Service, only the precipitational amounts are recorded, as well as the temperature of the air, the strength and the direction of the winds, the absolute and relative humidity of the air, the thickness of the snow coat, etc. The compactness of the snow is not measured, neither are the number of correlations followed up between the snow coat and the rest of the factors. The front and the rear area of snow melting is not studied, the relations between the compactness, thickness, radiational property, albedo -- heat conduction and evaporation of the snow, between the intensity of snow melting and the temperature are not studied and not investigated.

(p.49) The study of the process of snow melting, under our climatological conditions, represent an enormous study and practical interests not only for the spring time high waters and flood waters, but also for the establishment of the course of the spring time accumulation of the humidity in the ground, so necessary for the rural economy.

At investigating the high water of heavy rain, the intensity of the rain must be known. Neither the Hydro-Meteorological Service (HMS) nor the rest of the scientific research institutions studied and investigated with sufficient profoundness the relations between the length and the intensity of heavy rains, between the length the intensity and the area irrigated by the rain for small drainage areas. The self-recording pluviometers have been not sufficiently well placed, especially in the mountainous districts, to make it possible to follow the course of the rain, its intensity and strength.

At the investigation of the average yearly or of the yearly runoff, in addition, data are necessary on the precipitations and the evaporation, too. The HMS and the rest of the scientific research institutions do not have sufficientobservations at their disposal on the deficit in the humidity of the air; they do not have direct observations of the evaporating surface of the water and land, located in the drainage areas. Data of a number of studies such as those of B.V.POLYAKOV and P.S.KUZIN on the computation of evaporation have not been determined nor investigated for our conditions. The retaining power of the mountains in respect of the surface runoff, the absorption and the filtration(seepage) has not been studied. We do not have sufficient data on the investigation of the underground waters, their formation, their volume, etc.

Conclusions.

When we start out from the methodological deficiencies and the formalism of the statistical method, of their metaphysical position at the computation of the value of the runoff and of the requirements of our water engineering construction enterprise, we have to make the following conclusions:

1. At solving the problem of the river runoff, of the average annual water amount for maximum and minimum waters, it is not necessary that the method of mathematical statistics and the curve of assurance be used as the single scientific method, but as an auxiliary supplemental aid to the genetical method.

2. The curve of assurance may be used for the calculation of the fluctuation of the runoff, but in the upper and lower ends it gives unreliable results which often times may be misleading.

3. The construction of the curve of assurance is on the basis of ungrounded assumptions between the relationship of C_s to C_v.

4. Our efforts at examining the river runoff must be combined with the method of genetical analysis(as the data of hydrometrical observations are used with corresponding statistical elaboration), with (p.50) the studying of the factors, their influence and the relations between them, with the research and consideration of the hydrological phenomena.

5. Closer collaboration is necessary between hydrologists and water engineers, meteorologists, hydrogeologists, pedologists, and geographers who jointly should solve a number of problems, should look for and detect the basic relations between runoff and its factors, should systematize them and use them at the investigation of the dynamics of the river runoff.

6. A scientific foundation and harmony is necessary between the hydrological and the meteorological networks as well as to widen the network of the evaporating surfaces of water and land.

(p.51) Engineer I.MARICHOV:

SCIENTIFIC FOUNDATION OF THE NETWORK OF HYDROMETRIC STATIONS IN THE PEOPLE'S REPUBLIC OF BULGARIA.

Preface

In the present work, the entire problem of the hydrometrical network is examined the first time, and a proposition is made as to the number and the distribution of the network of hydrometric stations over the entire territory of the People's Republic of Bulgaria.

At the composition of this project for the hydrometric network, only the most basic elements are taken into consideration which influence the runoff, since it is absolutely impossible to pay attention to all factors which are taking part in its formation, while their great number is well known, and especially those very diverse combinations which are met with in Nature among them, and hence the great diversity comes in the shaping of the runoff.

The main principle at the compilation of the project for the network of hydrometric stations is:- with a minimum number of stations to fully cover the hydrological characteristics of the entire country.

Thus, the composition of the project only represents a general scheme which must be worked out in detail locally both in reference to the closure and the removal(transfer) of the existing stations as well as in reference to the opening of new stations.

Therein, the problem is investigated about the supporting hydrometrical network only, while it does not exclude the possibility of the existence of a special network of hydrometrical stations which could be opened mainly for the needs of the different jurisdictions and could have a rather temporary character.

To this special network many of the stations which are proposed to be closed and transferred whouls be passed over.

In this respect, the task of the work is chiefly to removed all admitted errors at the creation of the existing network of hydrometric stations which were chiefly due to the chancy and ungrounded opening of many stations, and to give a possibility for creating a network which will be in condition to give data adequately for a complete and total elucidation of the hydrological regime of the country.

At the analysis of the solution of this charged task, especially valuable help was rendered by the specialists of the review "Hydrology" (p.52) of the Institute and of the review "Networks" of the Service; they are engineer Rangle MINCHEV, engineer Kiril TODOROV, engineer Stefan STEFANOV, engineer Aleksandr PETKOV, engineer Gancho STOJANOV, Trifon STANEV, and station technician Vladimir GIDIKOV to whom we express our sincere thanks.

INTRODUCTION

Water is an enormously vital factor of Earth. It has been always playing an important role in the life of Man. Originally, with the primitive mode of life, water was at the service to satisfy his elementary needs. But later, with the development of technics and with the progress of culture, its use as a factor which is creating welfare had been steadily improved. And today, with the high development of the water engineering construction enterprise, in almost all of the more advanced countries we find an endeavour at the most wide-spread utilization of the waters for water supply, irrigation, for production of electric energy, for water transportation, etc. In the past, for all types of water usage--energy production, irrigating, water supplying, etc., separate water engineering structures were constructed while today of particularly great importance is the complex utilization of the water resources which makes the maximum effect for national economy since, at the given investment of capital, more than a few water economical tasks have been solved.

In our country the problem of the complex utilization of waters for ameliorative, energy productive, water providing, industrial and for other economic goals was set up at its total range after 9 Sept. 1944 only. The reconstruction of our water economy takes one of the important places in the general plan of the quickly developing socialistic construction, since for the latter the water resources of the country are widely and in many ways utilized. The development of the water economy of our country imposes enormous requirements in respect to the hydrological materials needed for the planning of the new water engineering measures as well as for a rational exploitation of the erected structures.

Without a good hydrological foundation, however, even with technically very well elaborated projects, unsatisfactory economical effects can be reached. An erected structure may happen to stay for a number of years without water, or it may not be fully able to fulfill the functions wor which it had been designated, and these structures are frequently destroyed, chiefly for the circumstance that the catastrophal waters had been incorrectly computed. All this indicates the extreme importance of the hydrological researches for the total construction of the waters ever a given territory.

The main water sources which Man endeavours to utilize are in the first place the rivers, and then the underground waters and the lakes. It is characteristic for them that in their uninterrupted course they show fluctuations, in some cases at sufficiently large amplitudes the limits of which can be determined after systematic observations over years-long periods(usually 25-35 years), called a n o r m a l . Only the observations throughout such a cycle can give a clear idea(p.53) about the variation and fluctuation in the runoff of a given water source through the different seasons of the year, and in the different periods of the year. Therewith, together with the examination of other elements of the water source, too, (turbulence, icing phenomena, etc.) its regime is determined.

In hydrology, the conclusions are based above all upon the statistical data about the hydrological elements. Lately, the Soviet scientific hydrologists cleverly began to combine the genetical research of the phenomena of runoff with the statistical elaboration, when they have been using widely the physico-geographical means and the profound mathematical analysis.

For the correct and purposeful construction of the water resources, complete and serious hydrological investigations are necessary.

Through the complex study of the elements of the runoff and of the factors which condition it, the complete characterization of a water source can be made, and a given water engineering structure can be also planned and constructed upon a sound basis.

That is why the water sources as a national treasure are the object of basic and systematic studies for many years which are accomplished almost everywhere by the State. These studies over a given territory or State are made through creating a network of hydrometrical stations. The site and the number of these stations is so determined that, with the data from them, it is possible to get the full hydrological characteristics of the river regime.

This network of hydrometric stations over the given territory must be spread out in such a way that from the hydrological and meteorological elements, observed at the different stations, the hydrological characteristics can be determined with sufficient accuracy.

The hydrometric stations must be spread out in such a way that they give the possibility to study the regime of the chief river at its upper,middle and lower course,and in addition to this to characterize also the regimes of the tributaries and their influence upon the main river.

The number of the hydrometric stations must be as small as possible,yet it should be adequate for obtaining the full characteristics of the regime of the river at its different sections.Therefore,at the distribution of the stations along the course of the river,both the increase of the drainage area and the variation of the physico-geographical and meteorological factors must be taken into consideration.

The distribution of the hydrometric network over a given territory is a complicated task,and it may be correctly solved only on the basis of profound and many-sided studies of the hydrological peculiarities of both the different water structures and the entire territory over which its establishment is organized. The hydrometric stations and posts,by their destination, are divided into supporting and special ones. The network of the supporting hydrometric stations over a given territory must be so distributed that with the data on meteorological and hydrological elements, observed at these stations, the complete and total hydrological characteristics can be given for the entire territory.

(p.54) The special hydrometric stations are opened for the needs of the jurisdiction or organization whose more specially arising needs cannot be staisfied with the general data of the supporting network.They have a limited period of activity.

The object of the present reasoning is particularly the supporting network of hydrometric stations.

At the distribution of the supporting hydrometric stations and posts the following must be taken into consideration:

1) The variability of the hydrological and meteorological elements in dependence upon the physico-geographical characteristics of the territory,as well as the homogeneity of the natural conditions of the geographical environment as a whole.

2) The representability of the observations in the station, i.e., do they express the characteristic peculiarities of the given district?

3) The degree of accuracy by which the hydrometric elements and the phenomena are determined in correspondence with the requirements of science,of national

economy, and the national defense.

4) The plan for the construction of the water engineering measures and

5) Economizing(thrifty) structures at otherwise equal conditions.

Each hydrometric station, though all these conditions are being observed at their erection, presents itself in the course of time(with the appearance of new needs and greater requirements as well as with the construction of many water engineering structures which have a repercussion upon the natural regime of the river system) to become exposed to re-appraisal(criticism) as the new conditions are taken into consideration.

Such a foundation of the hydrometric network in our country prevails also for the reason that the entire appraisal had not been done, and while provision has been made to do it in phases, chiefly for the needs of the different jurisdictions, there will surely be lacks or deviations in it in one way or another. Such a foundation also prevails for the reason that many meteorological and hydrological elements which condition the distribution of the network have been already elaborated for a longer period.

The problem of the scientific foundation of the hydrological network is sufficiently important and serious. Its correct solution is of profound importance to our national economy. The first attempt at reorganizing the network had been done in 1950. This reorganization was exclusively only on the basis of the peculiarities of physico-geographical character. It is clear that such a foundation is not enough. It is not a whole, since it is not in conformity with the remaining hydro-meteorological elements upon which the distribution of the network depends. That is why such a foundation is prevailing, with the purpose to include in it the prerequisites which are more or less taking a part in the correct solution of this problem, and which are consequently influencing the accuracy of the collected hydrological data. For this reason it will be urgent to open eventually new stations as well as to transfer and to close existing stations. At the transfer and at the closure of the existing stations, of particular interest is the period of observations and the quality of the data at these stations, wherefore it is necessary to delay briefly at the development of the hydrometric network in our country.

(p. 55) The first recorded water stands in our country are dating from the year 1876, with the unusual observation of the Marica river, a fact which was recorded on the side of the church "Prosperity of the Holy Mother of Christ" at the town of Pazardzhik.

The oldest water reading was started in 1901 at the Black Sea, and later, in 1905, such stations were also opened for the Marica river which in 1911 have reached eleven in number.

Generally, the period before 1920 is characterized by the fact that the hydrological network was created by accident, and no scientific engineering basis had been available. Only in 1920, with the bringing of the Law on the Water Syndicates, was hydrography mentioned since the problem of opening water measuring posts and of collecting the data was also settled. In spite of this, before 1924 the work went along the same way. In this period, 62 stations were created, yet no useable data were at hand.

Only in 1924, under the editorship of the late engineer Boris ANGELOV, the first yearbook for hydrological observations had been published.

The yearbooks were printed in the subsequent two years, too, -- in 1925 and 1926, and then their publication was discontinued. In these yearbooks, the water stands were published only, and there were no data on the measured water amounts. In the period from 1906 to 1935, the Department for Waters had probably at its disposal a Voltman Voltman screw also, but from the preserved records it seems that a few measurements were only made of the Marica river at Plovdiv and Pazardzhik, and of the Tundzha river at Koprinka.

With the development and the strengthening of the water syndicates, the need of more complete hydrological data became acute, due to which in 1935 new Voltman crews were brought in, and from then on, the systematic measurement of water amounts has started.

Generally, the data from 1935 on till now are considered as useable hydrological data.

In a brief summary, the hydrological network developed before 1949 in the same vein, as the stations increased in number as follows:

TABLE 1: LEGEND: a) year, b) number of stations.
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At the end of 1949 there were 259 hydrological stations open; of these, 20 were wells for the study of the underground waters, and 8 were posts at the Black Sea and at certain lakes.

The huge water engineering construction after 9 September 1944,and particularly after 1947, in reference to the two-year and to the five-year national economic plans, required more accurate and more complete hydrological data for water economical investigations both at the planning and at the exploitation of the already erected objects,too. The data of the hitherto opened stations could not staisfy these enormous needs of the practice.The most enormous weakness of the network(p.56)created before 1949 consisted in the distribution of the stations. They were opened capriciously in more than one cases. A leading start has been that they should be near railroad lines or near other arteries of communication so that they could be easily serviced by the teams created for the measuring of the water amounts.Therewith,a great number of stations was explained(in relation with the network of that time) for the river Marica and for its tributaries.On the other hand,at that time,it was the goal to chiefly satisfy the needs of the water syndicates of irrigation for data, but not the needs for energy production or for water supply,etc.,too. At the opening of the stations, the most suitable site was not always selected, which led to the transfer of the same station repeatedly. Thus,e.g., the station of the river Cibyr,at the village of D.Cibyr,was transferred four times,that of the Luda Yana at Sbor four times, that of the river Iskyr at Kurilo three times, the station at Nastan three times, and so on. The variabilities of the water amounts at the stations are small in number for years(mostly 1-2), and they are chiefly produced at low and middle stands of the water. As an exception, different individual measurements of moderately high and high waters are met with.

All these defects resulted in the condition that when our practice required hydrological data from the Hydro-Meteorological Service, the data were accompanied by many restrictions such as:" for flood waters the key curve is for orientation only" ; "above so many cubic meters the water amounts are computed"; "the station is local for the period",etc.

All this urged in 1949-50 to put hydrology upon its feet as soon as possible. The arrival of the Soviet specialist hydrologist engineer ELISEEV had also made matters easier in this respect. With his active aid,the deficiencies of the network of that time had been investigated,and proposals had been made for the closure of certain stations and for the opening of some new ones. As a result of this, in 1950, 38 stations have been closed, and 44 new stations opened due to which the number of the stations has been raised to 265 in 1950. Subsequently, as seen from Table 1, the number of the stations until this year was increased by 17 places. Moreover, in one section of the network, the observation of other hydrological elements such as turbulence, chemical analysis and others has been also introduced.

By estimating the importance of the hydrometric data for our socialistic economy, the Central Committee of the Bulgarian Communist Party and the Cabinet Council came out in 1950 with a special arrangement for the unification of the Hydrological Service of the Ministry of Electrification, and of the Meteorological Institute of the Ministry of Agriculture in a single Hydro-Meteorological Service. Thereby, the beginning of a new phase in the development of hydrology and meteorology was established in our country. Regional services of the Hydro-Meteorological Service (HMS) had been also created. Each region is divided into sections each with 2-3 stations where at least two people are working on the collection of hydrological data, besides the voluntary observers of the water stands. A large number of devices were imported from abroad for the measurement of the hydrological elements, and made in our country, many instructions and guide books were written on the measurement of the different hydro-meteorological elements. A larger number of flood waters (p. 57) were subjected to measurements by which the extrapolation of the key curves was improved. From the data collected for periods of 15 years, certain hydrological elements such as the modulus of the runoff (M_0), the coefficient of runoff (α), the coefficient of variance (C_v), and others have been already elaborated. A taring station was made for taring of the hydrometric screws. Almost all stations have been provided with equipment for measurement of the flood waters. Some courses were carried through for instruction of the technical personnel that does the measurement at the stations. The first runoff landing areas have been created in our country for the investigation of the runoff, etc.

This is then briefly the development of the hydrological network in our country up to the present year.

At the present time, the hydrological network consists of 292 hydrometric stations which are divided into two categories:- supporting and special stations. The supporting network which is composed of 282 hydrometric stations has its main mission to elucidate the entire hydrological regime of the country. The remaining ten stations are special, i.e., stations opened temporarily for the needs of other jurisdictions. The period of observations in the stations of the supporting network is very different which is evident from Table 2.

TABLE 2: LEGENDS: a) period of observation in years; b) posts; c) number of stations; d) water amounts; e) chemical analysis; f) floating drifts.

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From Table 2 it is seen that the larger portion of the stations have a period of observation from 1 to 5 years. Only 60 stations have a period of observation more than for 15 years.

Along with the observations of the water stand, of the temperature of the water, and with the measuring of the water amounts, at 85 stations chemical analysis of the water is also performed, and at 103 stations the turbidity is measured.

The distribution of the stations over the entire territory of the country is given in Chart I in the Annex wherefrom it can be clearly seen that there are districts in which an extraordinary large number of stations has accumulated, chiefly in the higher sections, e.g., in Petrokhan where there are 9 stations for a homogeneous area of 50 square kilometers; in the upper course of the Marica river, Ibur river and others, stations are found at distances from 3 to 5 Km without additional tributary waters, and so on, and at other places there are rivers of which no observations are made in general, as at the river Little Lom, at some of the contributaries of the Marica river, at some rivers which flow directly into the Black Sea, etc.

The water engineering structures built in the last few years -- water electrical centrals, water reservoirs, dams, (p. 58), etc., disturbed and destroyed the regime of many rivers, due to which a large number of stations are either incorrectly giving the regime of the rivers, or they are purposeless in general. Such is the case with the stations of the river Lom at the village of Upper Lom, of the river Rusha at the village of G. Village, of the river Vidima at the village of Vidima, where the regime is disturbed by the erected centrals, of the river Iskur at Resedec -- disturbed by the water reservoir of the irrigation system, etc.

On the distribution of the network it had been also of an influence to a large extent to which jurisdiction the hydrological service belonged. Thus, e.g., while the Hydrological Service had been with the Ministry of Agriculture, the hydrometric stations opened chiefly in the flatland areas in regard to the needs of the water syndicates, and after it has been transferred to the Ministry of Electrification, the network has been widened in the high-mountainous regions--(chielfy)chiefly for the needs of energy production.

Moreover, the charts compiled with isolines for 15-year period for a few hydrological elements such as the modulus of the runoff(M_0),the coefficient of runoff(α) the coefficients of variance(C_v) and of asymmetry (C_s) as well as with the finished studies at the elaboration of the charts with isolines for the turbidity and chemical analysis have indicated that lacks,i.e.,weakly covered areas, are met with at many places.

All this urges to make a basic appraisal of the hydrometric network,as the foundation of each station is given,as well as the proposal is made for the opening and closing of some stations in regard to securing the complete hydrological characteristics of all hydrological elements for the future.

At the present layout, the following more important elements ,which determine the number and the distribution of hydrometrical stations, are yaken into consideration:

I. Peculiarities of the drainage basin in physico-geographical respect.

a) vegetal cover of the drainage area,

b) declivity of the drainage area,

c) forestry cover of the drainage area,

d) pedo-geological structure of the drainage area.

II. The needs for hydrological data in the construction, national economy, and the national defense:

a) the constructed water engineering structures and their exploitation,

b) a perspectival plan of the ~~gb~~ water engineering construction.

III. The variability of the observed hydrological and meteorological elements.

a) precipitations,

b) temperature,

c) modulus of runoff,

d) coefficient of runoff and the coefficient of variance.

Beside these elements,at the recommendations for either a transfer or a closure of an existing station, the period of observation of the hydrological elements is also taken into consideration.

(p.59) In this order the influence of the different elements is investigated upon the distribution of the network of hydrometric stations in our country.

I.PECULIARITIES OF THE DRAINAGE BASINS IN PHYSICO-GEOGRAPHICAL RESPECT.

One of the most important factors which condition the number and the site of the hydrometric stations is the homogeneity of the natural circumstances in the territory over which such a network will be spread. The more heterogeneous is a given geographical environment in regard to the elements that influence the runoff, the larger must be the number of the hydrometric stations.They must be so ditributed that with the data which they collect it should be possible to give the complete hydrological characteristics of the river flow as well as these data should serve as analogues for those rivers at which such stations have not been opened. For this purpose it is necessary that the stations be distributed in proportion to the growth of the area of the drainage basin,and this should be done so that all the most characteristic changes are embraced such as the slope,the forest cover,the density of the river network,and the geological structure of the drainage basin.All these elements show the most different influence at the formation of the river runoff,Thus, for instance,with the increase of the slope of the drainage basin,the time of running off of the fallen precipitation to the river bed is reduced. Contrary to this, with the increase of the forest coverage the running off of the fallen precipitations to the river bed is delayed by which the possibilities for the seepage of the water into the ground are also increased and the subterraneab storage of the river flow is assured. The latter is also in proportion with the geological structure of the drainage basin.The combined influence of all these elements is best expressed in the density of the river network.

For the correct distribution of the hydrometric network in the country it is necessary to examine how the influence of each of these elements is separately provided.

THE VEGETAL COVER OF THE DRAINAGE BASIN.

If we throw a glance upon the map of the hydrometric network (7)(see the map in the Annex of the original text) and upon the diagrams on the vegetation of the drainage basins(6),it can be seen that there is a distinct grouping of the rivers at some sections, and also that there are larger districts which are not distinguished in this respect.

THE RIVER BASIN OF THE RIVER STRUMA.- In regard to the vegetal cover of the drainage area of the Struma river,the hydrometric stations,taken generally, are well distributed. Even the more important tributaries on both sides of the river are covered. Independently from this, however, it may be said that there are also superfluous stations such as the station for the river Glogoshka whose drainage area is entirely too small and its character is very close to that of the rivers Nevoselska and Bistrica; the station for the river Bistrica which is under the reservoir of the water supply of the town of St.Dimitrov and its data are compromised; the station of the river Sushichka whose drainage area is very small and not a representative one. (The same station must be transferred along the course of the river so that it would give the complete characteristics); the station for the river Struma at the town of Pirin which is very near to the station at Kupnik and it is without an especially adequate tributary net; the station of the river Petrovska which has been opened for the needs of the Central only. Along with this, there are districts which have not been elucidated such as:- the district of the river Konska, with a drainage area of about 350 Km^2 which crosses the Breznishke field that is characterised by a small surface runoff; the district of the river Treklyanska which is of a drainage area of about ~~5~~ 510 sq.Km, and with a considerable runoff; the district of the river Struma between the stations Rushdavica, with a drainage area of 2171 sq.Km, and Krupnik, with 6777 sq.Km, due to which it is necessary to open a station directly under the inflow of the river Dzherman. Independently from the made proposals, the impression is gained that the number of the stations, especially on the slopes of the Pirin, is large, yet it is thereby the purpose that the measurement of the modulus of the runoff should be better comprehended, with the increase of the altitude above the sea-level.

For an improvement of the data of the station of the Bistrica river at Gyrlyano, whose regime was destroyed by the Central, a station must be opened for observation of the canal, too. This need arices due to the lack of suitable quarters below the inflow of the canal into the river as well as due to the disturbance of the regime of the river by the many irrigational reservoirs.

RIVER BASIN OF THE RIVER MESTA.- In the river basin of the Mesta river, the stations have the same peculiarities as in the basin of the Struma river. In the high mountainous sections of the basin the number of the stations is relatively larger than expected which is due to the disturbed regime of the runoff in the lower sections of the river and of its tributaries by much water-taking for irrigation. Along with this ,in some districts a superfluous accumulation [redacted] found as those of the river Retizhe, of the river Breznishka, and of the Kornishka river, as well as the three stations of the river Karadzhadere. Because of the uniform character of the drainage areas of the first three rivers, and because of the relatively small vegetal cover of the drainage areas of the river Karadzhadere, the stations of the rivers Retizhe, Kornishka, and that of the Karadzhadere at the village of Zmejca can be eliminated.

On the other hand, there are also less strongly elucidated districts as those of the river Byala, and of the river Draglishtenska for which hydro-meteorological stations must be opened in their lower course. To elucidate the runoff regime of the river Dospat, the opening of a station at its upper course is similarly necessary.

RIVER BASIN OF THE MARICA RIVER.- It is the largest and the most varied basin in physico-geographical respect in our country. Because of this varied character and because of the great importance of the Marica river and of its tributaries for our national economy in regard to improvement and energy production, the first hydrological observations have been started here, and the largest number of hydrometric stations has been opened here the large portion of which originally was special station, and then they were included in the supporting network, without hacing made a more profound estimate of their necessity. (p. 61) Thus, the accumulation of many stations in small drainage areas of uniform terrain can be explained. This is also confirmed by the following stations:- in the upper course of the river, above the station at Raduil, with a drainage area of 97 sq. Km, there are five stations of which three are at the Marica itself. Up to the station at Raduil the drainage area of the Marica is uniform; on this account one of the station pairs could be closed:- stations 232 and 233 for the Marica river, and 234 and 235 for the Ibǎr river. The stations 233 and 234 are proposed for closure. Almost the same is the case with the river Kriva, too, above Sestrimo; for this reason the station 245 can be closed whose data are anyhow very uncertain due to the lack of facilities of observation. In the upper course of the Stara river, at an altitude of about 1900 m, of drainage areas similar in size and character, two stations are in existence (255 and 256) one of which may be closed(No. 256). For the same river, below Belingrad, above its emptying into the Marica, two stations are found (257 and 249) who differ very little in respect of the drainage area, and even the tributary system between them is small, without substantial tributaries. Consequently, one of the stations can be closed, as station 257 is proposed which is anyhow very near to the station in Velingrad. Nothing justifies station 271 for the river Gizdica, a tributary of the Stara river at Peshtera, along whose course there are four stations, three of which have almost equal drainage areas, without any peculiar characteristics.

In the upper course of the tributaries of the river Vycha,-- Shirokolyshka, Tenesdere and Trigradska,--there are three stations with almost identical drainage areas and of homogeneous character, situated over one of the almost similar slopes. One of these stations can be close, as station 276 of the Tenesdere has been proposed. Because of the disturbed regime caused by the water reservoir for the water supply of Plovdiv, and due to the impossibility to transfer the station to above the water reservoir, station 303 of the river Pyrvenecka should be the one to be closed. Another station in the river basin of the Marica which could be closed is 337 of the river Stara at Levskigrad, a tributary of the Strema river. Moreover, with the presence of stations 242, 241, and 243, the station of the river Topolnica at Mukhovo is not justified since the differences in the drainage areas of the stations 242 and 243 are very slight.

Because of the large number of stations in the basin of the river Marica, few are the sections in which the opening of new stations would be necessary. In view of the fact that the vegetal cover of the drainage area must be properly covered it would be necessary to open a new station for the river Marica,--between the stations at Pyrvomai, with a drainage area of 12,722 Kg^2(Km^2?), and Kharmanli, with 19,650 Km^2 as the most suitable parts around the town of Dimitrovgrad. With the present distribution of the stations along the river Vycha a station must be opened for the same river below the influx of the river Shirokolyshka which is in its upper course (of the river). Another more characteristic tributary for which a new station should be opened is the river Biserka which collects the waters of a characteristic channel-crossed region.

(p.62) With such a distribution of the stations, the impression remains that the left portion of the drainage area of the river, exactly from the basin of the river Strema up to the basin of the river Tundzha, is not well elucidated with hydrometric stations. However, in this section all tributaries, with the exception of the river Syutlijka, and this chiefly for its great length, are of almost equal marks, i.e., almost all of them take their origin from the southern slopes of the Middle Mountain:

their waters gather from many small ravins; in the middle and the lower course the fall of the river bed is very small; some of them dry out and stay so through a larger part of the year, and those which do not dry up are of a regime disturbed by the many water takers which are along their course.

RIVER BASIN OF THE ARDA.- Generally speaking, the hydrometric stations in this river basin are well distributed from the point of view of the vegetal cover of the drainage area. Almost all larger tributaries are covered. Proposition for the opening of a new station can be made only for the river Chamdere which gathers its waters from the most eroded parts of the Eastern Rodopi Mountains, and it directly flows into the section above the pool of the future "Kyrdzhali" dam. In return for this, the station 318 at Srednogorci could be closed which is about 10 Km away from the stations at Rudozem and Vekhtino. Moreover, the hitherto recorded data are almost compromised by the constantly changing river bed, due to the materials which are washed up by the mill.

RIVER BED OF THE TUNDZHA.- The drainage area is especially characteristic by its form-- great length and little width, as well as by its very great assymmetry. Almost all tributaries are from the right side of the river. The impression is gained that most of the hydrometric stations of the tributaries are at their more upper courses which is due to the regime disturbed by the numerous water takings, after the rivers enter into the plain section. However, because of the uniform character of the drainage areas of these stations, some of them should be closed; for instance, one of the stations 329 for the river Akdere and 330 for the river Leshnica whose drainage areas are very similar in character. The same is tru also for stations 339 for the river Enina and 340 for the river Myglishka, as it is proposed to close the station of the Enina river. In the middle section of the river are situated the stations 375, 374, and 371 the first of which gives the characteristics of the tributary of the Beleska river, and the remaining two are distributed:- the one above the influence of the tributary, the other below the influence. Consequently, on of the latter two stations is superfluous, and, since station 374 has the longer period of observations, station 371 should be closed more properly. Similarly unjustified is the simultaneous existence of the two stations in the lower course-- 372 and 373 where the vegetal cover of the drainage area from one station to the other is about 180 Km^2. As priority is given to the station with the longer period of observations, it is station 372 which should be closed.

ALONG THE RIVERS FLOWING DIRECTLY INTO THE BLACK SEA ABOVE THE KAMCHIYA RIVER.- The rivers in this section of the country are small and mostly uniform, with the exclusion of those which originate from the Strandzha, (p. 63) due to which fact, with one or two stations the most, their regime can be elucidated. Generally, it may be said that the network of the stations for these rivers is well distributed, as along those which have a more uniform character only one station opened for each river, and along those which take their origin from the Strandzha, two-two stations were opened for each river:- one in their upper course, and one in the lower course. Here, it may be possible eventually to close station 363 of the river Mladezhka, since it is very close to the station 361 for the Veleka river. The river Rusokastrenska remains not well elucidated with hydrometrical stations in this district; the character of its drainage area is very similar to that of the river Sredecka and Aitoska between which it is situated.

RIVER BASIN OF THE KAMCHIYA RIVER.- In this river basin there are altogether 8 hydrometric stations which are sufficient to give the complete hydrological characteristics of the river basin. In the middle course of the Upper Kamchia, and its tributary river Brana, three stations are grouped at near distances two of which are on the Upper Kamchia-- one below the influx of the Brana river, and the other above the influx. The drainage area between these three stations grows to about 300 sq. Km. Moreover, the way they are distributed, with the two stations' being able to give the same characteristics that would be rendered by the three, too, it follows that one of them can be closed, as it is proposed for station 8 which is of a shorter period of observations, and in addition to this, its data are less qualified. Near to the mouth of the river, at the place Poda, there is station 22 which should be also closed on account of the data compromised by the back flood, and the large spilling of the river in its lower course. The removal of the station outside the area of the backflood is not justified since it would come very close to station 11.

The district not-covered by stations is the upper course of the river Upper Kamchia where stations should be opened in the district of the Ticha which is especially urgent due to other elements which are considered later.

THE RIVER BASIN OF THE PROVADIISKA RIVER.- For this river basin only the transfer of station 30 from the Kriva river to the Kamenica river must be proposed where the drainage region will be more representative for the river.

THE RIVERS IN THE DOBRUDŽHA. – The network of hydrometric stations in the Dobrudzha has been revised and built up after 1951, with the exception of two stations. As it is well known, the regime of the rivers in the Dobrudzha radically differs from that of the rivers in the remaining part of the country. They have water constantly in their upper courses only which gradually decreases as we go along the course of the rivers, while at one section of them there is entirely no water in the lower course. Most of them take their origin from karst-like springs. For the complete elucidation of the hydrological regime, mainly two-two stations have been placed on each river, nothwithstanding their length, and in the river basin of the river Sukha, even four stations were opened. We think that the number of the stations(13) and their distributions are satisfactory for the hydrological characterization of the Dobrudzha.

THE RIVER BASIN OF THE RIVER RUSENSKI LOM. – The existing four stations for hydrometry in the river basin of the Rusenski Lom are not enough for the complete hydrological characterization of this basin.

(see continuation on next page).

(p.64) The river Rusenski Lom is formed of four tributaries which are very close to each other as to regime and character of the drainage areas, with the exception of the tributary Banski Lom which has a rather semi-Balkanian character. In relation with this, a hydrometrical stations should be opened before its emptying into the Black Sea. This way, together with the station of the Ch. Lom, below the influence of the Banski Lom, the full characteristics of the two rivers can be also obtained. For the Beli Lom, only one station is in existence, namely the one at its upper course. In order to obtain the full characteristics of the hydrological elements of the Mali Lom(:Little Lom) and the Beli Lom(:White Lom), in addition of the stations No.1 and No.2, another station must be also opened in the lower course of one of the two rivers. It is proposed to open one for the Beli Lom which is a little more water-filled and with a larger drainage area.

THE RIVER BASIN OF THE RIVER YANTRA.- The river basin of the Yantra is characterized by great uniformity in physico-geographical respect and by a dense river system. It gathers its waters from the ridge of the Stara Planina(:Old Mountain) down to the Duna river. All this has made necessary to create a thick network of hydrometrical stations. In an endeavour to cover all characteristics of the river basin some stations were opened at unsuitable places. Such is the case with stations 77, 85, 73 where the drainage area from station 73 to station 85 grows with 69 Km^2 only. From this it seems that these stations are completely doubled, hence one of them may be closed. It is proposed to close station 73. Moreover, on account of the closure of station 75 of the Belica river, station 85 would be more appropriately moved to the lower course of the Belica river, below its confluence with the river Dryanovska. By such distribution of the stations 77, 85, and 76 the full characteristics will be given for the rivers Dryanovska, Belica, and Yantra from the town of Tyrnovo to Gabrovo city. The closure of station 75 is justified by the fact that from two sides of its drainage area completely homogeneous drainage basins are in existence.

Along the river Risica, especially in its upper course, there is also an accumulation of stations which is the case with stations 68 and 72 from which the closure of station 72 is proposed.

A tributary of the Rosica river is the river Vidima. Along the course of this river, only the stations at the State Nursery near the towns Sevlievo and

Gumoshtnik should remain. The station at the village Vidima should be closed, since it is no more in a condition to give the natural regime of the river, because it is seriously disturbed by the regime of the VEC (Vodna elektricheskaya central: Water electric central) called "Vidima". The influence of this VEC extends pretty far, down to the village Gumoshtnik. For this reason, and also as a result of the fact thatthe basin of the station at Gumoshtnik village represents a peculiarity in climatological and hydrological respect, the proposal also comes that this station should remain in the supporting network. In the entire river basin the river Dzhulyunica is not elucidated with stations, hence it is proposed to open a station in its lower course. This station will make it possible, together with stations 80 and 78, to give also the characteristics of the river Golyama, a trâbutary of the Lefedzha river.

(p.65) THE RIVER BASIN OF THE OSYM RIVER.- With regard to the length of the drainage area the stations in the river basin are well distributed. All characteristics of the river are covered. The influence of the Duna river is shown upon station No.66 which forces this station to be removed more upstream. In the case of by this removal the station would be very close to that in Levski Station No. 66 should be closed.

This circumstance holds good for all near-Duna stations and it may be taken as a rule.

THE RIVER BASIN OF THE VIT RIVER.- The number of the hydrometrical stations in the river basin is sufficient, and, in general, the stations are well distributed. In the middle section of the river, to make it possible to receive the complete characteristics for its tributary river Katunishka through the stations 54 and 67, the latter station (67) should be moved directly below the confluence of the river with the Ugyrchinska river. Moreover, as it is well known, in the upper course of the Vit, directly below the influx of the White and Black Vit, a large portion of the waters is lost in a place, on account of which it is necessary to open a new station directly below this district so that an experience is gained for the elucidation of the regime of the river in this section.

THE RIVER BASIN OF THE ISKYR RIVER.- The river basin of the Iskyr river is standing at the first place in the country in respect to its size and it is characterized by its wide variation in respect of physico-geographical characteristics. The river Iskyr gathers its waters from the highest mountainous parts in our country-- the Rila and the Old Mountain. Because of its peculiarities, in the river basin of the Iskyr river a large number of stations have been opened which are fully sufficient to a complete characterization in hydrological respect-- many of the stations in the river basin had been originally operative, i.e., opened especially for the needs of some jurisdictions, and then ,without much consideration, included in the supporting network. On account of these reasons, some of the stations seem to be superfluous. Such are for instance the stations at Reselec and Kunino, between which the drainage area is only 96 Km^2, without a special additional net of tributaries. Due to the disturbance of the regime of the river by the water reservoir for the irrigation system, the station at Reselec should be justly closed. In the upper course of the Little Iskyr two stations are in existence for drainage areas which are almost equal in size and similar as to physico-geographical characteristics., of which stations one should be closed. No.107 station is proposed for closure. The large number of hydrometrical stations is impressive along the tributaries in the Sofia field, however this is mostly necessary for the great wellfare measures which will be carried out in the near future in this district. In this section of the basin perhaps sometimes in the future the station of the river Panchareveka(Egylya) should be closed which characterizes an entirely small drainage area that by its character is very close to that of the station of Vladaiska. Also the latter station, which could be discarded in the river basin of the Iskyr, --this is No.102, whose drainage area is completely identical with that of No.103 of the Black Iskyr.

THE RIVER BASIN OF THE SKYTA RIVER.- The river basin is characterized with two stations-- one in the upper course of the river and one in the lower course. (p.66) These stations are fully sufficient ,with the provision that station 119 is removed outside the boundaries of the influence of the Duna.

THE RIVER BASIN OF THE RIVER OGOSTA. - This river basin is characterized by an extraordinarily large number of stations in the upper course of the river, where for an area of about 50 Km^2 9 hydrometrical stations are in existence. This is due to the great interest in the energy relationship of this section of the river basin . The stations had been special originally, and then they remained in the supporting network. At the examination of the upper section of the river basin, therein are also included the stations of the rivers Srebyrna, Sredna, Ginska, and Vodenichna from the southern part of the Balkan, whose waters are driven through two channels into the eualizer of the Byrziya river. For this reason (in this way) unlikely data had been obtained for the runoff od the river Byrziya. To get the correct hydrological characteristics of this section and to avoid the superfluous expenditures at the maintenance of the stations, it is proposed to keep in the supporting network the following stations only:- on the southern side of the Balkan to keep station 141 of the river Ginska, which will render data on the waters that are in the river above the water reservoir, and to open two stations at the two channels which transfer the waters from this district to the north, through which this artificial tributary of the Byrziya river will be given an account; at the northern slope to keep only the stations at Vyrshec and Berkovica which are outside the boundaries of the violated regime of all the small rivulets above them and are sufficient to give the characteristics of the section of the basin. This way, the stations 140, 166, 142, 170, 180 and 224 should be closed. Entirely artificially are also condensed the stations 137 and 136, as also 138 and 139, whose drainage areas are very slightly different as to surface area and character. The closure of stations 137 and 136 is proposed. For station 121 the same holds good , which is said also for station 119. Along with the closure of the so specified stations a station must be opened in the lower course of the river Byrziya, as well as one station for the river Ogosta, directly below the influence of the Byrziya. With these stations the characteristics of the river Ogosta above the influence of the Byrziya river can be also obtained.

RIVERS WEST OF THE OGOSTA.- The regime of the larger part of the rivers in this district is characterized by one-one station, namely in the lower course. For these stations the same holds good what was also said for the other stations directly do the Duna, i.e., they must be removed from within the limits of the influence , Whereas for the rivers Topolovica and Voinishka these stations are completely sufficient , for the river Cibrica which is relatively longer a station should be opened at its upper course, directly above the violation of its regime by the many water takers. At the river Archar, two stations are opened, namely in the upper course of the river, chiegly because of the disturbance of its regime directly below the station and because of this the two stations must also be kept. The only river in this district along which a larger number of stations are open is the river Lom namely especially its upper course. By the water reservoirs constructed directly below station 131 the regime of the tributaries before the Hydroelectric Central is violated, on account of which station 129 could be closed, and station 128 should be equipped for the correct observation of the hydrological elements. (p. 67). With the provision that station 133 is removed outside the boundaries of the influence and thus it gets much closer to station 135, the latter should be closed.

SITUATION OF THE HYDROMETRICAL STATION IN RELATION TO SLOPE OF THE DRAINAGE AREA.

The slope of the drainage area also shows a large influence upon the number and site distribution of the hydrometrical stations. The hydrometrical station must elucidate as much as possible the regime of a homogenous drainage area, i.e. the drainage area with a persistently average slope and with uniform declivities. Moreover the hydrometrical stations must be evenly distributed also in a vertical direction, i.e., the mountainous and the plains sections of the country must be evenly covered. Upon the correct distribution of the stations in this respect the characteristics of the runoff and its relation with its conditioning factors such as precipitation and temperature, the determination of the start of the hydrological year and of the seasonal distribution of runoff depend to a great deal. The provision of the drainage area with hydrometrical stations at an altitude is especially necessary for the correct statement of the hydrological forecasts. This factor plays a particularly important role for countries with great diversity in the configuration of the terrain. With the exception of the rivers in the Dobrudzha, the Ludogorie ("Mad Mountains") (Ludogorie) and parts of these which flow into the Black Sea, all the rest have their origin in the high maountanous peaks, they cut through the pre-mountainous parts and after a sharp meandering in the plains they flow into the Duna or directly into the sea. On account of this character of the rivers, the hydrometrical network in our country must be so disposed that all these peculiarities are reflected. The formation of runoff in the high mountanous parts is entirely different from the formation of runoff in the pre-mountains and in the plains. And as the great differences of the meteorological elements are added to this, the differences in the precipitation, temperature, evaporation, etc., the need for a correct distribution of the hydrometrical station in altitude and by the slope stands clear.

As the hydrometrical network of our country is inspected, it is evident that more stations are distributed correctly in respect to these elements. Covered are the high mountains, the pre-mountains and the plains sections. This is particularly clearly expressed in respect to the slopes of the Old Mountain and the Central Mountain. Correctly are elucidated the defiles of the larger rivers as the Iskar, Struma, Kamchiya, etc. Yet, along with this, there is also a number of districts characterized in respect of the slope which are not elucidated with hydrometrical stations, such as the stations which are giving characteristics of non-homogenous drainage areas. The proposals for the opening of new stations, for the transfer and closure of existing such stations are made on the basis of the map on which the mountains, the premountains and the plains regions are clearly outlined. (p.68).

THE RIVER BASIN OF THE STRUMA.- To give the full characterization of the runoff with the increase of the altitude above sea-level, it seems to be necessary to open two new stations in the river basin of the Struma river:- one near the origin of the river, at an altitude of about 1000 m, directly above the "Studena" dam, and another directly below the influx of the Dzherman river from where the narrowing of the valley into a defile actually begins. Moreover, station No.190 for the river Riska should be transfered to below the village of Rila where the river leaves the declivities of the Balkan slope. This way, along this river, two stations will be situated:- one will reflect the runoff regime of the greater uniform heights, and station 190-- the runoff regime of the entire slope. This way, the full characteristics of the distribution of the runoff will be obtained for the entire slope, covered by these two stations. The same holds good also for station No.195 of Gradevska which, by similar considerations, should be directly trabsferred below the departure from the mountainous sections. Along with the proposal for opening and transferring the stations, stations No.205 for the Struma and No.199 for the river Petrovska should be closed since the first gives entirely similar data in respect of the slope (similar to those of station 202), and station 199 gives the characteristics of a very small drainage area directly at the state borders. In the river basin of the river Mesta, for the taking of a profile and for the eastern slopes of the Pirin, at least one station should be opened for the river Byala, directly under Razlog. In exchange for this, one of the stations 258, and 259, and 114 and 1146 should be closed sincethey reflect the characteristics of uniform drainage areas.

ALONG THE DOSPAT RIVER AND ITS TRIBUTARIES station 262 could be closed which is very near to stations 263 and 261, in exchange for which a station could be opened in the upper course of the Dospat river.

Larger changes in respect to the slope and the altitude above sea-level are sought for the stations in the upper section of the RIVER BASIN OF THE MARICA. This is due to a large degree to the great diversity of the terrain's configuration in that district.

Directly below the only origin of the Marica river and of its tributary river, the Ibar, there are four stations-- two at the height of 1900 m andtwo at the height of 1400 m. The drainage areas of these stations along the Marica and the Ibar are very similar in respect to the slope characteristics, for which reason it would be all right to keep only two of them-- one at the altitude 1900 m for the Marica river, and one at altitude 1400 m for the Ibar river which will make it possible, with the aid of station 231 also, which is directly below the influx of the Ibar river into the Marica river, to obtain the characteristics of both rivers, too. Almost the same is also the case with the Kriva river above Sestrimo where three stations are in existence-- station 238 at altitude of about 1900 m, and No. 245 and No. 246 at the height of about 1400 m. On account of the entirely close site, station 246 should be closed since the remaining two stations will be in the position to give the characteristics of the runoff distribution at the increase of the above-the-sea-level altitude. However, after the construction of the "Belmeken" dam, the regime of the Kriva river will be violated, and the observation in station 238 discontinued, for which reason the proposal is made to close station 245 whose water regime (p. 69) will be anyhow disturbed after the construction of the dam. At the river Yadenica, in regard to the fact that the uniform character of the drainage area should be taken entirely, the station should be transferred to the river's lower course. At the river Chepinska, due to the uniform slope between stations 254, 257, and 249, station 257 could be closed. Similarly, one of the stations 256 and 255 could be closed due to the closely similar character of the drainage areas, while a transfer should be the share of station 256 which characterizes a small more uniform drainage area. For the river Stara and for its tributaries, the rivers Gizdica and Ravnogorska, almost at the same altitude, with the same type of drainage area in respect to sie and character, three stations are in existence:- 269, 271 and 272, of which the station No. 271 could be closed, and station 270 should be transferred by the course of the river, to the exit of the river from the mountainous section. In the river basin of the Vacna river, because of the uniform terrain in the drainage areas of the stations No. 266 and 267 above the "V. Kolarov " dam, one of these stations should be closed. For the same reasons, one of the stations 275 and 276 should be closed. It is proposed to close station 275 which gives the characteristics of a small non-homogeneous drainage area. Together with this, a station should be opened directly below the unflux of the river Shirokol'shka which station will serve for giving the characteristics of the Vacha river and of its tributaries as a whole, before it flows into the river Devniska that gathers its waters from a drainage area of a higher altitude above the sea level. Station 273, in accordance with the slope of the drainage area, should be transferred to the exit of the river from the defile. The existence of station No. 343 for the river Yugovska is likewise unjustified; it characterizes a drainage area not homogenous in respect to slope, and very similar in character to the drainage areas of the stations ~~344~~ 325 and 324 for the river Chaya. For the same reasons, station 344 for the river Dobrich could be also closed. Because of the almost unchanging character as to the slope of the drainage areas of stations 241, 242, and 243 for the river Topolnica, station 242 at Mukhovo should be closed. For the complete characterization of the distribution of the runoff along the southern slopes of the Middle Mountain, a station should be opened in the upper course of the river Omurovska at an altitude of about 700 m. In the river basin of the river Arda, the stations are properly distributed. In the upper course of the river, there is a certain unnecessary density, for which reason one of the stations in the Srednogorci and the Vekhtino could be closed, in exchange of which a new one should be opened in the lower course of the river Chamdere. Along the river basin of the Tundzha river, the stations in its upper course, numbered 332 and 329 and 330, characterize almost the same drainage areas as to the slope. Consequently, at least one of these stations should be closed, or transferred to the exit of the river to the plains. However, station 329 expresses the character of a similar drainage area, as well as the regime of the rivers below the site of the stations is disturbed by water takers; consequently, nothing else remains but to close one of these stations. It is proposed to close station 329 of the Akdere river, since its drainage area lies between the remaining two stations, No. 332 for the river Tuzha, and No. 330 for the river Leshnica. The stations 339 of the river Eninska, and 340 of the river Muglishka also characterize drainage areas (p. 70) in respect to slope similar, for which reason it is proposed to move station 339 along the course of the river to the exit to the plains, too, in order to make it possible this way to have the complete characteristics of the southern slope of the Stara Mountain in this district. Because of the entirely short length and the heterogeneous character of the drainage areas of stations No. 372 and 373 in the lower course of the river Tunzha, it is proposed to close the first of them since it has the shorter observational period. For the same reasons it is proposed to close station No. 371 also at Strupec. The hydrometric stations along the rivers in the Dobrudsha and along those rivers which empty directly into the Black Sea, generally taken are well distributed in regard to altitude above the sea-level and slope of the drainage areas. In this part, only station 363 for the river Mladeshka can be closed since it is such which characterizes a small and heterogeneous drainage area. On the other hand, a new station should be opened in the upper course of the river G. Kamgiya at Ticha which will characterize a uniform drainage area that cannot be obtained by the nearest station No. 7. For the same reason that was pointed out at the examination of the extent of the drainage area, station 8 may be closed while station 30 at the Kriva river should be also moved to the river Kamenishka.

THE RIVER BASIN OF THE RIVER RUSENSKI LOM is characterized by a terrain that is but slightly changing as to altitude above the sea level. For the covering of the entire homogeneous terrain, a station should be opened at least for one of its tributaries, namely above the influx of the river White Lom. Along the river basin of the Yantra river, due to the homogeneity of the drainage areas, it is proposed to close station 62 for the river Ostreshka, and station 73 for the river Yantra since they characterize the same drainage area No. 85. In the river basin of the Vit river, to secure in this section a profile of the northern slope of the Old Mountain, a station should be opened in the upper course of the White Vit, at an altitude of about 1400 m, as well as a station should be opened at the exit of the river from the mountain, i.e.

could be closed due to the closely similar character of the drainage areas, while a transfer should be the share of station 256 which characterizes a small more uniform drainage area. For the river Stara and for its tributaries, the rivers Gizdica and Ravnogorska, almost at the same altitude, with the same type of drainage area in respect to sie and character, three stations are in existence:- 269, 271 and 272, of which the station No. 271 could be closed, and station 270 should be transferred by the course of the river, to the exit of the river from the mountainous section. In the river basin of the Vacna river, because of the uniform terrain in the drainage areas of the stations No. 266 and 267 above the "V. Kolarov " dam, one of these stations should be closed. For the same reasons, one of the stations 275 and 276 should be closed. It is proposed to close station 275 which gives the characteristics of a small non-homogeneous drainage area. Together with this, a station should be opened directly below the unflux of the river Shirokol'shka which station will serve for giving the characteristics of the Vacha river and of its tributaries as a whole, before it flows into the river Devniska that gathers its waters from a drainage area of a higher altitude above the sea level. Station 273, in accordance with the slope of the drainage area, should be transferred to the exit of the river from the defile. The existence of station No. 343 for the river Yugovska is likewise unjustified; it characterizes a drainage area not homogenous in respect to slope, and very similar in character to the drainage areas of the stations 344 325 and 3 324 for the river Chaya. For the same reasons, station 344 for the river Dobrich could be also closed. Because of the almost unchanging character as to the slope of the drainage areas of stations 241, 242, and 243 for the river Topolnica, station 242 at Mukhovo should be closed. For the complete characterization of the distribution of the runoff along the southern slopes of the Middle Mountain, a station should be opened in the upper course of the river Omurovska at an altitude of about 700 m. In the river basin of the river Arda, the stations are properly distributed. In the upper course of the river, there is a certain unnecessary density, for which reason one of the stations in the Srednogorci and the Vekhtino could be closed, in exchange of which a new one should be opened in the lower course of the river Chamdere. Along the river basin of the Tundzha river, the stations in its upper course, numbered 332 and 329 and 330, characterize almost the same drainage areas as to the slope. Consequently, at least one of these stations should be closed, or transferred to the exit of the river to the plains. However, station 329 expresses the character of a similar drainage area, as well as the regime of the rivers below the site of the stations is disturbed by water takers; consequently, nothing else remains but to close one of these stations. It is proposed to close station 329 of the Akdere river, since its drainage area lies between the remaining two stations, No. 332 for the river Tusha, and No. 330 for the river Leshnica. The stations 339 of the river Eninska, and 340 of the river Muglishka also characterize drainage areas (p. 70) in respect to slope similar, for which reason it is proposed to move station 339 along the course of the river to the exit to the plains, too, in order to make it possible this way to have the complete characteristics of the southern slope of the Stara Mountain in this district. Because of the entirely short length and the heterogeneous character of the drainage areas of stations No. 372 and 373 in the lower course of the river Tunzha, it is proposed to close the first of them since it has the shorter observational period. For the same reasons it is proposed to close station No. 371 also at Strupec. The hydrometric stations along the rivers in the Dobrudzha and along those rivers which empty directly into the Black Sea, generally taken are well distributed in regard to altitude above the sea-level and slope of the drainage areas. In this part, only station 363 for the river Mladezhka can be closed since it is such which characterizes a small and heterogeneous drainage area. On the other hand, a new station should be opened in the upper course of the river G. Kamgiya at Ticha which will characterize a uniform drainage area that cannot be obtained by the nearest station No. 7. For the same reason that was pointed out at the examination of the extent of the drainage area, station 8 may be closed while station 30 at the Kriva river should be also moved to the river Kamenishka.

THE RIVER BASIN OF THE RIVER RUSENSKI LOM is characterized by a terrain that is but slightly changing as to altitude above the sea level. For the covering of the entire homogeneous terrain, a station should be opened at least for one of its tributaries, namely above the influx of the river White Lom. Along the river basin of the Yantra river, due to the homogeneity of the drainage areas, it is proposed to close station 62 for the river Ostroshka, and station 73 for the river Yantra since they characterize the same drainage area No. 85. In the river basin of the Vit river, to secure in this section a profile of the northern slope of the Old Mountain, a station should be opened in the upper course of the White Vit, at an altitude of about 1400 m, as well as a station should be opened at the exit of the river from the mountain, i.e.

directly above the influx of the river Kalnik. Similarly, station 63 should be transferred along the course of the Kalnik river by which a larger drainage area of the same character will be covered.

IN THE RIVER BASIN OF THE RIVER ISKʉR, because of the homogeneous and very close drainage areas, it is proposed to close one of the stations 102 and 103 for the river Black Iskʉr and of its tributary, as well as one of the stations in the upper course of the M. Iskʉr at Etropole, namely stations No. 107 and 108. In exchange for the latter, it is proposed to open a station at the M. Iskʉr at the village Dzhurovo by which a profile will be secured in the southern slope of the Old Mountain. For the same reason that was stated at the examination of the dimensions of the drainage areas it is proposed to close one of the stations at Kunino and Reselec. Because of the disturbed regime of the Reselec river, that one is proposed for the closure.

Also the following changes, proposed for hydrometric stations, refer to the RIVER BASIN OF THE RIVER OGOSTA AND LOM:- these of the southern slope of Petrokhan whose waters are carried into the river Bʉrziya, the tributary of Ogosta. In this river basin, due to the homogeneity of the slope (p. 71) of the drainage areas and to their small surface, it is proposed to close one of the stations:- Station 140 for the river Srebʉrna, and Station 155 for the river Sredna; Station 170 for the river Shirine, and No. 224 for the river Desna; No. 139 for the river Chiprovska, and No. 138 for the river Ogosta as well as stations No. 128 for the river Lom, and No. 129 for the river Golyama. Besides, station No. 136 for the river Little Ogosta, since at its present location it characterizes a drainage area which does not differ much from that of the hydrometric station No. 137.

DISTRIBUTION OF THE HYDROMETRIC STATIONS WITH RESPECT TO THE FOREST COVERAGE OF THE DRAINAGE AREAS.

The influence of the forest coverage upon the running-off of the produced precipitation is too complicated. It is the result of the simultaneous participation of many acting factors, different in accordance with the various places and conditions. The vegetal cover represents a surface sometimes greater than the land area which it covers whereby the running off of the surface waters is restricted, and in ratio with this, the time of the runoff of the fallen precipitations into the river bed is lengthened, and the infiltration is increased whereby again the surface runoff is decreased.

On the other hand, the vegetal cover absorbs from the ground a large portion of the water that had infiltrated into the ground, and it evaporates into the atmosphere. In connection with this, the moisture of the ground is decreased down to the depth of the root system of the vegetal cover, which shows an influence upon the formation of the underground waters, the main factors in the supply of the fluvial runoff.

It can be seen thereby that the influence of vegetation upon the formation of the surface runoff is very complicated, and it may be both positive and negative.

The positive influence of the vegetation includes the following:

1. The dens and thick vegetation stops the low moisture-laden winds, and it helps the formation of ascending currents propitious for the falling of precipitations.

2. The vegeǩation reduces the warming up of the land surface whereby the evaporation from the ground is considerably decreased. This decrease may reach up to 50-55% in the case when the ground is covered with dry leaves.

3. The thick vegetation, together with the dry leaves that are under it, increases the infiltration into the ground.

4. The thick vegetation also lengthens the period of snow-melting.

The <u>negative</u> influences of the vegetation are reflected chiefly in the following:

1. The vegetation is transpiring a considerable amount of moisture from the ground, and therewith the runoff is decreased which, by the underground pathway, would support the fluvial runoff; and

2. One part of the precipitation remains at the vegetation from where it evaporates, without reaching the land surface.

(p.72) The influence of the vegetation is different at the various slopes of the drainage region. Thus, for instance, a thick vegetation on the plain areas renders a runoff at intensive precipitations only. Similarly, the influence of the different kinds of thick vegetation upon the runoff is also different which depends upon the root system and on the perspiration of the vegetation. The influence of the vegetal cover is also different upon the runoff in the different seasons. Thus, for instance, at the present time, the problem on the influence especially of the forest coverage on the surface runoff can be thought solved in its general features in which two basic situations are distinguished:- influence of the forest cover upon the springtime flood waters, and influence of the forest cover upon the minimum runoff.

The influence of the forests upon the springtime floods consists in the fact that the floods are late and prolonged, i.e., the forests control the springtime floods. Simultaneously, a certain decrease in the volume of the runoff is possible, which is due to the increase of infiltration into the ground.

On the influence of the forests upon the minimum runoff, it may be said that it depends upon other factors such as the physiological needs of the various types of tree and the depth of the water-impermeable layer in the ground. In the case when the amount of precipitations exceeds the physiological needs of the forest and the water-holding layer is at a relatively greater depth, the underground waters will increase whereby the surface runoff is reduced. And in the case when the precipitations are small, and the water-holding layer lies at a not too great depth, the forest can spend larger amount of what would have been gathered in the river of the surface runoff if there would not be a vegetal cover whereby the minimum runoff is reduced.

All this variety, in which every element has an influence according to its size and strength, is working very strongly on reducing the possibility to extract accurate indicators for the influence of the forest cover on the runoff at every section of the drainage area. Indicators on the influence of the individual elements upon the formation of the runoff can be determined only by systematic, differentiating and very precise observations of the precipitations, of the runoff, of the temperatur, the humidity, the evaporation, etc. For this purpose the so-called "stock" stations are employed.

Particularly large is the influence of the vegetal cover on the size of the solid runoff in the rivers. With the increase of the vegetal cover in the drainage area, the erosional role of the surface runoff is reduced, and therewith the solid runoff in the river systems is decreased.

From all that was said until now it is evident what a large importance the regular distribution of the stream-gage stations has in respect to the forest cover, and mostly in respect to those stations in which observations are carried out on the solid runoff.

By principle, the stream-gage stations must be so distributed that they should cover homogeneous uniform drainage areas as far as forest and slope are concerned, even that the different types of vegetal cover are taken into consideration.

(p.73) From the map of the forest coverage it can be seen how great a diversity is in our country in respect to forest coverage; consequently, such an ideal distribution of the hydrometric network is impossible. This is the reason why, at the examination of the supporting network of hydrometric stations, we shall endeavour to cover each of the different forest coverages by some stations, also a more complete characterization of the elements of the runoff, and especially the solid runoff in the different parts of the individual river basins.

RIVER BASIN OF THE STRUMA RIVER:- The forest coverage in the river basin is very various. There are but very few stations that cover drainage areas with uniform forest coverage; for this reason a few new stations should be opened. Suitable sites for opening of such stations are:- directly above the pool of the "Studena" dam; in the lower course of the Konska river whereby an entirely deforested drainage area is covered; in the lower course of the Treklyanska river, whereby a drainage area of about 50% uniform forestation is covered. There are also stations which should be transferred so that drainage areas which have uniform forestation will be covered. As such stations the following are proposed:- Station 190 for the river Rilska, where the drainage area, in respect to the forest coverage, is stretched up to the Rila village; consequently the station should be transferred to this section of the river since it is anyhow very close to Station 192. By the same consideration, Stations 227 for the river Sushichka, and Station 198 for the river Bistrica should be also transferred. Because of the uniformity of the forest cover of the drainage areas of stations 183, 184 and 185, one of them could be closed, and it is so proposed for Station 184.

In the river basin of the river Mesta, because of a fully uniform forest coverage in the adjacent drainage areas, one of each of the following station pairs should be closed:- 209 for the river Belichka, and 210 for the river Votrachka; 214 for the river Breznishka, and 2146 for the river Kornicka; 258 for the river Vishterica, and 259 for the Kanina river.

THE RIVER BASIN OF THE MARICA RIVER.- This river basin is also characterized by a great diversity of the forest coverage. While it is very massive on the right-hand section of the river basin, on the left-hand section it is wholly disrupted, and a decision can be hardly reached in the determination of the site of the stations. Because of this character of the forest coverage on the left side of the river basin, only the station for river Topolica, near Mukhovo, could be closed, because in respect to the drainage are its character is showing but a very slight difference from the character of the drainage area of such stations as Station 240 and 243; and stations should be opened for the river Bratnica at Radnevo whereby the characteristics of a clearly deforested are will be given.

On the right-hand section of the river basin, somewhat larger changes must be made, which changes are reflected in the following:- because of the likeness of the drainage areas in regard to the forest covergae, one of the following stations must be closed:- Station 233 for the Marica river, and Station 235 for the river Ibur; Station 245 for the Kriva river, and No. 246 for its tributary; No. 254 and No. 257 for the Stara river at Velingrad; No. 255 for the Sofan river, and No. 256 for the river Balukdere; No. 266 and No. 267 above the dam "V. Kolarov"; No. 275 for the river Trigradska, and No. 276 for the river Tenesdere; No. 270 for the river Stara near Peshtera, and No. 271 for the Gizdica river; No. 343 for the Yugovska river, and No. 324 for the river Chaya at Bachkovo. To cover(p. 74) the entire forested section of the Vucha river which is covered exclusively with coniferous vegetation a station must be opened at Levin. To completely cover the forested parts of the drainage areas of the rivers Yadenica and Vucha, stations No. 274 and No. 273 must be transferred by the course of the rivers to the point where they leave the forested districts.

Due to the great diversity in the drainage area of the Arda river in regard to forest coverage, the forestation could be hardly covered by hydrometric stations (with the eception of its forest flow). To obtain the characteristics of the very deforested and eroded district in the river basin, a station must be opened in the lower course of the river Chamdere, in exchange of which Station 318 could be closed at Srednogorci whose water drainage area is very similar to that of Station 315 at Vekhtino.

In the course of the Tundzha river, by the same consideration that have been also pointed out for the river basin of the Marica river, one of each of the following station pairs could be closed:- No. 372 and 373 of the Tundzha river; No. 371 and 374 also of the Tundzha river; No. 329 of the Akdere river, and 330 of the Leshnica river; to entirely cover the forested section in the basin of the Eninska river, Station 339 should be moved to the exit of the river from the forested section. No clear need arose for opening of new stations in the river basin in respect to forest coverage.

The hydrometric network in the district of the rivers which directly flow into the Black Sea, such as those in the Dobrudzha and in the Ludogorie, generally taken, is well distributed. Thus, for instance, almost all stations in the forested course of the rivers in the Dobrudzha are covering entirely such districts with an average forestation of 25 - 30%. There are also many other stations which cover districts of different degree of uniform forest coverage; the following stations can be specified as such:- Station 2 for the river White Lom; No. 6 for the river Vrana; No. 379 for the river L. Kamchiya; No. 365 for the river Sredecka, and so on. As it has been already said, the role of the forest coverage depends upon the matter, too, what type is the forest vegetation. To cover a drainage area which is completely forested with beech forest, a station has to be opened in the upper course of the river G. Kamchiya, at the village of Ticha, which is in direct neighborhood of the drainage area of Station 379 that is forested almost entirely by ashtree and elm. A station must be also opened below the influx of the Little and White Lom. Along with this, one of the following stations might be closed:- Station 363 for the river Mladezhka, and No. 361 for the river Veleka, as adjacent and uniform drainage areas. Similarly, one of the following stations may be closed:- Station 7 and No. 8 for the river Kamchiya, and preference is given to Station 7 because of the longer observational period.

In the river basin of the Yantra river, the stations are correctly distributed in respect to the forest coverage, i.e., a large part of the network characterizes uniform drainage areas, while all the characteristics in regard to this element are covered. Thus, for instance, Station 86 entirely characterizes the non-forested area; Station 81-- about 15% forested drainage area; Stations 61 and No. 71-- about 20% forest coverage; Stations 59, 62, and 72-- entirely forest covered areas; because of this, Station 62 could be closed, and in exchange for it, a station could (p. 75) be opened for the river Yantra at the village of Etyryt. Similarly, one of the stations No. 73 and No. 85 should be closed, as characterizing identical drainage areas. Here also, it would be proper to transfer Station 83 for the river Belica whereby a drainage area of uniform forestation (about 20% forested) would be covered. In this case, one of the stations No. 75 and No. 76 could be closed. This way, the eastern section of the river basin remains the less elucidated area, for which it is proposed to open a station in the upper course of the river Golyama whereby a drainage area of about 35% average forestation will be covered.

In the river basin of the rivers Osум and Vit, the forest coverage is well taken care of by the existing hydrometric stations. To cover accurately the limits of the different types of forest coat, a few stations seem to be necessary to transfer at small distances, as it is the case with the following stations:- No. 65, in whose drainage area also enters a small section which is not forested; No. 86, where a small part is also included with smaller forestation (about 15%); No. 57, which, if moved a little along the course of the river, will entirely cover a forested district of beech trees. The same holds good for the stations 51 and No. 52 also, for the rivers of White Vit and Black Vit. However, because of the long period of observations in these stations, their transfer is not justified, and it is impossible for stations 51 and No. 52, since the river starts to lose its waters directly below them.

THE RIVER BASIN OF THE ISKЪR RIVER.- In this river basin, the forest coverage is very well taken care of by the hydrometric stations:- covered are the districts of different forestation. However, there are also some stations whose drainage areas, in regard to the forest coat, are very cimilar, and some of them could be discontinued. As such may be pointed out the stations No. 102, and No. 103, also No. 107 and No. 108, as well as No. 115 and No. 116, one of each pari may be closed. To completely cover the forested district of the river Musalenska Bistrica at Borovec, Station No. 225 should be moved by the course of the river. Also here, as at the examination of the slope of the drainage areas, a station seems to be necessary to be opened for the river Little Iskъr, near the village of Dzhurovo, whereby the forested district in the upper course of the M/Iskъr river will be entirely covered.

In the district of the rivers west of the Iskъr river, due to the very similar character of the drainage areas, it is proposed that some of the stations, mainly in the district of Petrokhan, should be closed. Moreover, here, the regimen of the river is disturbed for the reasons already mentioned in connection with the examination of the vegetal cover of the drainage area; for this reason, small changes are proposed, namely to close the stations No. 170, No. 224, No. 140 and No. 142. The characteristics which were received from the first two stations will be obtained from the stations No. 178 and 179. For the same reason, one of stations No. 128 and No. 129 may be also closed in the upper course of the Lom river.

In the upper course of the rivers Chiprovska and Ogosta, there are two stations for each river very close to each other, and it would be the best to move one of each to entirely cover the forested sections of the upper course of these rivers.

(p.76) DISTRIBUTION OF THE NETWORK OF HYDROMETRIC STATIONS IN REGARD TO THE PEDOLOGICAL STRUCTURE OF THE DRAINAGE AREA.

The soil characteristics and the geological structure of the drainage area show a considerably influence upon the runoff. This influence depends upon many pedological and geological elements which also explain its rather complicated form. On a sandy surface, the runoff and the evaporation are usually smaller than with soils which are only slightly penetrable and wettable-- sandy-clayish soil, turf, black earht. The decrease of the runoff and of the evaporation in case of a sandy soil is the result of the fact that such a soil enables the moisture to quickly penetrate into the earth crust where it is stored in the underground waters. This way the ground strata which are less permeable at greater depth become reservoirs of the underground waters which reservoirs are little accessible to evaporation, and they serve for the steady supply of the rivers during the seasons or even during the years when precipitation is poor.

At the interruption of the river bed by karst-like outgrowths, one may observe a more or less disappearance of the water in the ground which may even reach a degree where the entire river vanishes, in consequence of which very large springs may appear at other sites. Such cases are many in our country:- Zlatna Panega, Debnya, Iskrecka Khubcha, etc. On the surface runoff, influence is also exercised by the physical conditions (saturation with moisture, and freezing) and especially by the structural condition of the ground.

The structureless grounds imbibe less water of the precipitated rain, for which reason larger surface runoffs are the result. With structured ground, the precipitated rain quickly penetrates, and in large quantities, deep into the ground. The evaporation is greater in case of structureless ground, and smaller when the ground has structure.

The geological conditions of the basin, independently from the pedological characteristics, show influence upon the general flow of the underground run according to the different qualities and slopes of the water-permeable and water-impermeable layers of the earth.

Since the size of infiltration depends upon the moisture of the ground, the latter may be considered as one of the factors actively influencing the runoff.

The influence of the pedo-geological factors, and especially of the latter, is still not sufficiently studied. One of the reasons of this is the multiplicity of combinations between the individual factors that may be present at one or the other drainage area.

In connection with this, it is very difficult to make a complete and correct distribution of the hydrometric stations in regard to the pedo-geological structure of the drainage region. This is why, at the examination of the network of hydrometric stations in regard to this element, more serious attention is paid to the soil character and the karst-like outgrowths of the geological structure of the drainage areas.

At the examination of the hydrometric stations in regard to the soil characteristics, attention is paid chiefly to the opening of (p.77) new stations, and to the transfer of existing ones, with the purpose of covering uniform drainage areas in regard to the soil condition. Attention is also paid to those stations which are proposed for closure in regard to the already examined elements.

THE RIVER BASIN OF THE STRUMA RIVER.- In this river basin, proposal is made for the opening of three new stations of which one is in the upper course of the river Struma, directly above the "Studena" dam, whereby adrainage area of brown forest soil will be covered. XX Another drainage area of the same soil will be also covered when a station will open in the lower course of the river Treklyanska. The third station which is proposed for opening is in the lower course of the Konska river whereby a drainage area of black earthy bituminous substance will be covered. With the same consideration, the transfer of Station No 190 on the Rilska river, directly above the village of Rila, is proposed. On the other hand, because of the extremely similar character of the drainage areas, one of each of the following station pairs could be closed:- Station No.184, on the Glogoska river, and No.185 on the Novoselska river, and No.202 and No.203 on the Struma river.

THE RIVER BASIN OF THE MESTA RIVER.- Because of the closely similar pedological character of the drainage areas in this river basin, one of the stations No.214-a at the Breznishka river, and Station No.214-b on the Kornicka river could be closed, and for the reason that the entire drainage area of the river Dospatska and of its tributaries is homogeneous in soil condition(brown forest soil), one of the following stations could be closed:- Station No.261 and No.262 on the river Karadzha. By the same consideration,proposal is made to transfer one of the stations No.258 on the Visherica and No.259 on the Kanina directly below the influx of these rivers.

THE RIVER BASIN OF THE ARDA river.- The hydrometrical stations along the main river are well distributed.The station at Vekhtino ,and all above it, give the characteristics of the drainage area of brown forest soil; consequently,in regard to this element,weight must be given to the already examined elements(Hydrometrical station No.318). The station at Kurdzhali covers the transition from the brown forest soil to the gray and dark-gray forest soil. The remaining part of the drainage area is very diverse as to soil characteristics,and therefore drainage areas of homogeneous composition cannot be covered.

THE RIVER BASIN OF THE MARICA RIVER.- The homogeneous soils in the river basin of the Marica river occupy vast areas,while on the left side of the river basin the brown forest soils occupy entirely the upper and middle courses.

Hence,it follows that the number of stations in this part can be reduced,yet a proposition has not been made for this,and the soil character in this district is not taken into consideration at the examination of the network in regard to the other factors. In the lower course and on the right side of the river,the diversity of the soil characteristics is larger but generally takn it is well covered,due to which the proposal is made to open only one station,in the lower course of the river Obcharica.This way the drainage area will be entirely covered that is coated with black earthy bitumenous substance.It must be that the station No.306 is transferred to a more upper course,to the village of Little Borisovo,whereby an area of drainage with cinnamon colored forest soil--podsolized,will be entirely covered.

THE RIVER BASIN OF THE TUNDZHA RIVER.- With the existing stations,the districts of brown forest soil are entirely embraced(No.328,332,330,339,and 340),and the districts of cinnamon colored forest soils(podsolized) are covered by Stations No.331 and No.334. To entirelt catch also the drainage areas of light-gray forest soils, Station No.341,on the river Radova,should be transferred upstream the river to about 5 Km. Because of the wholly identical character of the drainage areas, one of the following stations pairs could be closed:

-No. 329 on the river Akdere, and No. 330 on the river Leshnica; No. 339 on the river Eninska, and No. 340 on the river Myglishka, while those of the latter two stations which will stay should be transferred by the river course a couple kilometers only; No. 371 and No. 374 on the river Tundzha, No. 372 and No. 737 also on the same river. (737 to be read 373?)

For the district of the rivers which flow directly into the Black Sea the need was established to open one station only-- in the lower course of the river Ruso-kastrenska whereby the drainage area of black earthy bitumenous material will be covered entirely.

In the Dobrudzha and the Ludogorie, due to the homogenous soil character, at the opening and closing of stations advantage is given to the remaining factors.

THE RIVER BASIN OF THE RIVER YANTRA.- With the existing stations, the various types of soil characteristics in the river basin are properly covered. Because of identical conditions, one of the following station pairs should be closed:- Station No. 76 on the river Belica, and No. 76 on the river Dryanovska; stations No. 68 and No. 62 on the river Rosica, while preference is given to station No. 68 whereby the district of the light-gray and gray forest soils will be entirely covered.

THE RIVER BASIN OF THE ISKYR RIVER.- Because of the very similar soil characteristics of the drainage areas, one of the following station pairs could be closed: - Station No. 102 on the river Pryaka, and No. 103 on the Black Iskyr; No. 107 and No. 108 on the river Little Iskyr above Etropole; No. 115 and No. 116 on the river Iskyr. The station in Borovec should be transferred by the course, with its penetration into the Samokovsko field. To cover, at least by one station, the drainage area of mountanious meadow soils, it is recommended to open a station in the upper course of the river of Black Iskyr.

In the district west of the river Iskyr, the changes in the network at the upper course of the rivers are necessitated exclusively by the already investigated factors, since the soil characteristics of the drainage areas are very similar.

In this part it is imperative to opne only a station on the river Ogosta at Mikhailovgrad whereby the district of light-gray and gray soil will be entirely covered in the course of the river. By the same consideration, station No. 145 should be transferred on the river Botunya closer to the village of Krivodol.

Having made such an estimate of the network in regard to the soil characteristic,

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we shall delay a while to consider the need of new stations for the elucidation of the influence of the strongly expressed karst-type districts upon the surface runoff.

As a result of the strongly manifested karst-like districts of a few places, a more or less penetration of the surface runoff into the ground is shown which sometimes may even come(p.79) to a drying up of the river, and very large springs will appear at another site. To express its influence upon the surface runoff, a hydrometric station should be opened at each one of such springs sites. The observation at these stations will be conducted by special instructions, according to which the number of measurements would be minimum, and mainly distributed by the seasons, and the observation of the water stand would be made once a day, and in some cases through several days, too.

There are many such well-manifested karst-type districts in our country, namely chiefly in the basins of the rivers Struma, Mesta, in the Rodopi Mountains, and in the mountainous slopes of the Middle and the Western Old Mountain ranges. Because of this, the country is rich in karst-type springs of which the greater part are small, and they do not show any particular influence upon the runoff. The larger and the permanent springs, for which hydrometric stations should be opened for the investigation of their regimen, are the following:-

1. In the river basin of the Struma river-- for the Skakavica springs, between the rivers Treklyanska and Rishdavec;

2. In the river basin of the Mesta river-- for the springs Yazo and Istok,-- while stations are opened for the collecting channel, dorectly above the equalizer;

3. For the river Musomishka-- directly below the Central;

4. For the river Kanina-- directly below Ognyanovo where the springs come up. However, a station could be here opened, and a certain number of measurements could be made whereby only the discharge of the springs would be determined;

5. The old river at Velingrad-- for the Kleptuza spring;

6. For the springs at the river Toplika-- below the "V. Kolarov" dam;

7. For the spring in the lower course of the river Shirokolushka-- above the Bedenski Baths;

8. For the 40 springs at the village of Muldavo, Asenovgradsko;

9. In the river basin of the river Arda-- for Khubcha.

10. For the Devnensk springs(there is such a station).

11. For the river White Lom, at Razgrad;

12. In the basin of the Vit river-- for the Kalnik river(there is a station, yet for the study of the surface runoff a station must be opened at the village of Dzhurovo);

13. For the river Vit--above Toros whereby we could elucidate the question on the loss of the waters of the Vit river in the district below the influx of the White and the Black Vit;

14. For the river Zlatna Panega, directly below the spring;

15. For the river Iskrecka, directly below the spring;

16. For the Blato river--at Opicvet.

II. NEED OF THE HYDROMETRIC DATA FOR THE CONSTRUCTION INDUSTRY AND FOR THE NATIONAL ECONOMY.

At the construction of Socialism, one of the most important tasks is to generalize the possibility that the natural phenomena(resources) be managed in accordance with the needs of the national economy, i.e., to transform Nature in such a way that our needs are best satisfied.

(p.80) The natural regimen of the rivers is subjected to constant changes as a result of human activity which is chiefly expressed in two directions:

1. changing the surface of the drainage areas, and thence, changing the course of the surface runoff, and

2. effecting directly the river runoff by constructing artificial structures in the rivers as well as by taking water from them for other needs or, vice versa, pouring strange waters into them.

The changing of the surface of the drainage area may be manifested by a change in the vegetal cover, in the condition of the soil cover, and in the direction of the surface runoff.

The direct effect of Man upon the river regimen is mainly generalized in two directions: a) creating water reservoirs for the regulation of the river runoff, and b) taking a part of the fluvial water for irrigation, water supply, industrial and other needs, or, on the contrary, pouring water into the river from adjacent drainage areas.

At the creation of artificial water reservoirs for the regulation of the runoff, not only the regimen of the fluvial course is changed(water amount, solid runoff, and the ice regimen) but also the reserve of the underground waters, the evaporation is increased which depends upon the water surface of the reservoir. The water reservoirs redistribute the runoff, and particularly substantially influence the maximum water amounts while they lower them. The consumption of the river water from the water reservoir for various water economical needs is accounted for by gaging the consumed water. Thence it follows that, below each constructed dam, hydrometrical stations must be erected directly through which the overspilling waters are registered as well as the waters that are taken for national economical needs.

For this purpose, directly below each already erected dams, or dams now under construction, hydrometric stations must be provided by which the overspilled water is measured, and the water is also measured which is redistributed by the Central at the dam; and in case if the waters of the dam are also used for irrigation, such stations must be also installed at the beginning of the main irrigational channel, when they are provided with limnigraphs.

In connection with the statements hitherto said, stations must be opened below the dams Studena, Stalin, V. Kolarov, Batak, G. Dimitrov, and Al. Stambolijski, as one is also kept at the Topolnica dam.

Beside the erected dams and those under construction, data must be also secured for the straight construction industry which, on its part, demands that a few more stations should be opened:- for the river Konska below Breznik, in the lower course of the river Treklyanska; for the river Struma, below the influx of the river Dzherman; for the river Mesta, directly below the influex of the river Eleshnica; for the river Bryagovska --at Bryagovo; for the river Ogosta--at Mikhailovgra; for the river Golyama--at Yastrebite; for the river Stara--at Lesiche, Along with this, Station 136, on the river Ogosta should be transferred as well as Station 127 on the river Lom, below the influx of the river Golyama, while at the sameplace the following stations are also kept:- ...on the river Yadenica(p. 81), Station 262 on the river Karadzha-dere, tributary of the Dospatska(while Station No. 261 on the same river is to be closed); No. 343 on the river Yugovska, and No. 318 on the Arda at Srednogorci.

Frequently, a portion of the river runoff is used for irrigation, for water supply and others wor which reservoirs are constructed in the river bed. Occasionally, to satify these needs by the river, almost its entire holding is taken.

At the irrigation systems of larger scale, the water loss due to filtration into the channels and into the irrigational surfaces may be also considerable. This water is made to revert into the river by an underground pathway, and occasionally also by a surface flow-off, while neither it the possibility excluded that at some places swamping is produced.

This method of returning a part of the water into the river may cause a certain redistribution of the river runoff which is determined by more special investigations only; this cannot be, however, among the tasks of the supporting network, especially at the scale of our irrigational system. That is wgy attention is only paid to the water takings which have already reached considerable number and are particularly strongly disturbing the regimen of our rivers.

For the determination of the regimen of water taking for irrigational needs it is proposed to provide hydrometric stations at the water reservoirs of the already erected irrigational system, equipped with limnigraphs. For this purpose it is proposed to open stations at the beginning of the main canal of the following irrigational systems:- Cherven Bryag (Red Bank) at Sadovo, on the river Vit, on the irrigational canals of the dams Al. Stambolijski, and G. Dimitrov, on the Pazardzhik irrigational systems. Along with this, Station No. 132 on the river Cibur must be transferred outside the irrigational system.

Together with this, for the needs of the future irrigational systems (according to the prospective perspectival plan of the "Vodstroi" (Water Construction), new stations must be opened which must fulfill an operative role, and, after the new irrigational systems have been constructed, permanent stations must be organized.

In our country, waters of one drainage area must be all too frequently thrown into another for energy production or for irrigation. In such a case, the regimen of the water amount which is transverted must be determined as well as the water that remains in the river. Such is the case with Petrokhan where, by means of two canals, the waters of 4-5 rivulets are collected from the southern slope of the Western Old Mountain, and they are transmitted into the basin of the river Burziya. To get the characteristics of the runoff of the Burziya river it is proposed to open two new stations at the two southern canals, directly above their influx into the equalizer, while in addition to this the stations determined by the examination of the vegetation of the areas are retained, and one stations is opened directly

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the latter Central in the basin of the river.

The specified stations of some of the rivers above the collecting canals must be also retained which will serve for the characterization of the regimen of the higher parts of the drainage area-- so as it is specified by an examination of the factors-- vegetation of the drainage area, slope, forest coverage, etc. (p.82) Similarly, we have such a thing also at the hydroelectric channel "Batak", which will be examined after it has been completed.

From the hitherto made analysis of the distribution of the network of hydrometrical stations, the following changes were found necessary:

In addition to the propositions made for changes in the network of the hydrometric stations, the requirement must be added that the stations in the lower course of the rivers that are flowing into the Duna river, must be transferred outside the zone of backpush. With the situation that the so transferred stations are brought very near the more upstream stations erected on the corresponding rivers, one of them could be cancelled, after a survey, at the site where it seems to be advantageous.

It is evident thereby that, for the entire country, it is proposed generally:

to close	42	hydrometrical stations
to transfer	10	" "
to open	46	" "

However, it must be noted that, in the so made proposals for changes in the hydrometrical network, each of the hitherto examined factors does not have identical weight. Preference is given first of all to the vegetal cover of the drainage area, to the slope and to the erected or planned water engineering constructions. There are also stations where all factors urge that they should be closed, yet, in spite of that, they still remain for the needs of the direct development of the country in the field of energy production and irrigation. As examples may be cited the stations on the river Karadzhadere at the village Zmeica, in the lower course of the river Yugovska, the river Arda at Srednogorci, on the river Topolica at the village of Mukhovo, and others.

But there are also such stations on which some of the examined elements imposed that they be closed, transferred, or opened, and they have not been taken into consideration, such as the stations: a) in respect to the increase of the area:- in the lower course of the river Draglishtenka, in the middle course of the river Dospatska, in the lower course of the river White Lom, in the lower course of the river

Vidima; -b) in respect to slope:- the middle course of the river Dospatska, river Trigradska, river Stara at the Hydroelectric Plant Peshtera; c) in respect to forest coverage:- river Pirinska Bistrica, river Sofan, river White Lom, river Chiprovska; d) in respect to soil character:- river Botunya, river Myglishka, river Omurovska, and many of the stations in the upper and the middle courses of the river Marica, the rivers in the Dobrudzha, and part of those in the Ludogorie, and others. Without taking into consideration the influence which the different factors show at some of the stations, due to the complexity at the combined effect of all examined factors, it is impossible to give the same weight to each one of them, since in the opposite case a very large number of hydrometric stations would be obtained, which is economically an evil.

At the present time, let us consider the thus more precised hydrometric network in respect to some of the elaborated meteorological elements which are of particularly high significance for the formation of the runoff as well as in respect to some of the already elaborated hydrological elements.

(p.83) TABLE 3: (LEGEND of words and phrases as lettered and numbered in the original):

A//- Number of series; B- river; C- Changes and locations a) closure, b) transfer; c) opening; D- Factors which urge the changes.

I. THE RIVER BASIN OF THE STRUMA.

1) B: River Glogoska; Ca: village of Zhilenci; D- growth of the area, forest cover, and soil characteristics.- 2) B- river Bistrica; Ca- village Bistrica; D- growth of the area and disturbed regimen of river, due to water reservoir for water supply of the town of St.Dimitrov.- 3) B- river Struma; Ca- town of Pirin; D- growth of the area, slope and soil characteristics.- 4) B: river Petrovska; Ca- village of Petrovo; D- growth of the area, slope and its construction.- 5) B- river Rilska; Cb- from Pastra village to below Rila village; D- XXXXXXX growth of area, slope, forest coverage, and soil characteristics.- 6) B- river Sushichka; Cb- from the village of Sushica to Krupnik village; D- growth of the area, forest coverage, and slope.- 7) B- Struma river; Cc above the pool of the Studena dam; D- Slope, forest coverage, and soil characteristics. - 8) B- Struma river; Cc- below the dam wall of the Studena dam; D- erection of a water engineering structure.- 9) B- Konska river; Cc- near its influx into the Struma; D- growth of the area,

forest coverage, soil characteristics, and future water engineering structure.- 10) B- Treklyanska; Ca- near its influx into the Struma; D- growth of the area, forest coverage, soil characteristics, and a future water engineering structure.- 11) B- spring; Ca- at Skakavishkiya falls; D- elucidation of the influence of the spring upon the hydrological characteristics of the Struma river.- 12) B- Struma river; Ca- below the influx of the Dzherman river; D- growth of the area, slope, and future water engineering structure.

II. THE RIVER BASIN OF THE RIVER MESTA.
(Table 3 continued)

13) B- river Petisha; Ca- the village of Gostun; D- growth of the area.- 14) B- the Kornishka river; Ca- the village of Kornica; D- growth of the area, slope, forest coverage, and soil characteristics.- 15) B- the river of Karadzhadere; Ca- Zmeica village; D- growth of the area, soil characteristics, and slope.- 16) B- river Vishterica; Ca- from the forest house above the village Kovachica; D- slope, forest coverage, and soil characteristics.- (p. 84)(Table 3 cont.) -17) B- at the springs; Cc- for the canal above the equalizer of the Hydroelectrical Central Razlog; D- the karst-type springs--Yazo and Iztok.- 18) B- Iztok(outflow); Cc- below the town of Razlog; D- growth of the area, and slope.- 19) B- river Mesta; Cc- below the influx of the Eleshnica river; D- future water engineering structure.- 20) B- river Musomishtenska; Cc- the village of Musomishte; D- karst-type springs.

III. THE RIVER BASIN OF THE MARICA RIVER.

21) B- the Ubyr river; Ca- elevation 1900; D- growth of the area, slope, forest coverage, and soil characteristics.- 22) B- river Marica; Ca- elevation 1400; D- growth of the area, slope.- 23) B- river Kriva; Ca- the place of Khadzhidedejca; D- growth of the area, slope, forest coverage, and soil characteristics.- 24) B- river Balykdere; Ca- the forest house Chekhlovo; D- growth of the area, forest coverage, and soil characteristics.- 25) B- river Stara; Ca- village Korova; D- growth of the area, slope, forest coverage, and soil characteristics.- 26) B- river Gizdica; Ca- town of Gizdica; D- same as above.- 27) B- river Chernodere; Ca- the V. Kolarov dam; D- same as above.- 28) B-river Tenesdere; Ca- village Mugla; D- growth of the area, forest coverage, and soil characteristics.- 29) B- river Pyrvenecka; Ca- village of St. Spas; D- disturbed regimen at the water reservoir of the water supply of Plovdiv.- 30) B- river Baneka; Ca- place Durkhana; D- growth of the areas and slope.- 31) B-river Stara; Ca- the hydroelectric Central Levski Grad; D- growth

of the areas.- 32) B- river Topolica; Ca- village Mukhovo; D- growth of the areas, slope.- 33) B- The Kleptuza spring; Cc-the town of Velingrad; D- karst-type spring.- 34) B- river Mytnica; Cc- below the Y Batak dam; D- new water engineering structure.- 35) B- river Beglizhka; Cc- below the dam V. Kolarov; D- erected water engineering structure.- 36) B- river Toplika; Cc- the spring of the place Poroen Bridge; D- karst-type spring.

(p.85) (TBALE 3 continued)- 37) B- river Shirokolushka; Cc- the springs above the Bedenski Baths; D- karst-type spring.- 38) B- river Vycha; Cc- below the influx of the river Shirokolyshka; D- growth of the areas, forest coverage, slope, soil characteristics.- 39) B- the forty springs; Cc- at Asenovgrad; D- Karst-type springs.- 40) B- river Bryagovska; Cc- village Bryagovo; D- Future water engineering structure.- 41) B- river Omurovska; Cc- in the upper course; D- slope.- 42) B- river Marica; Cc- Dimitrovgrad; D- growth of the areas.- 43) B- river Blatnica; Cc- village Radnevo; D- forest coverage.- 44) B- river Oschcarica)(Ovcharica); Cc- above its influx into the Syutlijka; D- soil characteristics.

IV. RIVER BASIN OF THE RIVER ARDA.

45) B- the Khubcha Spring; Cc- village Sokolovci; D- karst-type spring.- 46) B- river Chamdere; Cc- above its influx into the Arda; D- growth of the areas, forest coverage, and slope.

V. RIVER BASIN OF THE TUNDZHA RIVER

47) B- river Akdere; Ca- village of Skobelevo; D- growth of the area, forest coverage, slope, soil characteristics, and disturbed regimen.- 48) river Tundzha; Ca- village Strupec; D- growth of the areas, forestry, soil characteristics, and slope.- 49) B- river Tundzha; Ca- village Konevec; D- growth of the areas, forestry, soil character and slope.- 50) B- river Eninska; Cb- from the water reservoir above the village of Enina; D- for slope, forestry, and soil characteristics.- 51) B- river Tandzha; Cc- below the G. Dimitrov dam; D- erected water engineering structure.- 52) B- river Mochurica; Cc- above Polyanovgrad; D- growth of the areas.

VI. THE DISTRICT OF RIVERS FLOWING DIRECTLY INTO THE BLACK SEA

53) B- river Mladezhka; Ca- place Karamlyka; D- growth of the area, forestry, and slope.- 54) B- river Kamchiya; Ca- village Salamanovo; D- growth of the areas, forestry, and slope.- 55) B- river Kamchiya; Ca- place of Poda; D- growth of the areas and, mostly, the impossibility to measure the water amounts because of large spilling.-

56) B- river Kriva; C- from Novi Pazar to the Kamenishka river; D- growth of the area, and slope.- 57) (p.86) B- river Big Kamchiya; Cc- above the village Ticha; D- growth of the areas, slope and forestry.

VII. RIVER BASIN OF RUSENSKI LOM

58) B- river White Lom; Cc- the springs at Razgrad; D- karst type springs.- 59) B- White Lom; Cc- above its influx into the Little Lom; D- growth of the areas, forestry, slope, and soil characteristics.

VIII. RIVER BASIN OF THE YANTRA RIVER

60) B- river Yantra; Ca- village Vetrenci; D- growth of the area, forests, and slope.- 61) B- river Belica; Ca- village of Vuglevci; D- growth of the areas, forests, and soil characteristics.- 62) B- river Rosica; Ca- village of Valevci; D- growth of the areas, and soil characteristics.- 63) B- river Ostreshka; Ca- village of Ostrec; D- forestry, slope, and soil characteristics.- 64) B- river Yantra; Cb- from the HydroElectric Central "Sini Vir"(Blue Pools) of the river Belica below the influx of the river Dryanovska; D- quick growth of the areas.- 65) B- The Stara river; Cc- the upper course; D- future engineering structure.- 66) B-river Dzhulyunishka; Cc- village Dzhulinica Dzhulyunica ; D- growth of the areas.- 67) B- Gorna river; Cc- the upper course; D- future water engineering structure.- 68) B- river Rosica; Cc- below the dam Al.Strambolijski; D; erected structure of water engineering.- 69) B- river Yantra; Cc- village Eterut; D- growth of the areas and forestry.-

IX. RIVER BASIN OF THE VIT RIVER

70) B- river Katunishka; Cb- from the village Katunica below the influx of the river Ugurchinska; D- growth of the area.- 71) B-river White Vit; Cc-village of Ribarica; D- slope; - 72) B- river Vit; Cc-below the place Boaza; D- growth of the areas; slope and karst-type phenomena.- 73) B- river Kalnik; Cc-below the influx of the river Lesidrenska; D- for the slope and determination of the influence of the karst-type springs on the hydrological characteristics of the river by transferring the hydrometric station No.63 of the springs.-

(p.87)(Table 3 cont.) X. RIVER BASIN OF THE ISKUR RIVER.

74) B- river Pryaka; Ca- village of Govedarci; D- growth of the areas, slope, forests, and soil characteristics.- 75) B-river Pancharevska Bistrica; Ca- village Panchareva(-vo); D- growth of the areas.- 76) B- river Sukha; Ca- place of Ravna; D- growth of the area, slope, soil characteristics, and forestry. - 77) B- river Iskur; Ca- village of Reselec; D- growth of areas, slope, soil characteristics, forestry.-

78) B- river C.Bistrica; Cb- from the [redacted]ponds; D- forestry and soil characteristics.- 79) B-river Iskyr; Cc- village Pasarel below the dam wall; D- rected structure of water engineering.- 80)B- river Ch.Iskur; Cc-upper course; D- soil characteristics.- 81) B- river Blato; Cc- village of Opocvet; D- karst-type springs.- 82) B- river Iskrecka; Cc- at the springs; D- karst-type springs.- 82)(83) B- river Little Iskyr; Cc-village Dzhurovo; D- slope and forestry.

XI. THE RIVERS WEST OF THE ISKYR RIVER

84) B- river Srebyrna; Ca- village Komoshtica; D- growth of the area, forestry, slope, and regimen disturbed by the irrigation canal.- 85) B-river Sredna; Ca- village of Komoshtica; D- growth of the area, forestry, slope, and regimen disturbed by the irrigation canal.- 86) B- river Vodenichna; Ca- place Petrokhan; D- growth of the area, soil character, forestry, and disturbed regimen.- 87) B- river Stara; Ca- above the village Zanozhene; D- growth of the area.- 88) B-river Shirine; Ca- place Petrokhan; D- growth of the area, slope and forests.- 89) B- river Dyasna; Ca- village of Byrziya; D- growth of the area and forests.- 90) B- river Chiprovska; Ca- Chiprovci; D- growth of the area, and slope.- 91) B-river Golyama; Ca- village of G.Lom; D- growth of the area, forestry, and slope.- 92) B- river Little Ogosta; Cb- from the village Goveshda, above its influx into the Ogosta; D- forestry, slope, and soil characteristics.- 93) B- river Cibrica; Cb- from the village Cibyr above the irrigational system; D- regimen disturbed by the irrigational system.- (p.88) 94) B- river Stanevska; Cb- from the village of Borodica above its influx into the river Lom; D- because of a future structure of water engineering.- 95) B- ~~xx~~ at the left irrigational canal at the place Petrokhan; Cc- above the equalizer; D- due to waters thrown from the southern slopes into the basin of the river Byrziya.- 96) B- at the right irrigational canal of the place Petrokhan; Cc- above the equalizer; D- due to the reason under No.95.- 97) B- river Byrziya; Cc- above the influx into the Ogosta river; D- growth of the area and disturbed regimen of the river.- 98) B- river Ogosta; Cc- at Mikhailovgrad; D- growth of the area, soil characteristics, and future structure of water engineering.

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III. CHANGES OF THE OBSERVED HYDROLOGICAL AND METEOROLOGICAL ELEMENTS IN RESPECT TO THE THUS PROPOSED NETWORK OF HYDROMETRIC STATIONS.

In the formation of the surface runoff, a series of meteorological factors such as precipitation, temperature, evaporation, humidity, etc., exercise an influence, but we shall consider the distribution of the network of hydrometric stations only in reference to the precipitations, the temperature and the deficit of humidity. Of particular interest is also the evaporation, but, due to insufficient data about it, we cannot say much about it.

DISTRIBUTION OF THE HYDROMETRIC NETWORK OF STATIONS IN RESPECT TO PRECIPITATIONS FOR THE PERIOD 1896 / 1945.

The precipitations are the most important meteorological factor at the formation of the surface runoff. With all other conditions equal, with the increase of precipitations the runoff is also increased. The magnitude of the runoff depends not only upon the amount of the fallen precipitations but also upon the circumstance when and how these precipitations have occurred. Thus, for instance, if the precipitations have occurred in winter time, the larger portion of them will go in the form of a surface runoff into the river; if the same precipitations have occurred in the summer warm period, the percentage of loss by infiltration and evaporation would be considerably larger.

On the other hand, the runoff in a given year is undoubtedly influenced also by the precipitations of the preceding year, and in some instances also by several preceding years. The indirect influence of precipitations of the previous year is also manifested in the preparedness of the drainage area for a surface runoff during the next (current) year. (p. 89) Because of this mentioned different influence of the precipitations upon the runoff, it becomes necessary to uniformly cover all districts of different precipitations by the network of hydrometric stations.

The full idea of the distribution of hydrometric stations in the thus proposed network, in reference to the precipitations, can be gathered from Table 4, and for the map of precipitations (8). In the Table, the distribution of hydrometric stations is given according to the volume of precipitations.

TABLE 4: (LEGENDS of the columnar heads): a- precipitation in mm; b- precipitation volume in million cubic m; c- number of hydrometric stations; d- precipitation volume corresponding to one station, in million cubic m.

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On the basis of the data of Tabel 4, on Fig. 1 the ratio between the precipitation volume and the distribution of hydrometric stations is graphically represented.

FIG. 1: (LEGENDS); a) ordinata: Precipitation volume in million cubic m; b) on abscissa: Number of hydrometric stations.---

From the thus determined functional relationship,it,can be seen that in general in reference to the precipitation volume, the hydrometric stations are evenly distributed for the entire country.

The data of Column 4 of Table 4 show that ,with the exception of the precipitations between the isohyets 1100 and 1200,there is a precipitation volume of 310 million cubic m to 201 million cubic m per station. The upper limit of 310 million cubic m is related to the lower plains sections where the precipitation gradient is the smallest,and the physico-geographical conditions are the most homogenous. Between the isohyatal lines 600 and 700,relatively smaller precipitation volume corresponds to the individual stations. This is due to a large number of stations in this zone which must be opened chiefly(p.90) for the needs of the future larger water engineering structures. If these stations are not takne into consideration, about 250 million cubic m of precipitation volume is reached per station. According to this precipitation limit,the precipitation volume,corresponding to the individual stations, steadily decreases,which fully coincides with the increase of the precipitation gradient and with the increase of the diversity in respect of physico-geographical characteristics. The latter characteristics particularly well illustrate the correct distribution of the network in respect to precipitation.

All these characteristics are deduced on the basis of generalizing the precipitation data for the entire country where the positive and negative deviations in the individual river basins mutually cancel each other. That is why the individual drainage areas must be examined, and the network of hydrometric stations in them must be subordinated to the so deduced relationship.

From Table 5,in which the precipitations are given by the different drainage areas, it can be seen that there are districts between the separate isohyets which are characterized by few stations,or there are no stations in them,while there are also such districts in which a certain accumulation of hydrometric stations can be found.Of the latter,there is nothing that would catch our attention,since they are forced by the already examined elements, and we shall only consider those districts in which new stations must be opened in regard to the precipitation volume.

The districts with insufficient number of stations in the individual river basins,as well as those without stations,are examined in regard to the precipitation volumes for the corresponding isohyets(Table 4- column 4). The results are given in the next column of Table 5,according to which new stations should be opened in the following river basins:

RIVER BASIN OF THE STRUMA RIVER.- In the river basin of the Struma river, according to the finished analysis, 8 stations should be opened, namely between the isohyets 800 and 1000. The districts with this precipitations are in the high sections of the Pirin, Rila, and Vitosha mountains, and along the western border itself. The characteristic for this district, with the exception of Vitosha, is that the precipitation gradient after isohyet 800 is decreasing evenly and significantly. Moreover, while the great maintenance difficulties of the hydrometric stations in the high mountainous sections are taken into consideration, it is proposed to open only 3 stations, namely:- one in the upper course of the river Eleshnica, at the village of Rakovo; one in the upper course of the rivers Blagoevgradska Bistrica and Sandanska Bistrica. With these stations, the change in the precipitation gradient is chiefly enveloped. Along the Vitosha, the precipitation gradient does not change, on account of which no provision was made to open new stations, notwithstanding the fact that there are districts with such precipitation.

RIVER BASIN OF THE RIVER ARDA.- In the river basin of the Arda river, only three stations should be opened one of which should be between the isohyets 700 and 800 and two between 900 and 1100. Between the isohyets 700 and 800 a station is opened for each river, with the exception of the river Davitkovska, which in regard to precipitation gradient is not different at all from the Chamdere river; for the latter, it was planned to open a station. The districts with precipitation over 900 are around Smolyan and along the southern border itself. The district around Smolyan is sufficiently elucidated by hydrometric stations for which reason (jump to p.93) only one station is planned for opening, namely for the river Syutlijka at the town of Zlatograd which coincides with the mid-continental-marine moisture-bearing air currents, and has a strongly torrential character.

(p.91). TABLE # 5: (LEGEND : Average yearly precipitations by river basins for the period...

(COLUMNAR HEADS OF TABLE 5): a- river basin; b- precipitation in mm; c- volume of precipitation in million cubic m; d- number of hydrometric stations; e- number of hydrometric stations to be opened.

(RIVER BASINS LISTED ON TABLE 5.): f- Struma; g- Mesta; h- Arda; i- Marica; j- Tundzha; k- south of the river Kamchiya; (p.92 Table 5 cont.) l- Kamchiya; mm- Provadijska; n- the Dobrudzha rivers; o- Rusenski Lom; p- [redacted] q- Osym; r- Vit; (p.93) s- Iskyr; t- Ogosta; u- west of the Iskyr; v- Total*(FOOTNOTE: In the number of stations(263) the posts along the Black Sea and the lakes as well as those of the karst-type springs were not included).

(text of p.93 cont.) ROVER BASIN OF THE MARICA RIVER.- As it is seen from Table 5, in the river basin of the river Marica, in regard to the precipitation volume, only one station should be opened, namely in the district between the isohyets 600 and 700. In this district, on the left side of the river basin, one of the stations proposed for closure may remain for the river Gizdica at Peshtera, for the river Chepinska below Velingrad and for the river Pyrvenecka whose regimen is disturbed by the water reservoir for the water supply of the city of Plovdiv. While the distribution of the precipitation gradient is taken into consideration, the most suitable is to continue the existence of Stations No.303 for the river Pyrvenecka, while it is transferred in regard to the fact that the disturbance of its regimen is avoided. In this section of the river, from the isohyet 600 to the isohyet 800, a marked increase of the precipitation gradient is observable.

(p.94) On the left side of the river basin, the precipitation gradient is very small, and there is no sense in opening a new station.

IN THE RIVER BASIN OF THE RIVER TUNDZHA only one station should be opened between the isohyets 500 and 600. Because of a slightly changing precipitation gradient in this district of the river basin, it is not planned to open this station.

THE DISTRICT OF THE RIVERS FLOWING DIRECTLY INTO THE BLACK SEA SOUTH OF THE KAMCHIYA.- In this district the number of stations is also sufficient, though it should not be subordinated to the common relationship. In the larger section the precipitation gradient is very small, and in that part where the gradient is larger the stations are sufficient in number. By this consideration one station might be only opened for the river Rusokastrenska at the village of Rusokastro.

NORTHEASTERN BULGARIA.- In this section of the country the river basin of the rivers Kamchiya, Provadijski, Rusenski Lom and the rivers in the Dobrudzha are included. Here, the precipitations move between 500 and 700 mm, with the exclusion of the river basin of the Kamchiya river where it reaches also up to 800 mm. From the map of precipitations(8) it is seen that the precipitation gradient is very small, and while attention is paid also to the fact that in the Dobrudzha the number of rivers is small, one also takes into consideration that a larger part of them are dry in their lower course, waterless; one may think that the already open stations and those which are planned for opening according to Table 3, will be sufficient and correctly distributed in regard to rainfall.

RIVER BASIN OF THE YANTRA RIVER. — In the river basin of the Yantra river, according to the already established relationships, 6 new stations should be opened. However, by the completed analysis, it is proposed that between the isohyets 700 and 800 a station be opened for the river Zlatarica and that the existence of Station No. 75 on the river Belica should be continued. The first is in a district of small precipitation gradient, and the other is directly under the zone of a large gradient. To continue the existence of Station 72 on the river Rosica, between the isohyets 1000 and 1100, which covers a district of a strongly changing precipitation gradient, a station between the isohyets 1100 and 1200 cannot be opened since this district is in the highest section of the Balkan, and it can be hardly maintained and serviced. The remainder of the stations are not proposed chiefly on account of the uniformly changing precipitation gradient, and for lack of special characteristics.

RIVER BASIN OF THE OSUM RIVER. — According to Table 5, in the river basin of the river Osum, four stations must be opened. However, on account of the special form of the drainage area of the river — long length and narrow width, without a more important tributary — it is proposed to open no new stations. It has been thought to open a station in the upmost course of the river to embrace the district of large precipitations — above 1000 mm, but for the already pointed-out reasons in regard to the Yantra river, such a proposition is not made.

RIVER BASIN OF THE RIVER VIT. — In this river basin, two stations are planned for opening. The first of them is between the isohyets 600 and 700, which district is of very slightly changing precipitation gradient, and moreover it is embraced by two stations, on account of which it is not proposed for opening. The second is in the upper section of the river, with precipitations above 1000, but here (p. 95) directly under the isohyet 1000 the opening of a new station has been proposed; hence it is not necessary to open a second station.

RIVER BASIN OF THE RIVER ISKUR. — In the river basin of the Iskur, three stations are proposed for opening one of which is between the isohyets 500 and 600 and two are between the isohyets 800 and 900. The first does not have any sense absolutely since this is chiefly a district of the lower course of the river where the precipitation gradient is very small ,and moreover there are no more important tributaries of the river. Between the isohyets 800 and 900 a station could be opened, only for the river White Iskyr which was also urged by other elements, but because of the regimen disturbed by the White Iskyr dam, and for the impossibility to maintain a station of the Hydrometeorological Service in this district on account of its defensive(military) nature, opening of a station is not provided for .

From the thus completed analysis of the hydrometrical stations in regard to the precipitation volume, it is proposed to open six new stations, and to continue the existence of three of the old stations.

DISTRIBUTION OF THE HYDROMETRIC STATIONS IN REGARD TO THE AVERAGE ANNUAL TEMPERATURE FOR THE PERIOD 1916/1945.

From what had been said about the precipitations, it can be seen that precipitations are one of the most important factors in the formation of the surface runoff. The different amounts of precipitation and their regimen of occurrence, however, are associated with a number of climatic factors, such as temperature, humidity of the air, air currents, evaporation, etc. That is why the temperature of the air must be related to the basic climatic factors of the runoff.

The temperature of the air influences the formation of runoff in other ways also, namely, the negative temperatures condition the falling of precipitations in solid form(composition), and during winter time the positive temperatures produce the melting of the snow cover, due to which the spring high waters are reduced. On the other hand, the high temperatures during spring, summer andfall provoke (produce) great losses of the fallen precipitations. This way the temperature of air directly influences the magnitude and shape of the runoff.

Almost in all empirical formulae for the determination of the surface runoff, the temperature also takes a part. The Soviet hydrologists, in their formulas for the computation of the annual runoff, also take into consideration , together with the precipitations, the magnitude and the distribution of the temperature during the year.

As the thus proposed network of hydrometric stations is arranged in juxtaposition with the map of distribution of the temperature(8), the results are obtained which are given in Table 6.

With the data obtained from the above Table, Fig. 2 was constructed from which it is seen that with the decrease of the average temperature the corresponding areas of the given stations also decrease, which fully coincides with the increase of the temperature gradient. This is especially(p.96) characteristic for the district with an average temperature above 10° C, from where the temperature gradient is rising very rapidly. At getting this relationship, the areas and the stations above 14° C, which are only two, were not taken into consideration.

TABLE 6: (LEGEND of columnar heads): a- temperature; b- areas in sq. Km; c- number of hydrometric stations; d- area per station.

FIG 2:(LEGENDS): a) square Km; b- are per hydrometric station.

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If analysis is made of the distribution of the hydrometric stations in respect to the temperature in the individual drainage areas, similarly to those which have been made at the examination of the precipitations, new stations should be opened (see Table 7).

RIVER BASIN OF THE RIVER STRUMA.- The lower and the middle course of the river are characteristically marked by an uniformly variable temperature gradient, and the upper course-- by a slightly changing one. According to Table 7, in the river basin eleven new stations should be opened. Of these, two are between the isotherms 12 and 14. This district stretches, however, in a narrow stripe on both sides of the river where the regimen of the tributaries is disturbed by numerous primitive water takers during the larger part of the year, for which reason the existing stations have been opened above this zone. Due to this reason, the opening of this station is not considered. A new station between isotherms 8 and 10 is not recommended because of the slightly variable temperature gradient in the larger portion of the river basij(p.97) Under isotherm 8°, only three stations, instead of 8, are proposed for opening, namely the following:- one on the river Eleshnica, at the village of Rakovo, between isotherms 4 and 6, directly at isotherm 4°, and one on river Blagoevgradska Bistrica, between isotherms 6 and 8. It is superfluous to open the remaining stations, since a large part of the river basin is a high plateau of one and the same temperature(Breznishko and Radomirsko fields).

TABLE 7:(LEGEND : a- river basins; b- temperature; c- area in square Km; d- number of existing hydrometric stations; e- number of hydrometric stations to open. (cont. Table)

(Entries in colum a1) 1. Struma; 1 b: below 4°; 2. Arda; 3. Marica; 4. Tundzha; 5. south of Kamchiya; 6. Kamchiya; 7. Provadijska; 8. the rivers of the Dobrudzha; 9. Yantra; 10. Osum; 11. Iskur; 12. Ogosta.

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(Text continued) RIVER BASIN OF THE RIVER ARDA.- As the district between the isotherms 10 and 12° is outlined, it is seen that the single chance for opening a new stations is that for the river Syutlijka, at Zlatograd.

RIVER BASIN OF THE MARICA RIVER.- In the river basin of the Marica river, only two stations should be opened one of which is between the isotherms 12 and 14° and one is between 6 and 8°. Instead of opening a new station between the isotherms 12 and 14° it is recommended to continue the existence of one of the Stations No. 303 on the river Purvenecka, and No. 344 on the river Dobrich, while chiefly the first is preferred because of the fact that it is also urged in respect to precipitations. As to a station between the isotherms 6 and 8°, it is recommended also that one of the following stations should be kept: Station No. 276 on the river Renesdere, and No. 245 on the river Kriva, above Sestrimo, while preference is chiefly giben to that which is also urged by some other factors.

IN THE RIVER BASIN OF THE TUNDZHA RIVER, according to Table 7, there seems to be need only for one station for the elucidation of the district between isotherms 6 and 8°. This district is directly under the ridge of Old Mountain where it is very difficult to supply and to maintain a hydrometric station, and also additionally, directly above the isotherm 8° there is Station No. 340 on the Muglushka river whose drainage area is entirely in this zone.

IN THE DISTRICT OF THE RIVERS FLOWING DIRECTLY INTO THE BLACK SEA AND OF THOSE IN THE DOBRUDZHA, the average temperature moves in the range from 10 to 13°, with the exception of a very small district in the southern portion of the seashore where the average temperature reaches 14° as well as in a small district in the upper course of the river Kamchiya where the temperature reaches up to 8°. From this it can be seen that over this section of the country the temperature gradient changes but very slightly. Consequently, it cannot be the decisive factor at the opening of new stations, and also it does not require a large number of stations. That is why in this district new stations in regard to the temperature are not recommended for opening.

(Entries in colum a:) 1. Struma; 1 b: below 4°; 2. Arda; 3. Marica; 4. Tundzha; 5. south of Kamchiya; 6. Kamchiya; 7. Provadijska; 8. the rivers of the Dobrudzha; 9. Yantra; 10. Osum; 11. Iskur; 12. Ogosta.

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(Text continued) RIVER BASIN OF THE RIVER ARDA.- As the district between the isotherms 10 and 12° is outlined, it is seen that the single chance for opening a new stations is that for the river Syutlijka, at Zlatograd.

RIVER BASIN OF THE MARICA RIVER.- In the river basin of the Marica river, only two stations should be opened one of which is between the isotherms 12 and 14° and one is between 6 and 8°. Instead of opening a new station between the isotherms 12 and 14° it is recommended to continue the existence of one of the Stations No. 303 on the river Purvenecka, and No. 344 on the river Dobrich, while chiefly the first is preferred because of the fact that it is also urged in respect to precipitations. As to a station between the isotherms 6 and 8°, it is recommended also that one of the following stations should be kept: Station No. 276 on the river Renesdere, and No. 245 on the river Kriva, above Sestrimo, while preference is chiefly giben to that which is also urged by some other factors.

IN THE RIVER BASIN OF THE TUNDZHA RIVER, according to Table 7, there seems to be need only for one station for the elucidation of the district between isotherms 6 and 8°. This district is directly under the ridge of Old Mountain where it is very difficult to supply and to maintain a hydrometric station, and also additionally, directly above the isotherm 8° there is Station No. 340 on the Muglushka river whose drainage area is entirely in this zone.

IN THE DISTRICT OF THE RIVERS FLOWING DIRECTLY INTO THE BLACK SEA AND OF THOSE IN THE DOBRUDZHA, the average temperature moves in the range from 10 to 13°, with the exception of a very small district in the southern portion of the seashore where the average temperature reaches 14° as well as in a small district in the upper course of the river Kamchiya where the temperature reaches up to 8°. From this it can be seen that over this section of the country the temperature gradient changes but very slightly. Consequently, it cannot be the decisive factor at the opening of new stations, and also it does not require a large number of stations. That is why in this district new stations in regard to the temperature are not recommended for opening.

RIVER BASIN OF THE RIVER YANTRA.- In the river basin of the Yantra river, according to Table 7, four new stations should be opened. From the map of isotherms it can be seen that after isotherm 8° the temperature gradient in the river basin is quickly rising. Therefor, it is XXX necessary to open stations above this isotherm. For the complete coverage of the change in the gradient in this section of the river basin it is proposed to open new stations on the river Zlatarica, a little below the isotherm 10, and on the river Belica, directly after its influx into the rivers.

It would be also necessary to open in this district a station for one of the rivers Vidiam--at Novo Selo, or the river Rosica--at Stokite; yet because of the fact that directly below isotherm 10° there are stations in existence for the two rivers, it is not recommended to open new ones. Between the isotherms 6 and 8°, the most suitable place for opening a new station is on the river Yantra at Etyryt. This way, in this temperature zone, there shall be two hydrometric stations, namely correctly distributed, i.e., one in the eastern side of the river basin, and the other in the western half.

For the river basin of the river Osym, the same holds good that was said at the examination of precipitations, for which reason it is not recommende to open a new station.

RIVER BASIN OF THE RIVER ISKYR.- Here, only one station should be opened-- below the isotherms 10 and 12°, yet this zone covers entirely the lower and partly the middle course of the river where the temperature changes very little, and this is anyhow the district which is elucidated by eight stations, due to which the opening of a new station is not recommended.

RIVER BASIN OF THE RIVER OGOSTA.- Here also, the need seems to be only for one station, namely between the isotherms 6 and 8°. However, directly above the isotherm 8° three stations are in existence:- on the river Ogosta--at (p.99) Chiprovci; on the river Dylgodelska, and on the river Botunya--at Vyrshec, due to which it is entirely superfluous to open a new station in a direct proximity to these stations. For the single remaining tributary, the river Berziya, there is no chance to open a station because of the disturbed regimen of the rivers in its upper course.

In this same way, an attempt was made to examine the network of the hydrometric stations also in regard to the deficit of humidity; yet, satisfactory results had not been reached which is due first of all to the insufficiently accurate map on the deficit of humidity which had been constructed for entirely different purposes.

Independently from this, the well expressed relationship between the number of the stations in the network on one hand, and the precipitations and the temperature on the other hand may be accepted as satisfactory. Of course, it would be much better if sufficient amount of data on the evaporation and on the distribution would be at our disposal, and the network could be harmonized in regard to this element too.

The existing relations between the precipitations and the temperature with the above-sealevel altitude corroborate the correct division (distribution) of the stations in regard to this element, too.

DISTRIBUTION OF THE NETWORK OF HYDROMETRIC STATIONS IN REGARD TO The MODULUS OF RUNOFF FOR THE PERIOD OF 1935/36 - 1949-50

One of the most importanttask of the network of hydrometric stations is, by the data which are collected in it, to render the complete characterisation of the modulus of the runoff for the entire country. Therefore, it is essential, in addition to a sufficient number of stations, that these stations should be correctly distributed also so that they would cover all characteristics of the runoff. A good possibility for the correct distribution of hydrometric stations in regard to this element is given by the map of the isolines for the modulus of the runoff during the period from 1935/36 to 1949/50, worked out in the Hydrometric Service. At the preparation of the map for the modulus of the runoff, great difficulties were encountered which chiefly consisted in the fact that very few stations had at their disposal 15-year period of observations, and it was urged to a larger degree by the stations which took part in the composition of the map that the series should be lengthened(extrapolated), which led to a certain uncertainty. And there were also districts in which no hydrometric stations existed, and the isolines were passed over very vaguely. But, independently from these weaknesses, the thus prepared map could be successfully used at the distribution of the hydrometric stations in the country, as by these stations those sites were namely filled where the need was felt for them during the elaboration of the modulus.

On the basis of the map of the modulus of runoff(8) Table 8 was prepared from which it can be seen that up to M_0= 20 l/sec Km^2 a well-expressed relationship exists between the runoff and the number of hydrometric stations.

From the results in Table 8, Figure 3 was composed which corroborates this relationship. The deviation from this relation over (p.100) $M_0 = 21$ l/sec Km^2 is due to the fact that in the top districts of the river more stations were opened, which is entirely not superfluous since there the runoff is the largest and usually the least explained, because of the difficult conditions for observation.

TABLE 8: LEGEND of columns: a- Modulus of runoff in liter/sec Km^2; b- runoff volume in liter/sec; c- number of hydrometric stations; d- runoff volume per one hydrometric station, in liter per sec.

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FIG.3: LEGEND: a) (ordinata) Modulus liter/sec/Km^2; b) (abscissa) liter/sec; c) runoff volume per one hydrometric station.

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By gradual re-addition of the runoff and the stations, Table 9 and Figures 4 and Fig.5 were composed, which also confirm the good relationship between the modulus of the runoff and the number of stations.

Apart from the existence of such a relationship in general for the entire country between the modulus and runoff, and the number of the stations in the separate river basins, as seen from Table 10, Columns 7 and 9, certain deviations exist, as in a few river basins the number of stations is insufficient (Struma, Arda, Yantra, etc.) and in others the number of stations is sufficient and even excessive (Mesta, Marica, Ogosta, and Iskŭr). For these river basins or for a part of the basins in which the number of the stations appears to be larger than what is necessary in respect to the modulus, proposal for the closure of the stations is not made since their existence is forced by the elements considered in paragraphs I and II (sections).

By subordinating the separate river basins to this general relationship between the modulus of the runoff and the number of stations, the following results are obtained:

(p.101) RIVER BASIN OF THE RIVER STRUMA:- in accordance with Table 10, in the river basin of the Struma river seven stations should be opened three of which are between the isolines of $M_0 = 10 - 15$. As the most suitable places in respect to the distribution of the modulus, the upper courses of the rivers are proposed:-Vlakhinska, flowing into the Struma at the town of Pirin; Blagoevgradska Bistrica, Sandanska Bistrica, and Elishnica. The following stations which should be opened are those in the district of the isolines 15 and 22. Such districts are in the highest parts of the mountains of Pirin, Rila and Vitosha, but here the maintenance of the hydrometric stations is very difficult and almost impossible, for which reason it is not proposed to open a station. The same holds tru, namely with a still greater difficulty, also for the station between the isolines 30 and 35.

DIG.4; LEGEND: a- Modulus liter/sec/Km^2; b) liter / sec; runoff volume per one hydrometric station.

FIG.5; LEGEND: a) Modulus liter/sec/Km^2; b) number of hydrometric stations.

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RIVER BASIN OF THE ARDA RIVER.- In the river basin of the Arda river, three stations are planned for opening:- the stations between the isolines 10 and 25 on the river Syutlijka at Zlatograd; between the isolines 7.5 and 10, on the river Chamdere. The stations below 7.5 l/sec/Km^2 are not proposed for opening because of the very accurate spacing of the existing stations, and the station above $M_0 \cong 25$ --- because of the fact that this district is directly at the very border line.

RIVER BASIN OF THE TUNDZHA RIVER.- Here, it is necessary to open only three stations, namely between the isohyets(isolines) 10 and 20 liter/sec/Km^2. The isolines in this zone are evenly distributed with one and the same gradient, for which reason it is recommended to open only one station, namely in the upper course(p.102) of the Radova river, and to transfer into this district and to continue the existing station No.320 on the river Akdere.

RIVERS FLOWING DIRECTLY INTO THE BLACK SEA.- In this district, of all seven stations which must be opened according to Table 10, it is proposed to open only four. Two of them are for the river Rusokastrenska, and the river Dvojnica, which XXXX are not hydrometric stations at all. The remaining two are recommended to be opened on the river Luda Kamchiya at the village of Lyulyakovo, and the village Gradec, with which the changes in the specified gradient of the river basin are covered.

TABEL 9; LEGEND; a- Modulus of runoff in liter/sec/Km^2; b- runoff volume in liter/sec; c- number of hydrometric stations; d- runoff volume per one hydrometric station, in liter/sec.

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IN THE DOBRUDZHA it is planned to open only one station which is proposed to be at the upper course of the Sukha river, above the village of St, Karadzha.

RIVER BASIN OF THE YANTRA RIVER.- In the river basin of the river Yantra three

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stations should be opened. Two of these stations must be between the isolines 7.5 and 10, for which it is proposed to continue the existing No.75 station on the river Belica, and Station 72 on the river Rosica. The third station may be opened for the Yantra river at the village of Etyryt.

IN THE RIVER BASIN OF THE OSYM AND VIT rivers, new stations are not proposed for opening between the isolines 15 and 20 since, even for the two rivers, stations (p.107 jump) are available directly below the isohyet 15 and still two stations to open is wholly unnecessary and formal.

(p.103) TABLE 10: <u>MODULUS OF THE MEAN MULTI-ANNUAL RUNOFF</u>

PERIOD 1935/36 - 1949/50.

(LEGEND OF COLUMNAR HEADS): 1- Modulus of runoff between the isolines; 2- runoff volume in liter/sec; 3- number of stations; 4- persistent sum of the runoff volume in liter/sec; 5- persistent sum of the stations; 6- runoff volume corresponding to one hydrometric station in liter/sec; 7- consistent sum of the required number of stations; 8- number of stations to be closed.

(LIST OF RIVERS:) Struma, ~~Marksa~~ Mesta, Arda, Marica(p.104 cont.) Tundzha, Aouth of the Kamchiya, Kamchiya;(p.105 cont.) Provadijska, rivers of the Dobrudzha, Rusenski Lom, Yantra, Osym;(p.106 cont.) Vit, Iskyr, Ogosta, (p.107 cont.) west of the Iskyr.

(Text continued on p.107) RIVER BASIN OF THE ISKYR.- In the river basin of the Iskyr river, all four stations should be opened one of which is below the isohyet 1. This district coincides with the zone of backpush of the waters in the river ~~EX~~ caused by the Duna, and there is no sense in opening it. Of the remaining stations the existing Station No.107 is to be continued on the river Sukha, and the possibilities are studied for the opening of a station on the river White Iskyr which is also urged by many other reasons.

DISTRIBUTION OF THE NETWORK OF HYDROMETRIC STATIONS IN RESPECT TO THE RUNOFF COEFFICIENT AND THE COEFFICIENT OF VARIATION FOR THE PERIOD OF 1935/36 - 1949/50.

Similarly to the elements examined until now, an analysis has been made of the network of hydrometric stations both in respect to the runoff coefficient and the coefficient of variation.

The results of this analysis are given for the runoff coefficient in Table 11, and Fig. 6, and for the coefficient of variation - in Table 12 and Fig. 8.

From Fig. 6, it can be clearly seen that between the runoff coefficient and the number of stations, expressed in surface area, corresponding with one station(p.108) a certain relationship exists. This relation consists in the fact that with the increase of the runoff coefficient, the surface area corresponding to single stations is decreased.

TABLE 11: (LEGEND): a) runoff coefficient; b- area in square Km; c- number of hydrometric stations; 4- area in square Km per one station.

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FIG. 6: (LEGEND): a- (ordinata) runoff coefficient; b)(abscissa) surface area per one hy rometric station in square Km.

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This indicates that, generally taken, the network of hydrometric stations is correctly distributed , and it covers well the characteristics of the runoff coefficient. However, this relation is not so close, i.e., not so well expressed as with the modulus of the runoff, which is due to a large number of factors that influence the runoff coefficient some of which are not taken into consideration. For the reason that this relationship moves in a wider range it is not used for the enlargement of the number of stations in the individual drainage basins.

The relationship which is obtained between the coefficient of variation and the number of stations is till weaker expressed(Fig. 7). Especially very much deviated from the mean dependence are the points above $C_v \cong 0.6$. This is due to the fact, too, that a number of factors have not been taken into consideration which factors influence the coefficient of variation. Thus, e.g., it can be seen from the map of isolines of the coefficient of variation that there are even districts in which, with the increase of the runoff, the C_v coefficient also increases, and there are also increasing some additional other deviations.

For this reason this relationship is also discarded in enlarging the density of the stations in the individual drainage basins. In exchange for this, the change of the gradient of the coefficient of variation has been examined in detail(p.109).

TABLE 12: (LEGEND of columnar heads): a- coefficient of variation; b- area in square Km; c- number of hydrometric stations; d- are in square Km per one hydrometric station.

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FIG. 7: LEGEND: a- (ordinata) coefficient of variation C_v; b- (abscissa) area per one hydrometric station in square Km.

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(Text continued)..from which it can be seen that with the proposed network of hydrometric stations and the addition to it in conformity with the precipitations, and the temperature and the runoff, all characteristic changes in the coefficient of variation are covered.

From the meteorological and hydrological elements examined until now it is proposed to open 13 more new stations, and to keep five of those that were proposed for closure.

In this way the data given in TABLE 13 are supplemental to Table 3.

// This way, a network of 304 hydrometric stations is obtained of which stations
// eight are posts at the Black Sea and some lakes. A complete list of the so re-
// formed network of hydrometric stations is given at the end, and its distribu-
// tion is given on the map in the Annex. In this number, the hydrometric stations
// which are proposed for opening at the head of the main canals of the irrigation-
// al system are not included.

(p.110) TABLE ~~XX~~ 13: (LEGEND OF COLUMNAR HEADS): a- number in series; b- river; c- to be continued; d- transfer; e- opening; f- factors which demand the change.

I. RIVER BASIN OF THE STRUMA RIVER.

1. b- Eleshnica; e- village of Rakovo; f- precipitation, temperature and modulus.- 2. b- Blagoevgradska Bistrica; e- in the upper course; f- as in 1.- 3. b- Vlakhinska; e- in the upper course; f- as in 1.

II. RIVER BASIN OF THE ARDA RIVER.

4. b- Chamdere; e- in the lower course; f- precipitation, temperature, and modulus.- 5. b- Syyutlijka; e- Zlatograd; f.- same as 4.

III. RIVER BASIN OF THE MARICA RIVER.

6. b- Pyrvenecka; c- middle course; f- precipitations and temperature.

IV. RIVER BASIN OF THE TUNDZHA RIVER.

7. b- Akdere; c- the upper course; f- modulus.- 8. b- Radova; e- the upper course; f- modulus.

V. RIVERS FLOWING INTO THE BLACK SEA DIRECTLY.

9. b- Rusokastrenska; e- village of Rusokastro; f- precipitations, modulus, and coefficient of variation.- 10. b- Dvejnica; e- in the lower course; f- modulus.-

11. b- L. Kamchiya; c- village of Lyulyakovo; f- modulus. - 12. b- L. Kamchiya; c- village of Gradec; f- modulus.

VI. RIVERS IN THE DOBRUDZHA.

13. b- Sukha; c- in the lower course; f- modulus.

VII. RIVER BASIN OF THE YNATRA RIVER.

14. b- Yantra; c- village of Etyryt; f- temperature and modulus. - 15. b- Rosica; c- village of Valevci; f- precipitations and modulus. - 16. b- Belica; c- village of Vylgevci; f- precipitations, temperature and modulus.

VII. RIVER BASIN OF THE ISKYR.

17. b- Sukha; c- Ravna; f- modulus. - 18. b- White Iskyr; c- in the upper course; f- modulus, precipitations andtemperature.

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Generally, for the entire country it is proposed

to close. . . . . 37 hydrometric stations
to transfer. . . . . . 10 " "
to open . . . . 59 " "

(p. 111) In the thus proposed number of hydrometric stations, those along the Duna are not included where three hydrometric stations of the existing five stations are completely sufficient for the elucidation of the regimen of the stream in the district of our border.

As the most suitable for closure are:- the station in Lom, which is very close to the station in Novo Selo, and the station in Silistra, since the latter is at the border where the river leaves our country, and the hydrological data are without any significance for us.

After such an analysis of the network of hydrometric stations in regard to the hitherto enumerated elements, the network is also considered in reference to the density of the river network. For the purpose the map, compiled on the density of the river network, has been used(8).

From Table 14 and Fig. 8, it can beseen that a good relationship exists between the density of the river network and the number of the hydrometric stations. The network of hydrometric stations is correctly distributed, as with the increase of the coefficient of density the area per station quickly increases.

TABLE 14: (LEGEND OF COLUMNAR HEADS): a- coefficient of density; b- to area per square Km; c- number of hydrometric stations; d- area per one station.

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Since on its part the density of the river net mostly depends upon the precipitations, on the forest coverage, on the slope and the pedo-geological structure of a given region, the relationship thus obtained once more corroborates the correct distribution of the network of hydrometric stations in regard to the examined physico-geographical characteristics.

For the acquisition of a complete and good hydrological characterization of some of the hydrological elements, the correct distribution of the hydrometric stations alone is not sufficient, but the given area must be also well elucidated by meteorological and pluviometric stations. Very frequently in the hydrological practice it happens that characterization of a given hydrological element is made, or interpretation of some hydrological phenomena is given, only on the basis of data for the meteorological elements.

All this requires an estimation of the distribution of meteorological and pluviometric stations in regard to the drainage areas of the hydrometric stations. For this purpose, on the map of the drainage areas, all meteorological and plubiometric stations have been marked, and on the basis of this, Table 15 was compiled.

(p. 112) From Table 15, it can be seen that the meteorological and the pluviometric stations are almost sufficient and evenly distributed over the entire territory of the country. Only a few small drainage areas are not provided with pluviometric stations, namely chiefly in the high mountainous sections. To cover also these gaps, for the country in general it is proposed to open 39 pluviometric stations distributed by the drainage areas in accordance with the attached list and Map 10 of the Annex.

Finally, it must be remarked that all the proposals made for opening of new stations, both hydrometrical and meteorological, must be specified as to the very site so that the most suitable quarters are selected.

Moreover, the stations which are proposed for closure and transfer must be investigated jointly with the interested authorities when those stations which are necessary for these purposes pass over into the special network.

This way as the scientific elaboration of the network is combined with the selection of the suitable quarters for the stations and the good provision of the same quarters, the collection of good and high-quality hydrological data is secured, so necessary for our construction enterprise and for the national economy.

FIG. 8: LEGEND: a- ordinata: coefficient of density; b- abscissa: surface area in square Km per hydrometric station.

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TABLE 15: LEGEND OF COULMNAR HEADINGS: a- surface area of the drainage region in square Km; b- number of drainage regions; c- number of meteorological and pluviometric stations;(from to); d- Average number of meteorological and pluviometric stations in the drainage area; e- new meteorological and pluviometric stations; f- are per one station, in square Km.

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CONCLUSIONS

The foundation of the network of hydrometric stations made thus over the area of our country is but a general scheme which should be worked out in detail at the site of each station.

From the final result of the accomplished analysis it is seen that the number of hydrometric stations is increased very little, which shows that with the correct placement of the existing stations good results can be obtained.

In this number of hydrometric stations those are excluded which should be opened at the main canals of the larger irrigational systems as well as along the Duna river which at the present time are under the Ministry of Transportation and Communication.

On the other hand, it is seen that the closure and transfer of the existing stations and the opening of new stations concerns nearly a third of the network. This compelles that all these changes be made gradually according to a plan worked out in advance, as the possibilities for these changes are taken into consideration at site, and in case of closure or transfer-- also the needs of the other organizations and jurisdictions.

Special attention must be paid to the hydrometric stations whose regimen is disturned by water engineering structures, as in the first place suitable quarter must be sought for the transfer of the station, and finally their structure is used for hydrometric purposes(according to the methodical instructions of the Hydrometeorological Service of the USSR-- No. 34).

Specially carefully must be solved the question on the hydrometric stations in the lower courses of the rivers which are flowing into the Duna, since they must be transferred outside the area of the backpush.

At the already constructed large water reservoirs, complex hydrometeorological stations must be organized.

In the scientific foundation now made there is no proposal offered for a network of hydrometric stations in which the solid runoff would be observed -- the floating drift and the chemical substances of the water. This will become possible only after during this year the data of current observations of these elements are elaborated and generalized.

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(p. 114) a) Map of the average annual precipitations for the period 1896-1945.

b) Map of the average annual temperatures for the period 1916 - 1945.

c) Map of the runoff modulus for the period of 1935/36 - 1949/50.

d) Map of the density of the river net.

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TABLE: LIST OF THE HYDROMETRIC STATIONS WHICH, ACCORDING TO THE FOUNDATION OF THE NETWORK, ARE PROPOSED FOR CLOSURE, TRANSFER, OR OPENING

GENERAL HEADINGS OF COLUMNS: a- serial number; b- river; c- changes and sites; d- closure; e- transposition; f- opening.

RIVER BASIN OF THE STRUMA RIVER.

1. river Glogoska; d- village of Zhilenci. - 2. Eleshnica; f- village of Rakovo. - 3. Bistrica; d- village of Bistrica. - 4. river Blagoev. Bistrica; f- in the upper course.

5. riv. Vlakhinska; f- in the upper course.- 6. Struma; d- town of Pirin.- 7. Petrovska- ;d- village of Petrovo.- 8. Rilska; e- from the village of Pastra to below the village of Rila.- 9. river Sushicka; e- from the village of Sushica to the vill. Krupnik.- 10. Struma river; f- above the pool of the Studena dam.- 12. river Konska; f- near its influx into the Struma river.- 13. river Treklyanska; f- near its influx into the Struma.- 14. river Izvor; f- at the Skakavishki water falls.- 15. river Struma; f- below the influx of the Dzherman river.

II. RIVER BASIN OF THE MESTA RIVER.

16. river Retizha; d- village of Gostun.- 17. river Kornishka; d- village of Kornica.- 18. river Karadzhadere; d- village of Zmeica.- 19. river Vishterica; d- from the Forest House above the village of Kovachica.- 20. at the springs; f- at the canal above the equalizer of the "Razlog" Hydroelectric Plant.- 21. outflow; f- below the town of Razlog.- 22. Mesta river; f- below the influx of the river Eleshnica.- 23. river Musomishtenska; f- Musomishte.

III. RIVER BASIN OF THE MARICA RIVER.

24. river Ibyr; d- altitude 1900 m.- 25. Marica river; d- altitude 1490 m.- 25. Kriva river; d- place of Hadzhidedeica. (p. 115. List cont.) (same headings as on p. 114); 27. river Balykdere; d- Forest House "Chekhl'ovo".- 28. Stara river; d- village of Korova.- 29. river Gizdica; d- place Gizdica.- 30. Chernodere river; d- the "V. Kolarov" dam.- 31. Tenesdere river; d- place Durkhana.- 34. Stara river; d- Levskigrad Hydroelectric Plant.- 35. Kleotusa spring; f- Velingrad town.- 36. Mytnica river; f- below the dam "Batak".; 37. Beglizhka river; f- below the dam B. Kolarov.- 38. Toplika river; f- Spring of the place Poroen Most.- 39. river Shirokolyshka; f- the springs above the Bedenski Baths.- 40. river Vycha; f- below the influx of the river Shirokolyshka.- 41. the 40 springs; f- at Asenovgrad.- 42. river Bryagovska; f- village Bryagovo.- 43. river Omurevska; f- in theupper course.- 44. river Marica; f- town of Dimitrovgrad.- 45. river Blatnica; f- village of Radnevo.- 46. river Ovcharica; f- above its influc into the Syutlijka.

IV. RIVER BASIN OF THE RIVER ARDA.

47. spring Khubcha; f- village of Sokolovci.- 48. river Chamdere; f- above its influx into the Arda.- 49. river Syutlijka; f- town of Zlatograd.

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V. RIVER BASIN OF THE RIVER TUNDZHA.

50. river Radova; f- upper course.- 51. river Tundzha; d- village of Strupec.- 52. river Tundzha; d- village of Konovec.- 53. river Eninska; e- from the water reservoir to above the village Enina.- 54. river Tundzha; f- below the dam G. Dimitrov.- 55. river Mochurica; f- above the town of Polyanovgrad.-

VI. THE DISTRICT OF RIVERS WHICH FLOW DIRECTLY INTO THE BLACK SEA.

56. river Mladezhka; d-place Karamlyka.- 57. river Rukokastrenska; f- village of Rukokastro.- 58. river Dvoinica; f- in the lower course.- 59. river L. Kamchiya; f- village of Lyulyakovo.- 60. river L. Kamchiya; f- village of Gradec.- 61. river Kamchiya; d- village of Salamanovo.- 62. river Kamchiya; d- place Poda.-63. river Kriva; e- from N. Pazar to the river Kamenishka.- 64. river G. Kamchiya; f- above the village of Ticha.

VII. (p. 116 cont. same legends of columns)

VII. RIVERS OF THE DOBRUDZHA.

65. river Sukha; f- in the upper course.

VIII. RIVER BASIN OF RUSENSKI LOM.

66. river White Lom; f- the springs at Razgrad.- 67. river White Lom; f- before its influx into the Little Lom.

IX. RIVER BASIN OF THE RIVER YANTRA.

68. river Yantra; f- village of Etyr/yt.- 69. The Ynatra river; d- village of Vetrenci.- 70. river Ostreshka; d- village Ostrec.- 71. river Yantra; e- from the hydroelectric plant "Sini Vir" at the river Belica, below the influx of the Dryanovska.- 72. Old river("Stara reka"); f- the upper course.- 73. river Dzhulyunishka; f- village Dzhulyunica.- 74. Big River(G. Reka); f- the upper course.- 75. river Rosica; f- below the dam "Al. Stambolijski".- 76. river Yantra; f- village of Etyryt.

X. RIVER BASIN OF THE VIT RIVER

77. river Katunishka; e- from the village Katunica below the influx of the Ugyrchinska river.- 78. river B. Vit; f- village of Ribarica.- 79. river Vit; f- below the place called Boaza.- 80. river Kalnik; f- below the influx of the river Lesidrenska.

XI. RIVER BASIN OF THE RIVER ISKYR.

81. river Pryaka; d- village of Gevedarci.- 82. river White Iskyr; f- in the upper course.- 83. river Pancharevska Bistrica; d- village of Pancharevo.- 84. riv. Iskyr;

d- village of Reselec.- 85. river R. Bistrica; e- from Borovec to below the fish-ponds.- 86. river Iskyr; f- village of Pasarel below the dam wall.- 87. river Ch. Iskyr; f- the upper course.- 88. river Blato; f- village of Opicvet.- 89. river Is-krecka; f- at the springs.- 90. river Little Iskyr; f- village Dzhurovo.

XII. RIVERS WEST OF THE RIVER ISKYR.

91. river Srebyrna; d- village Komoshtica.- 92. river Sredna; d- village of Komosh-tica; 93. river Velenichna; d- place Petrokhan.- (p.117) (TABLE cont.; same colum-nar legends). 94. river Stara; d- above the village Zanoshene.- 95. river Shirine; d- place Petrokhan.- 96. river Dyasna; d- village of Byrziya.- 97. river Chiprov-ska; d- village Chiprovci.- 98. river Golyama; d- village G. Lom.- 99. river Little Ogosta; e- from the village Govezhda to above its influx into the Ogosta.- 100. river Cibrica; e- from the village D. Cibyr to above the irrigational system.- 101. river Stakevska; e- from the village Borovica to above its influx into the river Lom.- 102. at the left irrigational canal of Petrokhan place; f- before the equalizer.- 103. at the right irrigational canal at Petrokhan place; f- above the equalizer.- 104. river Byrziya; f- above the influx of the river Ogosta.

TABLE

LIST OF HYDROMETRIC STATIONS PROPOSED FOR OPENING.

(LEGEND OF COLUMNAR HEADINGS): a- serial number; b- river basin; c- river; d- site.

1-5 STRUMA:

1. c- Glogoska; d- upper course.- 2. c- Eleshnica; d- upper course; 3. c- Gra-dovska; d- upper course.- 4. c- Sandanska Bistrica; d- upper course.- 5. c.- Lebnica; d- upper course.

6-7 BLAG. BISTRICA:

6. c- Blag. Bistrica; d- upper course;- 7. c- Rilska; d- upper course.

8-12: MESTA.

8. c- Belica; d- upper course.- 9. c- White Mesta; d- upper course.- 10. c- Ker-nishka; d- upper course.- 11. c. Despat; d- upper course.- 12. c- Karadzhadere; d- upper course.

13-20: MARICA

13. c- Stara; d- above Kostenec.- 14. c- Shepinska; d- upper course.- 15. c- Vycha; d- upper course.- 16. c- Trigradska; d- upper course.- 17. c- Beglishka;

d-upper course.- 18.c.Blatnica; d- Nova Zagora.- 19.c.Syutlijka; d- upper course.-
20.c. Ochushnica; d- upper course.

21-23: ARdA.

21.c- Elkhovska; d- upper course.- 22.c- Krumovica; d- upper course.- 23.c- Byala; d- upper course.

24-28: TUNDZHA:

24.c- Akdere; d- middle course.- 25.c- Turijska; d- middle course.- (p.118). 26.c- Eninska; d- upper course.- 27.c- Radova; d- up er course.- 28.c- Belenska; d- upper course.

29.b- Kamchiya; c- Lower Kamchiya; d- upper course.

30.b- Dobrudzha; c- Sukha; d- Tolbukhin.- 31.b- Dobrudzha; c- Sukha; d- upper course.- 32.b- PROVADIJSKA; c- Kriva; d- upper course.- 33.b- RUSENSKI LOM; c- White Lom; d- upper course.- 34.b- VIT; c- Cherni Vit; d- upper course.-35.b- OSUM; c- Osum; d- upper course.- 36.b- OSUM; c- Osum; d- Aleksandrovo.- 37.b- IKSUR(ISKUR); c- White Iskyr; d - upper course.- 38.b- ISKUR; c- M.Iskyr; d- upper course.- 39.b-LOM; c- Lom; d- upper course.

MAP(*Attached): HEADING--- HYDROMETRIC NETWORK OF BULGARIA.

II. NOTES:(on map) a- hydrometric station number;
b- new hydrometric station;
c- hydrometric station to be transferred;
d- hydrometric station to be closed;
e- water divide line for the mouth of the river;
f- water divide line for the hydrometric stations;
g- altitude in meters.

III.(At lower left corner): Compiled and formed by the p.o.KARTPROJECT at the UGK.- Author:Engineer Iv.MARINOV,of the Scientific Research Institute for hydrology and meteorlogy.

(In lower right corner): Printed by the Karto-Geo-Utensil Factory of the UGK, Sofia,1957.

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(next paper on next page).

engineer R. MINCHEV

Concerning the HYDROLOGICAL PROJECTIONS (p. 119-134)

* *

The prognosis(prediction) is the foreseeing of the future development of events(actions).

The need for learning the future regimen of the hydrological events forced the study of the past and the observation of the present evolution of these events. Without data, it is impossible to project for the future runoff and to construct any kind of aquatic work. The more accurate the forecast, the more correct the projecting and the more profitable the construction. The flood waters, at their extravasation, will cause damages if they are not foreseen, and preventive measures are not taken in time.

The beginning of hydrological predictions is put by engineer BELGRAN to 1850 in France where he foresaw the catastrophal waters of the Seine river. In the Soviet Union much work has been done in this respect after the Great Octobrist Socialistic Revolution. The Soviet hydrologists N.V. LEBEDEV, B.I. OLDEKOP, L.K. DAVIDOV, A.V. OGIEVSKI, V.A. NAZAROV, F.I. BAGINI and others created the best methods for hydrological predictions. In our country, at the present time, experiments are made for hydrological forecasting.

For the purpose that we correctly estimate the need and the possibilities of the hydrological forecasts, we have to examine theyr types and methods.

We may divide the hydrological forecasts according to various principles:- 1) by the time range; 2) by their subject matters; 3) by their objects; 4) by their accuracy, 5) by the methods which are used, etc.

1. By the time range we distinguish short-term and long-range forecasts.

The short-term forecasts are for a period from a few hours to ten days which depends upon the size of the rivers. The long-range predictions are for a period longer than ten days, which may go up to several months or years.

2. By their subject matters we distinguish forecasts:- a) of the water stands, b) of the runoff, c) of the drifts, d) of the temperature, e) of the ice conditions, etc.

3. As objects of the water predictions, the following may serve:- rivers, swamps, lakes, underground waters, etc.

4. As to accuracy we may distinguish among the water predictions such types as

orientational, qualitative, and quantitative ones.

The oriantational predictions are of less accuracy, and they are given in lack of sufficient data, and in the presence of a menace of high waters.

(p. 120) The qualitative forecasts give a more complete characterization of the hydrological events -- amount, fluctuation, amplitude, given in relation to the weather, &c.

The quantitative ones give in figures the probable size of the foreseen hydrological event, its repeatability, and the average square error.

5. As to methods (materials) the water predictions can be classified as hydrometrical, hydrometeorological, hydrological, hydro-synoptical, periodical, and complex.

The hydrometrical predictions are based upon the hydrological and meteorological characteristics and data.

The hydrological predictions are based upon the hydrological methods, researches, and characteristics made on the basis of hydrometric and hydraulic data.

The hydro-synoptical predictions utilize the synoptic meteorological forecasts and the hydro-meteorological researches and characteristics. The synoptic meteorological forecasts on their part are based upon the characteristics, observations, and data on the special course of the meteorological events. The hydro-synoptical forecasts provide usually for a short period of time, one to two days, and they are chiefly used for the forecasting of icy conditions.

The periodical hydrological predictions are based upon the prerequisites of periodicity in the course of hydrological events, which is due to an imposition of elementary wave-like movements upon its course, provoked by a wave-like course of some of the factors.

The complex hydrological predictions are given on the basis of the simultaneous use of some types of the above mentioned predictions.

All types of forecasting cannot be possibly made for every river, but they are not necessary either.

We shall investigate in general lines the more important types, as we also emphasize the degree of their feasibility in relation to the different rivers.

The short-term hydrological predictions foresee the regimen of the water stands, of the runoff, and of the other hydrological events, as it is said, for a period of a few hours to 10 days, which times depends upon the contents of the river, respectively upon the distance between the hydrometric stations and the speed of the water waves, wherefrom it follows, that for our small rivers, the short-term predictions will have a much lower upper limit of dating.

The short-term water predictions chiefly use the hydrometric methods, for our small rivers, however, the use of the hydrological methods is enforced, and for the lengthening of the time range, the forecasts of the weather may be also used.

The short-term hydrometric predictions may be divided into such types which use:

a) the correlation of the water stands,

b) the correlation of the runoff,

c) the isolines,

d) tendency to preserve the course of the hydrological processes,

e) (p.121) the balance of runoff and others.

The hydrometric prognosis, based upon the correlation of the water stands, or the runoff, proposed by BELGRAN, is the most accurate and the most frequently applied one. Its essence consists in the following:

From the characteristic points in the course of the water stands, or of the runoff, two or more hydrometric stations of a river, or of a river region, determine the time which is necessary for the one-phase runoff waves to travel the distance from the more upstream to the more downstream hydrometric station. By the established ration of the one-phase water stands or runoffs, and their noted values at the upper hydrometric stations, the values of the same element are foreseen for the lower standing stations. This method gives better results for forecasting the hydrological processes of large rivers. The runoff and the time period of the latter rivers fluctuate relatively less. In their lower courses the upper parts of the runoff are equalized. The atmospheric events, which are chancy for the small drainage areas, are smoothed out and summed up on the large surfaceareas, and they obtain an expression of regularity. The time range at the surging and running-off of the high waters fluctuates but slightly. At relatively large distances, the unobserved additional onflow system is percentually but slightly increased, and the observed onflow (tributaries) may take part in the prediction.

In the correlation, important role is played by the dynamics of the runoff wave. The theory is still not sufficiently elaborated for it. Some considerations (By BESHE) can be mentioned which again have a value. The formation of the runoff wave is step-wise -- it grows much at certain sections, with influx of the tributaries, and it gradually decreases at the sections without tributaries, due to its difference in slope and depth along the length of the river. (Fig. 1).

Fig. 1: (NO LEGEND)

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Let the curves ABC and A'B'C' (Fig. 2) represent the change of the level at the travel of the flood peak in time t, the distance (p. 122) between two sections

Fig. 2: (NO LEGEND)

- - - -

x and x#Dx, and the change in time Dt. For this time, volume v will change by Dv. This change in a longitudinal section will be represented by the widened part (enlarged part) (Fig. 2). The change of the volume may be expressed as

$$Dv = b.Dh.Dx \; . \; . \; . \; . \; . \; . \; . \; . \; . \; . \; 1)$$

This increase in the volume may be determined also as the difference of the product of the time Dt and the second runoffs in the two sections Dq.

$$Dv = (q \; 3 \; Dq)Dt - q.Dt = Dq.Dt \; . \; . \; . \; . \; . \; . \; . \; . \; 2)$$

If we equate the results of 1) and 2), we will get

$$b.Dh.Dx = Dq.Dt$$

$$b.Dh.Dx - Dq.Dt = 0,$$

for the finite values

$$b.dh.dx - dq.dt = 0$$

$$b\frac{dh}{dt} - \frac{dq}{dx} = 0$$

The way of the work by the correlation method can be seen from an example. We shall take as such the prediction of the water stands of the Duna river at the town of Vidin made by the observations at Budapest and of the tributaries Drava at Barcs, Tisza at Szeged, and Szava at Brod.

By the observations of 1947 until 1953 the needed regularities have been determined.

For the determination of both the dynamics and the strengthening of the runoff waves of the Duna and of the tributaries, course lines have been composed of the fluctuations of the water level (h) as a function of time (t).

$$h = f(t).$$

The latter is changed into a function of time (t) of the fluctuation of the level (h)

$$A = \varphi(h).$$

which when integrated by the fluctuation(h) will give

$$A = \int \varphi (h)\, dh. \qquad . . (Fig. 3)$$

FIG. 3: (LEGEND): (on ordinata) t days.

- - - - - -

(p. 123) The correlation is established separately for the tributaries and for the main flow of the river for intervals:

for the Tisza in the intervals from 23 Apr. 1954 to 24 May 1954,
for the Drava " " " " " "
for the Szava " " " " "14 May 1954
for the Duna at Budapest " " 2 1 May 1954 to 31 May 1954.

By the thus established correlations, the dynamics of the runoff waves are determined, on the basis of which the curve of their confluence is compiled (Fig. 4).

FIG. 4: (LEGEND): a (on abscissa): ...t days.

b (names on curve, from upper left corner along the line:) Budapest, Barcs, Duna, Drava, Brod, Sava, Szeged, Tisza, Zemun, Belgrad, Vidin.

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For the followed waves, a correlation ratio (Fig. 5) has been established by which the prediction is made along the course of its travle to the town of Vidin. The thus predicted values of the water stands are compared with the observed values (Table 1-5) and the error is determined whose course is represented on Fig. 6.

The error, as it is received, is expressed in the percentages of the multi-annual amplitude, and it is an average of 0.7%, and the maximum 3.2%; thereby, 25% of the cases are with an error of 1.14 to 3.20%, and 50% are with errors of 0.94 to 3.30%/.

The term of the prediction is increased if it is made by observations at more remote stations; however, thereby, the accuracy is decreased, due to the increase of the additional tributaries.

A deficiency of the method is the chance element in regard to the additional tributary system which is correlatively determined.

The balance method was hydrometrical and hydrometeorological.

The hydrometrical balance method is based upon the equilibrium of the observed runoff at the upper points, with forecasting (text jumps to bottom of p. 125) the runoff at the lower key point of the river which may be expressed this way:

$$Q = (q_1 + q_2 + q_3 + \ldots\ldots\ldots) (1 + k)$$

where (p.124)

FIG. 5: LEGEND: a)(ordinata)...in centimeters

b)(abscissa):Vidin water stand in centimeters; scale 1 cm:10 cm.

(LEGEND on side of ordinata):Sum of the water stands: Duna at Budapest 0.40 h; Szava at Brod 0.10 h; Tisza at Szeged 0.28 h; Drava at Barch 0.12 h.

(LEGEFD OF INSERT MAP):Drainage basin of the Duna; rivers marked Duna, Tisza, Drava, Szava; towns marked: Vienna, Budapest, Barcs, Szeged, Brod, Belgrad, Vidin, Ruse).

- - - -

(p.125) FIG.__:(LEGEND): a) abscissa:...days

b) top curve legend:...observed water stands

c) middle curve:...foreseen water stands;and observed stands

d) lower curve:...line of errors.

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(p.126) (cont. from p. 123) where Q is the preducted runoff at the lower point of the river; q1, q2, q2... are the observed runoffs at the higher situated points of the river and the tributaries; k...is the coefficient which expresses the additional unobserved tributaries.

By the observation of the past, XX the coefficient k is determined, isochrones are composed for the course of the runoff waves by which their future course and the confluence of the correlated runoffs at the lower points is determined. In case the course of the waves is not directly observed, it is determined by empirical formulas, or from the mean speed at the upper and the lower points of observation. With this method, the prediction of the runoff of the river Tundzha at the village of X Banya was composed by the observation of the G. Dimitrov dam.

According to the described method, as with the porgnosis for the Duna, the dynamics of the waves are determined. The function of the runoff (Q) is by the time (t).

$$Q = f(t)$$

which is changed into a function of the time(t) by the runoff(Q)

$$t = \varphi(Q)$$

which, when it is integrated for the runoff(Q)

$$t = \int \varphi(Q) . dQ$$

with equal values of the integrals $\int \varphi (Q) dQ$ for the lower point and

$\int \varphi$ i(qi)dqi for the upper points determines the one-phase runoff waves. From the same ones, the dynamics, the confluence, the intensity of the waves and their course at the lower point is determined.

The additional tributary system is not observed, and it is comparatively large; hence, it is important that, instead of expressing it by the multiplier (1 + k), it should be determined by observation of the precipitations by which the formula for the balance of the observed runoff must be supplemented by us with this for the water balance of the unobserved additional tributaries.

$$x = y + z \pm u$$

in which x... the annual precipitations, y... the annual runoff, z... the annual evaporation, u... the change of reserve of moisture in the basin. The formula gives a possibility to define the annual runoff(y) on the basis of the annual precipitations(x), and for the prediction the daily runoff is necessary. For its determination, we must take the intensity of the daily fluid precipitations(x), its runoff coefficient(α), the snow coverage , and the intensity of the melting of the snow. Then, we shall determine the runoff (q_v) from the expression

$$q_v = \alpha \int X, dF + Dq_c + q$$

where q_v... is the runoff of the unobserved drainage area; α ... the runoff coefficient; X... the intensity of precipitations; F... the drainage area; Dq_c... the growth of the runoff by the melting of the snwo; q... the runoff of the corresponding previous day.

In this expression, α and X and Dq_c are unknown.

The intensity of precipitations(X) may be determined from the entire precipitation fallen during 24 hours, and from its time duration, as an average for the corresponding period of time.

(p.127) The growth of the runoff from the melting of the snow(Dq_c) depends upon the snow cover, and upon the course of the temperature. Between these values the correlative ratio is determined by which the daily runoff from the snow-melt, by which also its growth is determined, is predicted.

The runoff coefficient(alpha) is a variable quantity which is not observed. Its change depends upon the moisture-loadedness of the drainage basin. The latter on its part depends upon the precipitations and on the evaporation of the preceding period, and it is , to a certain degree, reflected in the runoff during the correspending preceding time. By observations of 1936-1945, correlative ratio has been also established between the runoff coefficient(alpha), the precipitations(H), and the temperature(t) of the previous period:

$$\alpha = f\ (H.t)$$

From the equation for balance of the runoff

$$Q = q_1 \# q_2 \# q_3 \# \ldots\ldots\ldots \# \alpha \int X.dF \# Dq_c \# q.$$

and on the basis of the determined relations by the observations of the runoff at the upper points and the precipitations of the unobserved drainage area, separate in runoff relations, the runoff is predicted for the lower key point-- the hydrometric station at the village of Banya. The daily runoff has been thus predicted fro the time from 1 Febr. 1954 to 1 Sept. of the present year, with an average error of 2% and a maximum error of 11%(3 cases).

40% of the cases are without deviation(Table 1-5).

LONG-RANGE HYDROLOGICAL PREDICTIONS.

The long-range hydrological predictions use hydrometric methods, hydro-meteorological methods of typization, methods based upon the periodicity of the course of the hydro-meteorological processes, and methods based upon synoptic analysis.

The hydrometric methods are used for long rivers, and they are based upon the hydrometric observations.

The hydro-meteorological methods are based upon the relationship between the climatic and hydrological processes, and upon the differences in time between the corresponding phenomena which are determined by the observation of the past, on the basis of which, by the observation of the present development of the meteorological processes, the future course of the hydrological events is forecast.

The methods of the typization are based upon the selection of the method of development of the hydrometeorological processes during the individual years or periods. By their started yearly or periodical development, we determine the type to which they belong, and by the corresponding type we judge on the expected course of the predicted processes.

The methods based upon the periodicity start out from the prerequisite for periodical repetition of the schematized values of the growing hydrological and meteorological elements.

A few authors divide the methods as follows:

METHODS OF THE ANALOGY AND GENETIC METHODS.

The methods of the analogy start out from multi-annual observations on the basis of which the laws are determined in the evolution(p.128) of the hydrological processes,without any regard to the factors which influence their formation.

The genetic method consists in the determination of the degree and manner of influencing the individual factors in the formation of the hydrological processes during a relatively short-range observation.

The method of the analogy uses the mathematical statistics.It is based on what has happened,and what counts for its periodical repeatability. It is applied for prediction of the values of the individual elements,without forecasting the times of development-- they are chiefly quantitative. We must remark that by this method the forecasts do not conform to the change of the setting,which is particularly important when such a change is permanent ,as the change in the vegetal cover of the drainage basin,technical structures in the river system,etc.

The genetic methods count on introducing in the future the establishment of the observation in the past of the influence of constant(permanent)factors,and only as the influence of prediction on the variable works.They have their practical side that they can be oriented with the changes of the setting both of the slowly changing factors and of the climatic factors,,the fallen precipitations, the depth of the snow cover, the development of the temperature, the solar radiation,etc.

These methods are divided-- in dependence on which of the factors is given greater weight,or according to what the prognosis is given for the development of hydrological processes-- into synoptic, hydrometeorological, hydrological,etc.

For a synoptic prognosis,based upon the spacial atmospheric changes, a meteorological prediction is necessary which is in conformity with the following additional geophysical factors:- the drainage area, the altitude above sea-level, slope, vegetal coverage, snow coat, fallen precipitations,etc. It has greatest application at the prediction of the winter regimen of the rivers.

This method gives comparatively little justification,because of the imperfection of the synoptical meteorological prediction.

The hydro-meteorological method is based upon the climatic observations at the moment of the prediction,and its established relationship with the hydrological process.

Of the demonstrated methods for long-range prediction, application is made as follows:

The method of the analogy (especially the methods of mathematical statistics) — for forecasting the value and the repeatability of the extreme values in the development of the hydrological processes; necessary for the measurement of the water stands. Because of its great practical value at work, this method has found a large application in spite of the pointed-out defects. For its improvement, a condensation of several observational periods, with the participation of more points of the observed series, is necessary, which would give a chance to estimate the influence of the various factors.

Special attention is deserved by the hydro-meteorological methods among which the greatest use has that of KALININ. Byt it, the volumes of the monthly and of the seasonal runoffs are determined, on the basis of XXXXX (p.129) the observations of the runoffs, of the climatic observations, of the water reserve of the surface of the drainage basin in the river system, and of the underground reserves, and of the depth of the snow cover. It counts chiefly on the fact that the larger part of the runoff originates from the water reserve in the drainage basin and a completely small portion comes from the fallen precipitations which during the summer, and the fall and the winter is not enough (in the USSR) to fill up the reserve of the ground moisture, and they very rarely give a surface runoff — when they fall as torrential precipitations, which represents a very small percentage of the total volume of the runoff.

On our country, this method shall be applied with success for the plains section of the drainage basins of our rivers where the fallen precipitations still create a little surface runoff. For the mountainous rivers, where the falling precipitations create a large surface runoff, their part in the prediction must be taken into consideration. By this method, at the present moment, experiments are made for predictions of a monthly and of a seasonal volume of the runoff of the Marica river. The flood waters of rare repeatability may be predicted by the method of a probable repeatability of the climatic processes related to rather similar drainage basins.

(p.130) TABLE 1: WATER PREDICTION OF THE WAT-R STANDS(h) OF THE DUNA RIVER at the town of Vidin, by observation of the Duna river at Budapest, of the Szava at Brod, of the Tisza at Szeged, and of the Drava at Barcs.

(cont. table)

(LEGEND of heads of columns): 1. date; 2. observation ≤ h cm upstream; 3. Σ dh ≠ –; 4. date; 5. forecast h cm downstream; 6. observation h cm downstream; 7. Δ deviation cm ≠ –; 8. error in % from the amplitude; 9. 25% of the cases with error from...to...cm; 10. 50% of the cases with error from...to...cm.

(p.131) TABLE 2: (similar columnar headings as on p.130)

p.132) TABEL 3: (same columnar headings)

(p.133) TABLE 4: (same columns)

(p.134) TABLE 5: (same columnar headings).

End of this article

(see next page).

engineer R.RAIKOV and engineer SH.BENATOVA.

APPLICATION OF THE METHODS FOR THE REGULATION OF THE RUNOFF IN OUR COUNTRY.

In the widest sense, under regulation of the runoff we understand all conscious human interventions into the natural course of the runoff, all artificial changes of the field, of the speeds, and of the water amounts. With such a wide meaning of the concept, almost all branches of water engineering(hydro-energetic and water-improvement construction, water supply, etc.) are engaged in the regulation of the runoff, i.e., in the changing of the natural regimen of the runoff and in its adjustment to the vital activity of man.

The topic of the present report is the regulation of the runoff in its narrower sense, namely the re-distribution of the surface waters, i.e., the artificial increase or decrease of the water amounts at separate moments, in comparison with the natural ones. In this sense, the regulation of the runoff is substantially a subsidiary measure in solving many water economical tasks, such as the water supply, the irrigation, the energy production, the transportation as well as the complex types of water consumption.

In the beginning of the 20th century, the industrialization, the transport and the rural economy made comparatively little demands on the water economy. The constructed water engineering structures usually did not have large dimensions, and the dams have only realized a yearly regulation of the runoff. It is natural that at that time, the entire theory for regulation of the runoff has not been in existence. The first works in this field are related to the computation of dams for annual equalizationof the waters, and later for several years. Therewith, on the basis of hydrological observations, real or fictitious course lines of the runoff have been compiled and, after comparing the afflux with the consumption, the size of the dam was determined. In this way, the balance methods of computation have risen the first.

During 1912, MASTICKI published a balance solution of the task for the determination of the irrigational possibilities of the rivers with the regulation of the runoff. In 1914, HAZEN compiled a curve which expressed the relation between the following values:- multi-annual volume of the dams, coefficient of the regulation of the runoff, percentage of assurance of the consumption and coefficient of the variation. (P.135)

In the U.S.S.R. a wide-spread teaching of the methods based upon the theory of probabilities started after 1930 when KRICKI and MENKEL published their first works. Thereafter, the works of SAVARENSKI came out, also of POTAPOV, KRICKI, MENKEL, LYAPICHEV, etc.

There are various types of regulation of the runoff which can be classified by two basic marks: a) by destination, and b) by the length of the period of regulation.

By the first mark, we make a distinction on the basis of which branches of the national economy are served; there is a regulation for irrigation, for energy production, for water supply, water transportation, of complex denominations, etc.

By the second mark, we distinguish daily, weekly, seasonal, pluri-annual and mixed regulations.

II. REGULATION OF THE RUNOFF.

As starting data for the regulation of the runoff, the hydrometric data on the natural regimen of the rivers will serve. Depending upon the length and the fitness of these observations, both in our practice and in the literature, two basic methods are used in the regulation of the runoff -- the balance and the statistical method.

The availability of direct hydrological observations for a long period (30-50 years) makes it possible to have them used in basis of the calculation at the regulation, since the runoff is compared with the consumption.

This method is made by tabulation, or graphically, and it is called tabular or balanced.

In the presence of very short observational sets or in complete absence of such sets, the statistical methods are used which are based upon the theory of probability, and the averages or statistical data of the runoff are utilized, such as the standard runoff, the distribution of runoff within a year, obtained either by concrete observations or by analogy.

It must be emphasized that we do not talk here of two basic theoretical trends in the development of hydrology in general -- a genetical and a statistical, and for the utilization of the already analyzed and determined hydrological data at the regulation of the runoff which in the practice is made with the aid of the thus pointed out and mentioned methods.-

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Under the balance method we will understand that method on the basis of which rests the use of the results of direct hydrometrical observations of either of the water amounts, or of the annual water mass, -- and under statistical method-- that by which the direct hydrometric observations are worked over by the methods of mathematical statistics for the determination of certain indices-- average yearly water amount, coefficient of variation, coefficient of asymmetry-- (p. 137)--which characterize the regimen of the river, without giving an indication about the calendarly course of changes within this so characterized regimen.

With observations of shorter set, which is the case in our country (we have at our disposal 17-year observation of the runoff), a preliminary estimate is necessary on the representativeness of this number, or its completion by other indirect methods, when concrete data of adjacent rivers, observations on the precipitations, etc. are utilized.

Lately however, some of our colleagues are enthusiastic in applying only the statistical method, even in such cases where it is not applicable, when the concrete data for runoff are used only for the determination of their average statistical characteristics. The rejection of the direct observations on the runoff, and the promotion of our water-economical studies by this way only, may lead in some cases to serious mistakes. Therefore it is important that we investigate briefly the application of the two basic methods for the regulation of the runoff, while we stop for some time especially at the seasonal and pluri-annual equalizations.

As chief consumers of the water resources in our country, the energy production and the irrigation arise, and lately also the industrial water supply. Ordinarily, the mountainous dams, canals, and other structures will have the task of the energy-productive utilization of the waters, and those of the plains-- the regulation of waters for irrigational purposes. In our country the conditions are such that complex tasks were put upon most of these structures.

At the energy-production, the consumption is steady in the various years, while within the year it is characterized by an energy-load curve. This relieves much of the task, since one has to work only with one variable-- the runoff. In this case, independently from the length of the regulation period, tabularly or graphically, with the aid of the integral curves, the runoff is compared with the consumption, and the capacity of the dams is also determined at a given assurance. Vice versa, at given capacities of the dams, the magnitude of the assured water consumption is looked for.

In the absence of any kind of data, also in the presence of a very short set of observations, not permitting its extrapolation, the statistical method is employed. The seasonal volume is found when from the curve of assurance the size of the annual runoff is determined at the proposed assurance, accordingly the characteristic monthly distribution is arranged, and the curve of consumption is drawn. The seasonal volume is the difference between the consumption and the afflux in a period of emptying of the dam. With pluri-annual equalization, the working volume is deliberately divided into two parts -- volume for annual equalization, and volume for a pluri-annual equalization. The first is determined by the same method as at the seasonal equation of the waters, and the second, with the known standard and coefficient of variation of the runoff, and with the accepted assurance and established regulation(control)--with the aid of the curves of Pleshkov.

(p.138) At the regulation of the runoff for irrigational purposes, we run into a series of difficulties, because of the peculiar nature of ~~a~~ consumption. The required result is already the function not only of the variable afflux but also of the variable water consumption. The fluctuations of the irrigational standard, which depends upon the climatic factors, are very small in the drought-afflicted(afflictable) and semi-desert districts, and , since, until recently, irrigation has been practice only in such districts, the questions on the regulation of the runoff for irrigational purposes with variable standards have been very little worked out. At the present time, much greater importance was acquired by irrigation even in the other districts for which the irrigational standard is fluctuating within considerable limits. Such is the nature of irrigation in our country, too.

As a basic problem at the regulation of the runoff, the question arises about the presence or absence of the correlative ratio between the runoff and the irrigational standard. A complete functional relationship usually does not exist between the runoff and the irrigation standard, since the drainage basin and the climatic factors have a different influence upon these values; however, in a number of cases such a ratio may be determined, since the irrigation standard depends upon factors which undoubtedly will also influence the runoff.

The application of the balance method at the regulation of the runoff for irrigational purposes does not meet with any difficulty, whereas the application of the statistical method runs into difficulties at the computation of the correlative ratio between the irrigational standard and the runoff.

These questions in the literature are explained but comparatively little. This is the reason that he we stop some time to spend on them in more detail, to let us share in the planning experience of the water-economical group of the "Energo-Hydro-Project".

1. THE BALANCE METHOD.- For the regulation of the runoff for irrigational purposes by the balance method, the following initial data are necessary:- afflux into the dam for a pluri-annual period by months and, the need for water in the field, i.e., the irrigational standards for each year of the observational period, and their distribution by months.

In case of a seasonal or annual equalization, with a given capacity of the dam, for each concrete year the volume of water mass is determined which had been used according to the irrigation curve, and the size of the irrigated area. Here, we distinguish two cases chiefly:- if in some years the afflux in the extra-irrigational season is not in the condition to fill up the dam, the useable water mass equals the afflux in the year, substracted the losses of evaporation and infiltration. If the dam is full at the start of the irrigational season, and the afflux is larger than the water required for irrigation, a part of the water will overflow. The water mass useable for irrigation will be equal to the sum of the volume (capacity) of the dam and the part of the afflux in the irrigational season which could have been used for irrigation.

The thus obtained water masses for each year are made into the corresponding irrigational standards and the size of the areas ready for irrigation is obtained. For this new sequence of numbers, the curve of assurance (theoretical or empirical) is drawn, and the size of the area is determined (p. 139), assured for instance for 75%.-(FOOTNOTE: In accordance with the instruction on planning, our country observed the following assurances:- for energy production 85%, for irrigation 75%, for water supply 95%, and so on, and the searching after the economically justified assurance is not practiced at all). We think that raising the question is right, since the final purpose of irrigation is to guarantee with a given assurance

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not that there will be water available, but that there will be such and such an area irrigated, i.e., the crop.

When the capacity of the dam is not given, the task is solved by the reversed process, i.e., the size of the required capacity is sought which would assure a given surface area with the accepted assurance. When the size of the irrigated area is increased, the size of the required volume(capacity) of the dam will also increase. For an accurately determined area, there is a certain required volume for annual equalization. For the irrigation of surfaces which are already larger than this, a pluri-annual volume is required.

The calculations by the balance method for a pluri-annual equation are not different at all from those with a seasonal or annual equation. The common principle at the balance method-- comparison of the afflux for each month with the needs of the area taken for irrigation for the corresponding year, and thence-- finding of the required capacity for 75% assurance of the area-- holds good also here. By the solution of the task, repeated a couple of times, the ratio is established between the useful capacity of the dam and the irrigational area. Frequently, for the curtailment of the volume of the work, or in case of lack of data on the runoff by months, as with the statistical methods, the conditional division of the useful capacity of the dam is permitted into volume for an annual equalization and volume (capacity) for pluri-annual equalization. Each of the two capacities is separately determined, while the balance for the pluri-annual capacity is made according to the annual water masses.

Before explaining the determination of the pluri-annual capacity, it should be important to explain the contents of the concept" Coefficient of regulation α at the irrigation". One should think such a coefficient here to be the average (pluri-annual) consumption α_{co} expressed in relative values against the average pluri-annual inflow.

If:

F... is the size of the area irrigated by the dam; VV.. the average pluriannual inflow; M_0... the pluri-annual irrigation standard; VV_1.. the inflow in any year; M_1.. the standard in any year, the required pluri-annual capacity V_m, in this year for irrigation of F decares will be..

$$V_{1m} = M_1 . F - VV_1$$

or, if we divide the entire expression by VV_{sr}, and we multiply and divide the first member of the right side by M_0, then we will get..

$$\frac{V_{im}}{VV_{sr}} = \frac{M_i.F\ xM_0}{M_0\ x\ VV_{sr}} - \frac{VV_i}{VV_{sr}}$$

where (p.140)

$\frac{V_{im}}{VV_{sr}} = \beta_i$ ...is the modulated coefficient of the pluriannual capacity;

$\frac{VV_i}{VV_{sr}} = k_i$....is the modulate coefficient of the inflow;

$\frac{M_i}{M_0} = K_M$.. is the modulated coefficient of the irrigation standard;

$F\ A^o\ M_0 = VV_{reg}$ ... average regulated water mass;

$\frac{F\ A^oM_0}{VV_{sr}} = \alpha_\sigma$ ... coefficient of regulation(control).

Then:

$$\beta_i = \alpha_\sigma K_M - k_i \quad \ldots\ldots\ldots \quad (1)$$

If the right side of the equation is obtained with a minus sign, in the given year a pluri-annual capacity is not necessary. The expression (1) is computed for each year, and from the obtained figures of the pluri-annual capacities, the assurance is found 25%.

From the above demonstration it is seen that...

$$F = \frac{\alpha_{o\sigma}\ VV_{sr}}{M_0}$$

i.e., the irrigated area is equal to the average regulated water mass, divided by the average value of the irrigation standard. This is the reason that frequently, instead of the irrigated area, the average regulation(control), α_0 is taken to facilitate the work.

2. THE STATISTICAL METHOD.- For regulation of the runoff by the statistical method, the following starting data are required:- average pluri-annual inflow into the dam(or the standard of the runoff), the curve of assurance of the inflow, the percentual distribution of inflow per months for the measured year, the irriga-

tional standard with 25% assurance, and its distribution by months and the curve of assurance of the irrigational standard.

In case of a seasonal equalization, with a given capacity of the dam, 75% assured afflux is found, and accordingly, the characteristic percentual distribution ϕf is determined for this assurance. In the drawing of the dam by the irrigational graph, the useable water volume is determined. The latter, divided by the irrigational standard, assured for 25%, gives the size of the irrigated area.

With an annual regulation of the runoff, the required volume is determined for the complete equation by an irrigational graph to a 75% assured afflux.

With the water economical investigations of the pluri-annual dams, the variability of the irrigational standards per year is taken into consideration.

As we have seen above, the required pluri-annual capacity of the dam for an arbitrarily selected year, expressed in relative values in regard to the average pluri-annual afflux, is $\beta_i = \alpha_0 . k_m - k_i$. In this expression, both members $\alpha_0 . K_m$ and k_i are also variable, and have their own curve of assurance.

For the determination of the pluri-annual capacity of the dam, sufficient to cover the annual deficit of the afflux, from the high possible differences such value β_r must be selected which will give an assurance of r%.

For covering the deficit of the runoff for any "n" years, also with an r% assurance, $\beta_m = \beta_{max}$ must be taken for these "n" years.

An approximate solution of this task for the first time has been given by engineer TROFIMOV when, on the basis of the task, the first method of KRICKI and MENKEL was laid down. In a 1945 publication, a consultant for melioration of the VNIG and M, has given a solution of the same task in a slightly different form. Theoretically, there is no difference between the two solutions.

A more accurate solution can be obtained by the use of POTAPOV's method. The solution is based upon the grapho-analytical method for determination of complex curves of the assurance both with the full independence between the two variables (in our case the afflux and the consumption) and with the existing correlative ratio between the two.

The annual component of capacity with a pluri-annual equalization is determined by drawing the dam with an annual afflux equal to the regulated water mass.

III. REGULATION OF RUNOFF AT THE CASCADE.

The total utilization of the larger rivers for energy productive, for irrigational, and so on, pruposes is only possible through the consistent constructing of a few steps of water engineering structures as dams and centrals, i.e., through a cascade construction.

The colution of the cascade by the balance method, independently from the type of consumption, does not represent the principal difficulty. Any of the steps will be determined and decided by the already described way, only that the starting data for the second, third, and all successive steps are obtained after the previously constructed upper steps have been solved. Thereby, this is connected with the need of a number of assumptions which we shall investigate somewhat later by means of concrete examples.

In the existing engineering literature, the way is not pointed out by which a cascade could be decided when one has at his disposal only the average statistical characteristics of the natural runoff. On the contrary, in the works that deal with this question it is said that the problem is very complicated, and that it has to be solved in the future. Here is how KRICKI and MENKEL write in "Water economical Computations", publ. 1952 (p.366 and 371): " The theory of the use and planning of the regimen of the cascade of water junctions at the present time commences to be constructed from now on." "With the computation of the cascade, the analysis of the chronological consistency of the runoff(by the balance method; - our remark) acquired a special meaning(importance), since in many cases the complicated reciprocal action of the water reservoirs is not subjected to research which is based upon studying the probability of the distribution of the runoff. The statistical methods for the water economical(p.142) and hydro-energical computation of the cascade of water junctions are applied chiefly for an approximate estimation of the basic indices for the effectiveness of the regulation of runoff: - assurance and total consumption"...."At a detailed planning, they must be combined with research of the regimen of the cascade, obtained by the runoff, characteristic for a number of years."

The water economical studies along a number of our structures and especially along those of the TED(Heat-Electricity Department?) of the Tundzha river, finished side by side with the two methods, clearly illustrate the advantages and the defects of the balance method and of the statistical methods, applied at the various cases of regulation.

As examples we shall quote the conclusions of the elaborations at some of our structures.

1. THE KYRDZHALI DAM.- The dam was planned for the Arda river above the town of Kyrdzhali. The average pluri-annual afflux in the dam, by the data of 16 years' observations at the nearby water gaging post, amounts to 841 million cubic m, with the coefficient of variation $C_v = 0.29$.

The chief destination of the water junction is to satisfy the electric consumption of the Khaskovsk electric region.

With the aid of the statistical method, the basic parameters of the dam were determined as follows:- degree of the regulation $\alpha = 0.75$; required seasonal volume ...325.70 million cubic m. The required pluri-annual volume... 36.30 million cubic m. Consequently, the total useful volume...362 million cubic m.

With this capacity of the dam, VEC(hydroelectric central) "Kyrdzhali" can surely cover, with an 85% assurance, 50,300 Kwatt power and 96 million Kwatt hours annual production.

For a verification of the assurance of the guaranteed powers and production, the regimen of the Central was followed back for the available 16-year period of observations. In result of the detailed drawing by months, it was found that through 29 months of the observational period, the Central was not in a condition to guarantee the required powers and production, which makes 85% of the investigated period; or, with other words, the assurance of the Central was exactly obtained so as by the statistical method, and the results were in complete agreement by the two methods.

2. THE DAM TOPOLYANE.- The dam is planned at the similarly named village for the river Rakitnica. The average pluri-annual afflux into the dam is 61.5 million cubic m, with $C_v = 0.85$. It has direct observations at its disposal, for 17 years, on the runoff, for the period 1935/36 - 1951/52.

The destination of the dam is chiefly to satisfy the needs for water of the TEC(Topolyane Electrical Central) "Marica outflow". For the sake of control, the computation was done parallel by the two methods--the balance and the statistical, at three different outlets for TEC-- 0.50, 0.75 and 1.00 m^3/sec, emitted evenly through the entire year with 95% assurance.

The balance method was applied without dividing the volume into seasonal and pluri-annual.

For the determination of the pluri-annual volume by the statistical method, the Pleshkov curves were used.

The following required capacities (volumes) were obtained: (p. 143)

Q	0.5	0.75	1.00 m^3/sec
Balance meth. V	17.38	31.00	45.4 mill. m^3
Statist. meth. V	15.75	30.64	48.2 "
Difference in vol. DV	+ 1.63	+ 0.36	− 2.8 mill. m^3
Difference in %	+ 9.4	+ 1.2	− 6.2 %

The differences between the results of the two methods are with the limits − 6% and + 9%. At the discharge of Q = 0.5 m^3/sec, ~~[illegible]~~ the volume computed by the balance method is 9% larger than the one computed by the statistical method, and at the discharge of 1.00 m^3/sec the picture is the reverse — the statistical method gives a result 6% higher than the balance method. At Q = 0.75 m^3/sec, the difference is but 1%.

These differences may be explained in the following way: — with little regulation, the balance method gives the higher results in comparison with the statistical method, since the available series of data includes a drought period of 5 years out of 6 years, and at higher regulation, because of the large assurance of the consumption authorized, a drought period is a period of greater length, and the results are lower.

3. CASCADE "TUNDZHA". — For the entire use of the river Tundzha, the construction of a series of dams and centrals is provided along the river. The plan consists chiefly of the following dams: — the dam Kalofer in the upper course of the river, the dam G. Dimitrov at the village Kpronka, with a total volume of 96.00 million cubic m. and an average annual natural afflux of 300 million cubic m. the dam Zhrebchevo, at the village of Zhrebchevo, with a maximum capacity of 500.00 million cubic m. and an average annual natural afflux of 654.00 million cubic m. One of the variant schemes provides also a dam Gyurlya, with a capacity of 160.00 million cubic m. at the river of the same name — a right-hand tributary of the Tundzha river.

The scheme of the river basin includes also other smaller dams, but, because of their secondary importance, we shall not delay in their discussion.

The main task of the cascade is the regulation of the waters for irrigation.

At the G. Dimitrov dam and at the Zhrebchevo dam, water gaging posts are in existence which have at their disposal observations for 16-year periods on the runoff, fro the period from 1935. A number of other water gaging posts, distributed along the individual tributaries, have shorter periods of observation.

We shall stop individually at some of the dams, and at the cascade, also.

At planning the G. Dimitrov dam, the task was assigned to determine the possible area for irrigation by the dam, with an assurance of 75%. Because of its small capacity, the dam can realize only a seasonal regulation.

The calculation by the balancemethod of the irrigational area amounted to 314,000 decares, and by the statistical method... to 259,000 decares. The difference of 55,000 decares, i.e. 21.2%(17.5%) between the two methods is not within the limits of admissibility.

To what is this due?

1) first, to the fact that, at the computation by the statistical method, a functional dependence was assumed between the assurance of the runoff and of the irrigational standard, which in the reality does not exist. Thus(p.144) the afflux of 1935/36 is of 81.5% assurance, and, in accordance with the statistical method, the irrigational area is not assured. In reality, because of the fact that the assurance of precipitation, respectively of the irrigational standard, is only 11%, the cultivated plants require little water, and the dam might be able to perform its task. We had a similar case in 1945-1946, too, when the precipitation was assured for 93%, and the afflux for ..50%. Such a non-coincidence is also found in other years. The statistical method is unable to compute it, and it assumes the most favorable combination between precipitation and runoff...complete functional relation between them, which leads to the lowering of the value of the 75% assurance of the area. This has been also confirmed by Academician KOSTYAKOV in his book: "Bases of amelioration"(p.358) where it is said that the real assurance of the irrigational area, determined by the statistical method, is above 10% greater than the one made by computation. Moreover, indded, the obtained area of 259,000 decares may be satisfied through all the years of the observational period, i.e., to be 100% assured.

2) secondly, to the fact that for a percentual distribution for the 75% assured year, the monthly distribution of 1937/38 is taken, which is the most unfavorable in the entire observational period. In reality, even in the years of much smaller runoff, the dam could equalize larger water masses, according to the irrigational graph than it did in 1937/38.

The results were also verified by the graphic analytical method of POTAPOV who computed the correlative coefficient between the afflux and the irrigational standard. The irrigated area of the dam amounted to 330,000 decars, or 5% more than the one determined by the balance method. The entire cascade has been worked up, and solved by the balance method, which gives a possibility to compute comparativele easily the influence of waters of the G. Dimitrov dam spilled to the dam Zhrebchevo, of the waters deviated for irrigation in the Kazanlushko, in St. Zagor, and other fields, of the additional affluxes to the dams, and so on. The only and serious objection to the employment of this method is the question about the representativeness of the observed hydrological series. We shall consider this question in the following report.

The employment of the statistical method, however, meets with serious difficulties and objections, and it can be only realized on the basis of the following assumptions:

1.) That there is a functional relationship between the assurance of runoff in every water reservoir of the river basin, i.e., that the runoffs in all water reservoirshave an equal assurance in any year. In truth, in accordance with the hydrological observations, such a relationship does not exist.

2.) That the sum total of the runoffs of some tributaries which have equal assurances, let us say one of 75%, is also assured at 75%; even in the case when the natural runoff of the river is disturbed by separation of waters for irrigational purposes.

3) After, with the aid of the above assumptions, the affluxes in all dams have reached three assurances(25%, 75%, and average year), by guessing from the tabulations of FOSTER, we determine(p.145) the coefficients of variation(for the three years in order to) and of asymmetry. It is enough, it is not correct to measure the afflux in one of the three years because then both the coefficient of variation and the coefficient of asymmetry will be erroneously determined. It is natural that this will also reflect upon the reliability of the obtained capacity of the

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dam and on its effect. Thus, for instance, in one of the variants, the afflux to the G. Dimitrov dam was determined by the above method as follows:

75% assurance	. . . 81.77 million cubic meters
25% "	. . .123.94 " " "
average pluri-annual	. . .XXXX 102.77 mill. cubic m.

With these data, from the tables of FOSTER it was predicted that $C_v = 0.30$, and $C_s = 0.00$. The natural afflux to the dam, as we have also told above, is 300 million cubic meters average annually with $C_v = 0.35$.

The result is impossible, since it is not plausible that, after 2/3 of the water has been caught above the G. Dimitrov dam, i.e., mainly by the collective canal, a smaller coefficient of variation could be obtained.

The actual influence of the collective canal must have been exactly the reverse, since in the years of small water, the canals will catch almost the entire water volume, and in the moist years a significant percentage will spill over, and the relative difference between the afflux in the arid and in the humid years to the G. Dimitrov dam will get larger.

4. To avoid the assumption that the sum of a few different affluxes of equal assurance has the same assurance, at the determination of the effect of a few pluri-annual equalizers, the admittance was made that the capacity of the pluriannual equalizer is equal to the sum of the required capacities for the regulation of the individual affluxes. For instance, the pluri-annual capacity of the Zhrebchevo dam will be equal to the sum of the capacities needed for the regulation of the affluxes of the additional drainage area, of the afflux of the waters spilled over the G. Dimitrov dam, and of the water mass thrown in by the tributary river Belenska.

Between these three affluxes, many and numerous combinations are possible. One limes situation is that they are so adding up that in the individual years the total afflux to the dam will be constant. The other limes situation is that the flood-water and lo-water years and the affluxes for the three years will coincide.

The actual correlation coefficient between the three afluxes may be computed correctly by the balance method only, whereas the employment of the statistical methos requires us to take the most unfavorable combination between them -- the functional relationship.

The solution in this way is not synonymous. With one and the same capacity of the dam, depending upon what kind of regulation we will take for each individual afflux, different irrigational areas may be obtained. For instance, with the general regulation $\alpha_{b} = 0.80$ for all affluxes, and with a capacity of the dam of 455 million cubic meters, the irrigated area will amount to 832,000 decares. If however, with the same starting data, we take the regulation(control) degree at $\alpha_{e} = 0.70$ for the waters spilled over the G.Dimitrov dam, $\alpha_{6} = 0.80$ for the tributary from the Belenska river, and $\alpha_{e} = 0.85$ ...for the afflux from the additional drainage area, with the same capacity of the dam, the irrigated area(p.146) increases to 856,000 decares. With variation of the degree of regulation, many different results may be obtained, sometimes even absurd ones. Thus, e.g., with another variant for the Zhrebchevo dam, one may arrive at results that the waters spilled over through the spillway of the G.Dimitrov would reduce the size of the irrigated area as follows:

With a total capacity of the Zhrebchevo dam at 415,000,000 cubic meters, with the spilled-over waters from the G.Dimitrov spillway, 697,000 decares are irrigated, and without them...740,000 decares, or, the spilled-over waters would decrease the efficiency of the dam by 43,000 decares.

In the following tabulation, the results are given parallel of the accomplished water economical researches by the balance and by the statistical methods for the cascade, at two variants:- without the Hyurlya dam, and with the Gyurlya dam.

TABLE (om p.146):(LEGEND)(of headings as marked by written-in letters): a- part of the Gyurlya dam; b- method; c- dams; d- Gyurlya , V= 160,000 MM^3 decares; e- G.Dimitrov, V = 9600 MM^3 decares; f- Zhrebchevo, V = 415,0 MM^3 decares; g- total decares; h- with the Gyurlya dam; 1: balance; 2: statistical; 3: difference; i- without the Gyurlya dam; 1:balance; 2: statistical; 3: difference.

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From the above tabulation it can be seen that the contribution of the Gyurlya dam, according to the balance method, is 46,000 decares, and according to the statistical method... 155,000 decares. This difference is still outside the range of admissibility, and it is due only to the inability of the statistical method to compute all peculiarities in the regimen of a cascade irrigational dam.

IV. CONCLUSIONS FROM THE QUOTED EXAMPLES.

1. The available hydrological data, as well as their sequence and the applied

methods for the regulation of the runoff influence, in the most direct sense, the choice of the scheme for construction, the sizes of the structures, and the national economical effect of the regulation.

2. The employment of the balance method in all cases of regulation is entirely possible. The necessary condition for this is that the concrete hydrological observations are for a long period of time. The hydrological observations for shorter periods(15-20 years) may be, and must be, employed after proving the representativeness of this series in a pluri-annual segment.

3. The application of the statistical method is urged when any kind of hydrological data are unavailable, or when the available data are not sufficient, and their extrapolation is not possible.

4. In case of regulation when the main goal is energy production, water supply and so on, with which the consumption is not changed in(p.147) the individual years and with the same equalizers, the two methods give practically identical results.

For determination of the seasonal capacity, the use of concrete observational data is urgent, even of a shorter period.

With the determination of the pluri-annual capacity by the balance method, with high degree regulations and assurances, depending upon the length of the observed series, low results are obtained for the capacities. This is so because in such cases the length of the authentic "n" years is outside the bounds of the observed series. The task must be to decide by statistical methods, while the Pleshkov curves are used, which accurately determine the pluri-annual capacities at constant consumption.

5. In the case of variable consumption, such as the irrigation, the statistical methods are not sufficiently elaborated, and they cannot compute the peculiarities of the irrigational standard. Their employment at individual dams leads to lower results for the effect of regulation, and it may be used at the preliminary stages of planning. In this case, better results are given by the grapho-analytical method of POTAPOV.

6. At the solution of the cascades, especially when pluri-annual dams and dams of irrigational designation are included in them, only the balance method is applicable.

The experiences with the solution of similar tasks by the statistical method will lead to mistakes, and in some cases to absurd results.

7. In consideration of the fact that the basis of the water measuring network, having at its disposal observations of 16-20 years' periods, embraces the large rivers and chiefly their lower courses from where the waters will be distributed for irrigation, and since for (such a case the waters will be distributed) such a case the application of the balance method is especially necessary, the question must be seriously raised about the representativeness of this series and brought to the attention to our scientific research institutions and scientific workers.

8. The water gaging network for the mountainous rivers, whose use is chiefly for energy production, must be enlarged, and the observations must be improved in regard to increasing the security at the construction of the water-engineering structures.

9. Generally, the possibility for application of the different methods in the regulation of the runoff depends upon the hydrological data which are at our disposal, on the character of the consumption, on the degree of regulation, and on the mutual action of the equalizers with other equalizers. It may be thought that in the future much more attention is supposed to be paid to the analysis of the physico-geographical factors, and that the theory of probabilities will more and more retreated to the background.

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Engineer R.RAIKOV & engineer SH.BENATOVA.

REFLECTION OF THE HYDROLOGICAL CHARACTERISTICS UPON THE REGULATION OF THE RUNOFF.

1.General remarks.

The hydrological facts influence the methods of the regulation of runoff in two ways.

On one hand, the length of observations from which these data are extracted determines in many cases the use of one or the other method. On the other hand, the errors admitted to them reflect differently upon the results, depending upon the use of the various methods. Evidently, a more detailed investigation is necessary on the relation between the hydrological data and the methods for regulation of the runoff which could lead to valuable conclusions in respect to our practice and which would enable to clarify some of the important tasks which stand before hydrology in connection with the water economical researches.

The development of the computing methods for the regulation of the runoff in our country reasonably raise the question about the purposefulness of the application of the two basic methods, the balance and the statistical methods. The correct solution of this problem will save millions of levas in our economy. In the present report, the great importance of the balance method is outlined, by the aid of which in many cases it is only possible to solve the stated task. However, its use supposes hydrological data for pluriannual periods(35-50 years), which is not at our disposal for any single water gaging. The length of observation periods on the runoff in our country, in general lines, is indirectly proportional to the altitude above sea-level of the water-gaging posts. High in the mountains, we either do not have any such observations at our disposal, or they date only from 1-2-3 years. The longest are the hydrometric data in the middle and the lower courses of the rivers, but also even the longest ones, with very few exceptions, do not exceed 17 years for the period between 1935/36 and 1951/52. This circumstance does not make the balance method very much applicable, since it has been sufficiently demonstrated that this period is representative so that it could be placed as the basis of computations. In this, one of the most important tasks of the engineers and scientific workers also consists, those scientists who work in the field of hydrology, in connection with our water engineering construction enterprises.

(p. 150) From the data for the 17-year period form 1935/36 - to 1951/52, in many cases the standard of the runoff is determined (as an arithmetical average for this period), also the coefficient of variation, and the coefficient of asymmetry. The same data are also used as analogues for the determination of the hydrological parameters for points of very short runs of observation. The assurance is necessary that the thus determined hydrological characteristics are probable, or nearly probable, and that they express correctly the regimen of the river in a pluri-annual segment, since they are the starting data for the statistical method. It is necessary to define the limits of possible errors, as well as its reflection upon the results. With the present report we shall share a few established facts or our experience concerning the thus stated problems.

The safest method for the determination of the representativeness of a series by analogy with the river which is in similar physico-geographical and climatological conditions and has observations at its disposal for many years on the runoff in our country, is not applicable by the simple reason that it lacks such an analogy for which we would have a sufficient number of data. For this reason, we have been compelled to use indirect ways when we start out from the data on the precipitations, for which we have observations for many years from 1901/02 to 1950/51.

The runoff is chiefly a function of the precipitations. Consequently, if it is demonstrated that a good correlative ratio exists between the runoff and the precipitations, then the conclusions which can be made at the research of the precipitation series could be transferred, with a certain reliability, also upon the runoff series. To determine this, construction of the precipitation charts was necessary on whose basis the precipitation could be found that fell in the drainage area of the rivers at the points for which we have observations on the runoff.

Construction of such charts with sufficient accuracy is a very difficult task, because there are but few stations, especially in the higher sections, and it needs much time, which we do not have at our disposal for which reason the solution of the problems has been made on the basis of the 50-year data on precipitations at 27 separate pluviometric stations. All stations are in Southern Bulgaria, since at the present moment it represents the largest interest from the point of view of water economy, and it has been studied the best.

Experiments were made to determine the relationship between the precipitation of the individual stations in the drainage area and the runoff of the rivers at some water gaging stations. The following results were obtained:

The correlation coefficient between precipitation in Samokov and the runoff at the Stalin dam is 0.74; between precipitation at Kazanlyk and the runoff at the G. Dimitrov dam ...0.61; between precipitation at Kazanlyk and the runoff at the Zhrebchevo dam...0.59; between precipitation in Chirpan and the Old Zagora, and the runoff at the Topolyane dam...0.57 and 0.48. The better relation between the precipitation in Samokov and the runoff in the Stalin dam(alpha = 0.74) may be explained by the circumstance that Samokov is approximately in the center of the water drainage basin...at an altitude of 950.

(p.151) The obtained relations are encouraging when it is considered that the individual pluviometric stations cannot characterize the precipitation in the entire drainage area, still ,ore that the selected stations are in the plains, whereas the runoff is formed chiefly by precipitation in the mountains, where there is every reason to suppose a good relation between precipitation and runoff, due to which the results, obtained by comparison of the precipitations, may be transferred upon the runoff, too.

Inspite of the fact that at the moment we have at our disposal the 17-year observations on the runoff, we shall make its foundation on the 16-year series of 1935/36 - 1950/51 since it has been laid down on the basis of the water economical researches for a set of structures in our country which are then given as examples in the explanation.

II. THE STANDARD OF RUNOFF.

It is usually thought that 25-year observations on the runoff are sufficient to characterize it by size and by distribution. Unfortunately, in our country we do not have at our disposal data for more than 16 years. Therefore, the standard of the runoff is most often determined as the arithmetic average of the data for these 16 years, moreover in rare cases when the runoff is of a larger variation, i.e., C_v larger than 0.40. It is necessary to determine whether the arithmetic average of the data for the available 16-year observations would represent the standard of the runoff, or if it deviates from it, what are the sizes and directions of these deviations.

As we have already emphasized, the lack of long-range observations on the runoff compells us to make investigation on the available precipitational series, with full consciousness that the conclusions of these investigations will be only orientative for the runoff of the rivers. There were 27 stations investigated, eight of which were examined by the method of the creeping series. Two such series were taken:- one 16-year and one 25-year series while the conclusions were made on the 16-year series, since we have such a series available for the runoff, and the 25-year series was given for illustration and comparison. The only consideration at the choice of the eight stations has been their altitude above the sea-level, as we tried to include stations of low and high altitude above the sea-level. These stations are:

Chirpan	170 m	538 mm	average	precipitation
St. Zagora	234 m	594 mm	"	"
Sliven	270 m	577 mm	"	"
Kazanluk	372 m	617 mm	"	"
Shipka	570 m	739 mm	"	"
Samokov	950 m	651 mm	"	"
Batak	970 m	675 mm	"	"
Petrokhan	1400 m	1066 mm	"	"

The method of creeping series permits to determine the average annual precipitation for any series of "n" years, entering into the observational period. Thus, we investigate first of all the period from 1901 - 1916, thereafter the period 1902 - 1917, 1903- 1918, and so on up to (p.152) 1935 - 1951. The obtained results are systematized on Table 1 in which the average yearly precipitations of 50 years are given, the maximum and the minimum average yearly precipitation for a 16-year series, the maximum and minimum average pluri-annual precipitation for a 25-year series and the average pluri-annual precipitation for the period 1935/36 - 1950/51 as well as the deviation of this precipitation in comparison with the 50-year precipitation expressed in mm and percentage.

What conclusion can be drawn from these results?

The standard precipitation, obtained from the observations of 16 years in comparison with the 50-year standard, which we take as the most probable, varies between the limits of plus 14.00 and minus -13.3%. As we had supposed, the standard precipitation for a 25-year series varies between smaller limits, namely, between plus-minus 9.3%. as a remark, it is said that, with the exclusion of station Petrokhan which gives the greatest deviations (and about the probability of its data we have reasons to doubt), because of the reconstruction of 13 years, the standard precipitationin about 70% of the cases, both with the 16-year and with the 25-year series of observations, is higher than the 50-year standard. Between the periods in which the maximum and mikimum values of the standard precipitation appear, it was not possible to determine any kind of relationship for the individual stations. Thus, whereas for the stations of Petrokhan and Batak the period 1924/25 - 1950/51 gives the maximum standard precipitation, for the stations Stara Zagora and Kazanlyk the same period gives the minimum standard precipitation. It is true that the number of the examined stations is small, and their physico-geographical locations are also entirely different to enable us to accept the following conclusions as generally valid. In general, the conclusion can be made that a 16 year series, and even a 25-year series, picked by chance (at random) may give deviations from the standard precipitation which are outside the admissible limits, although not by very large values. Interesting is, in cases, the 16-year series 1935/36 - 1950/51. In Table2, comparison is made between the standard precipitation obtained as an arithmetical average of the observations of this period, and the 50-year period 1901/02 - 1950/51 for 27 stations.

The deviations are between smaller limits, plus 14.0 % at the Petrokhan station and minus -7.3% at the Kazanlyk station. At 19 of the examined stations, which makes 70% of the total number, the deviations are within the limits plus-minus 6%, and at 15 stations, or at 56%, the deviations are within the limits of plus-minus 4%.

In 8 stations the deviations are larger than 6%, as only in three stations are they larger than 10%. At the larger part of the stations... 22(81%), the deviation is positive, i.e., the 16-year oeriod is rainier than the 50-year period.

The results of the examined 27 stations tell that the 16-year series 1935/36-1950/51 determines the standard precipitation with sufficient accuracy.

The deviations for most stations are within the admissible limits, which gives us right to accept the arithmetic average of this period as the standard precipitation. It must be noted that a slight increase of the standard is at hand.

(p.153) Let us now investigate how an error in the standard is reflected at the solution of the tasks of regulation of the runoff of the rivers by the two basic methods:- the balance and the statistical methods.

At the balance method, the standard runoff is not used directly in the computations, but indirectly, since it deals more individually with the runoff for each year, or even for each month. Thereby, for the determination of the capacity of the dam, the runoff is authoritative in the years of low waters. The years with flood waters do not show practically no influence upon the results. Therefore, if the error in the standard runoff is due to increasing or decreasing some of the flood-water or XXXXXXXXX average years, this error does not have any effect upon the computation.

With the statistical method, the standard runoff is one of the required starting data. Each error in the standard runoff, independently from the circumstanc to what cause it may be due is reflected upon the size of the required capacity of the dam for the regulation of a certain water volume. This established fact is chiefly good in case of pluri-annual equalizers.

In the report which investigates the question on the regulation of the runoff, it was pointed out that the useful capacity of the dam Kyrdzhali, computed by the statistical method with a degree of regulation alpha = 0.5, amounted to 362 million cubic meters, while it assures ,with 85% assurance, 50,300 Kwatt power, and 95.72 million Kwatt hours production. The average pluri-annual afflux to the dam is 841,00 million cubic meters. If this afflux were determined to be 10% lower, XXX at about XX757 mill on cubic meters, so that it would enable the dam to assure the same power and production, its useful capacity volume should be 440,00 million cubic meters , or about 80,00 million cubic meters more, which would require 37 million levas extra investments.

III. DISTRIBUTION OF THE RUNOFF IN THE YEAR.

The basis and the most responsible task of water economical studies at the employment of the statistical method in cases of an annual equalization includes the correct selection of the proportionate distribution of the runoff within the year.

In the cases where the data are lacking on the runoff of the river, its distribution by months is determined by analogy with some other river which is under the same climatic and physico-geographical conditions. We do not have to examine such a case. We shall spend time on the methods applied in practice for the determination of the monthly distribution of the runoff within the year when we have observations at our disposal, i.e., observations in respect to the regulation of runoff.

1) Most frequently, the monthly distribution of the measured years is taken as some reall year that has the smallest runoff per year, or an annual runoff with assurance close to the accepted one. When a few years are which correspond to this condition, those are taken which by estimation have a monthly distribution typical for the river, or those which have the least favorable distribution.

This method cannot be recommended since each concrete year has its peculiarities which are not characteristic for the river in a pluri-annual section. The year may happen to be of a very(p.154) small runoff to have comparatively high low waters which will lead to the decrease of the water volume in the reservoir. Yet, the selection of the representative year is subjective, and as such it unavoidably bears greater or smaller error in itself. Thus, for instance, at the determination of the volume capacity of the Kyrdzhali dam, two years of the observational period 1946/47 and 1944/45 were shown to be suitable for the analysis of the monthly distribution of the runoff in the measured year. The year 1946/47 is the one with more flood waters, but it is marked by strong fluctuation of the runoff within the year -- a large volume of flood waters and strong reduction during the low-water period, whereas 1944/45 is a drier year, but it is characterized by less fluctuation and by a relatively larger runoff during the period of low waters.

In consideration of the fact that even the two years are satisfactory for the research in literature for the proportionate year, and that with independent elaborations each one of them could be selected as such, the annual volume of the Kyrdzhali dam was computed twice. The volume capacity, determined by the elaboration for which the 1946/47 year was taken as a basis, came out at 100 million cubic meters larger, the dam wall 7 m higher, and the capital output was increased by 43 million levas.

It is evident that this result could not be considered satisfactory. This makes necessary a third, more accurate work over, on the basis of another method which was selected for the determination of the monthly distribution(we shall describe it later). According to this computation, the capacity of the dam comes out exactly as the average of the first obtained results.

The quoted example is a good illustration for the inaccuracies which may be obtained, due to the subjectiveness at the taking of the characteristic monthly distribution.

In the first section of the report an example was pointed out ,that of the G.Dimitrov dam for the use of the statistical method at the taking of a typical monthly distribution-- this is of 1937/38. This is namely the chief reason to obtain a 100% assurance of the irrigation by the dam,instead of the pre-required 75% assurance.

2.) The endeavour to get rid of the chancy peculiarities of the runoff in the individual real years has lead to the method of the so-called fictitious hydrological years. By this method,the monthly distribution of the runoff in the year is either the average values of the monthly runoffs as determined for the entire observational period, or the runoff is taken for each month with an assurance determined in advance. The runoff obtained by this method for each month is expressed in percentages of the annual runoff,and by this percentual correlation the runoff is distributed in the measured year.

The method of fictititous hydrological year will almost always lead to the lowering of the capacities of the dams since the runoff in the individual months is artificially smoothed over,equalized. Usually, during the period of low waters of the measured year, relatively larger runoff is obtained, larger than it is characteristic for the river.If each month is taken with an assurance given in advance, let us say with a 85% assurance, the assurance of the total annual runoff will come out much larger. This is easily explainable when it is taken into consideration(p.155) that very rare is the year in which all months are arid months,and that the probability for the happening of such an event is very small.

The fictitious hydrological year,called also the averaged year, finds use at the determination of the capacity of the annual compilation of the pluri-annual equalizers,and a high degree of regulation, since in this case the deviations in the graph of the individual years are amended by the capacity of the pluri-annual equalization.

3) The water economical group at the "Energo-Hydro Project" is lately using another method for the determination of the monthly distribution of the proportionate year, which,according to a number of authors such as PATAPOV,NIKITN,and others, is the most acceptable. The essence of the method consists in the division of the year into two or more periods.At the selection of the number of periods and their length we may be guided either by the point of view of the runoff,of the river only, or by the point of view of both the runoff and the consumption. In the cases

of regulation of the runoff for a known purpose, the consumption is also justly paid an attention to. In this is found the advantage and the novelty of the method.

For example, the year is divided into two periods-- period of the filling up of the dam, and the period of its exhaustion. Usually, these two periods coincide with the period of high waters and low waters of the river, but there are cases possible when a part of the period of high waters enters into the period of emptying of the dam, and vice versa. At emptying with the purpose of irrigation, two periods are accurately defined--- from the start of the month of May to the end of the month of September. Of course, some different years will deviate from the so established time, but they are not characteristic for our rivers. With the energy production, two periods are determined, when the graph of the runoff (usually the graph of the averaged year) and the graph of the consumption are compared.

From the point of view of assuring the interests of consumption, the period of emptying is more important and responsible; therefore, when we deduct from the losses, the capacity of the dam is equal to the regulated water volume, reduced by the afflux during this period. The volumes of the water for the period of emptying are determined from the curve of assurance, constructed for the period, with the accepted assurance for consumption. The water volume during the period of filling is the difference between the annual runoff at the given assurance and the already determined volume of waters in the period of emptying. If the year is divided for example into 4 periods--- spring, summer, fall, and winter, and the most responsible is the summer period, we proceed in the following way:- from the curve of assurance for the summer period we compute the volume for this period at the accepted assurance. Thereafter, the curve of assurance is constructed for the sum of summer plus spring, and from this the total volume for these two periods is found at the same assurance. By deducting from it the already measured volume for the summer period, the runoff in the spring period is determined. Furthermore, from the curve of assurance for the total summer, and spring, and winter period the value is found which corresponds to the accepted assurance, and the value of the runoff in the (p.156) winter period is determined as the difference between these values and the earlier measured volume of the summer and spring runoff. By the same method, the runoff in the fall period is also determined as the difference between the total annual runoff at the given assurance, and the runoff in the summer, spring, and winter periods.

The distribution of the runoff within one period shows almost no influence upon the capacity of the dam. It is the most correct to take it analogically to the distribution for the same period in the averaged year.

In the cases when the dam has some destination and variable consumption, and the period of fillin and emptying is very different in the individual years, the year is divided according to the characteristic periods in the regimen of the runoff, for instance spring high waters, summer low waters, repeated autumnal high waters, and so on. The complexity of these cases consists in the determination of the calendar dates for the beginning and the end of each period, since in the individual years they are very different, and also in the determination of the volume of water within the periods. This urges a detailed analysis of the regimen of the river for each year.

The cited method has been used at the water economical investigations of the Kyrdzhali dam and the Tepolyane dam, and it gave results entirely close to those of the balance method. Therewith, any kind of subjectiveness is avoided, and inspite of the fact that the thus constructed year is a fictitious one, it gives a possibility to measure the capacity of the dams the most correct way for the assurance of consumption.

IV. COEFFICIENT OF VARIATION.

The coefficient of variation has been investigated by the data for 27 stations which have used it at the estimation of the standard precipitation. Its change was tracked down at the same eight stations by the method of the moving averages, also for a 16-year and for a 25-year series. The results of the research are given in Table 3. The comparisons are made with reference to the coefficient of variation, determined from the data for precipitation over 50 years, which may be taken as the most probable.

From Table 3, it can be seen that the coefficient of variation, obtained from the 16-year series, is changed within a very wide range, — from plus 31.3% to minus 85.8%. For station Samokov, where we have the greatest deviations, it varies from $C_v = 0.030$ to $C_v = 0.277$, with a most probable $C_v = 0.211$. For the 25-year series, the deviations are smaller than plus 18.0% to minus 34.1%. Characteristic are three peculiarities in the changing of the coefficient of variation:

1) Until about 1924/25, the coefficient of variation, obtained at the use of the 16-year series, is larger than with the 50-year series. After this year, it begins to decrease, and it reaches its minimum either in 1934/35 or in 1939/40. From 1944/45 until now it becomes again larger.

2) The deviations in a positive direction, i.e., to higher coefficients of variation, are considerably smaller than in the negative direction. (p.157)

3) With the exclusion of station Petrokhan, in 70% of the cases, with the 16-year series and about in 90% for the 25-year series, the coefficient of variation is smaller than that for the 50-year period.

From the obtained data the following conclusions may be drawn:

1) The determination of the coefficient of variation of a 16-year series, and even of a 25-year series is unsafe, and it may lead to grave errors.

2) The probability to obtain a lowered coefficient of variation is much larger than the probability to get and increased one.

Otherwise is the matter with the question of the coefficient of variation obtained by the data for the period 1935/36 - 1950/51. The deviations for the individual stations are in much tighter limits from plus 0.2 for station Kazanlyk to minus 10.5% for the station of Petrokhan. From 8 stations, only in one was the coefficient of variation smaller for this period than the 50-yearly. Similar is also the peiture of the results of the 27 stations given in Table 4. For some stations, e.g., Koprivshtica, the deviation in percentage is rather large,....30%, but generally taken the coefficient of variation of the 16-year series(1935/36 - 1950/51) is close to the one calculated from the 50-year series. Here is also emphasized that the 16-year series is a little less favorable in a pluri-annual section, than the 50-year series, since in 23 stations the coefficient of variation of the 16-year series is larger.

The coefficient of variation is used in the computation for regulation of the runoff with the statistical method. Especially important is its significance in the cases of the pluri-annual equalizations. Thus, e.g., with the preliminary computations for the capacity of the Belmeken dam, because of lack of the hydrological elaborations, by analogy with other water gagings(at a relatively high altitude), the coefficient of variation was taken for $C_v \cong 0.34$. Consequently, after more detailed researches it was shown to be $C_v \cong 0.20$.

Undoubtedly, this large difference in the coefficient of variation also reflects upon the required pluri-annual capacity which in the first case, with $\alpha = 0.85$, was 48 million cubic meters, and in the second case, only 10.5 million cubic meters, or a difference of 37.5 million cubic meters, which makes 42% of the overall capacity of the dam.

Expressed in investments, the difference represents about 80 million levas.

If instead of $C_v = 0.34$ in the first case, 0.25 were determined, i.e., with a true deviation of 25%, in comparison with the second research, the difference in the capacities would have been only 12 million cubic meters, or 13.5% in relation to the total capacity.

Consequently, with the true deviations of the coefficient of variation, the differences in the capacities are not within very great extremes, and they increase with the increase of the degree of regulation and assurance.

V. REPRESENTATIVENESS OF THE SERIES 1935/36 - 1950/51.

The chief difficulty in the application of the balance method is that as the dams are planned for the future, data are taken for the basis of computations on the afflux of the past period (p. 158), and this is well-known with such assumptions that the same consistency of the afflux will never be repeated. Unfortunately, this principal difficulty is not removable, but its use is possible on the basis of the consideration that the character of the afflux in the future would not be markedly changed from the one observed in the past, and in particular in the low-water period, investigated for the past time (also determining the capacity of the dam), gives at least an approximative idea about the low-water period how it may happen in the future. Evidently, this assurance in our country will be so much stronger the longer is the period of observations for which we have data on the afflux. Because of this, the length of the observation period, needed for the safe research of the pluri-annual equalization, obtains a first-rate importance. For illustration of the importance of the problem, we shall cite an example given by KRICKI and MENKEL:

For the Moskva river, 40-year direct data are available on the runoff. The first half of this period gives a capacity of the dam for pluri-annual equalization equal to 0.36 of the average pluri-annual runoff, and the second half --- 1.26 of the same period, i.e., 3.5 times larger.

As it has been already told above, due to the lack of observation on runoff longer than 17 years, its foundation for the representativeness of the period 1935/1936 to 1950/51 will be made on the precipitations when we compare this period with the pluri-annual period of 1901/02 - 1050/51.

From a hydrological point of view, the condition required on the part of a shorter period to be representative is: - the average runoff and the coefficient of variation for the longer and the shorter period must be equal.

At investigation of the standard precipitation and the coefficient of variation these two sets were equal. We shall give briefly the conclusions from this comparison.

1) The 16-year series 1935/36 - 1950/51 determines the standard precipitation with sufficient accuracy, while a slight increase in the standard is noted.

2) The coefficient of variation, determined from the 16-year series, is very close to that calculated from the 50-year series. Here also, we find a slight increase in the coefficient of variation.

These statements give us right to assume that the precipitation series 1935/36-1950/51 is characteristic from a hydrological respect, since it is thought that it gives a slightly increased value both for the standard and for the coefficient of variation.

When we transfer these conclusions on the runoff, we may say that, if the condition is satisfactory for the equality of the standard runoff and the coefficient of variation in the long and the short series in reference to the accurate determination of the capacities of the dams, the period of 1935/36 - 1950-51 is a representative one, since the slight increase in the standard and in the coefficient of variation is of an opposite influence upon the capacities of the dams, and the errors are mutually neutralized.

From the point of view of regulating the runoff, however, the above cited condition for the representativeness is not sufficient. Two sets of entirely identical statistical characteristics may require completely different volumes (capacities) for the regulation of the runoff. For the determination of the standard runoff and of the coefficient of variation, a perfectly indifferent arrangement of the dry and moist years is made. If in a series the low-water and the flood-water years are evenly distributed, and in another series the dry years are following one another in a close sequence, the capacity of the dam obtained by the second set will be several times larger than the capacity obtained by the first set, contrary to the identity of the statistical characteristics.

From the statement, the conclusion must be made that, on demonstrating the representativeness of a series ,from the point of view of the regulation of the runoff the greatest attention should be paid to the dry years in the period both to their number and to their condition of low-waters and distribution. In this respect, no criteria can be given which would determine the required number of dry years and their distribution so that the series would become a representative one. For each concrete case, these criteria will be different, depending upon the coefficient of the regulation of the runoff, and the assurance of consumption. The above cited example by KRICKI and MENKEL, in which two annual serieses gave 3.5 times larger difference in the capacities, is with a degree of regulation alpha = = 0.90. With a regulation of alpha = 0.80, the capacities are 0.25, resp. 0.62 of the average pluri-annual runoff, i.e., both the absolute and the relative difference is much smaller. The higher the degree of regulation of the afflux and the higher the assurance of consumption, the smaller the requirements for the representativeness of the available series. In the cases of annual equalization it is not important how the dry years are arranged. On the contrary, with a high degree of regulation and assurance, this is of the first importance. The probability of having a few dry years in close sequence is much greater in a long period than in a short one. Thus, greater cautiousness is urged in case of highhr (higher) degree of regulation and greater assurance in the determination of the representative period, and a more profound investigation of the dry years is necessary.

Theoretically, in a 16-year series four years must occur with assurance larger or equal to 75%. A larger number of such years shows that the series is unfavorable from the point of view of the runoff regulation, independently from the fact whether the standard runoff, extracted from this 16-year period, is larger than that of the 50-year period. This was proved for 27 pluviometric stations, while the result is given in Table 5, Graph 3. From this, it can be seen that in 20 of the stations, during the period of 1935/36 - 1950/51, there were 4 or more years with assurance equal to or larger than 75 percent, since the number of stations in which the assurance years are more is larger than the number in which the years are less than four. This shows that the 15-year series seems to be more unfavorable than the 50-year series.

As we have recalled above, the larger or smaller dryness of the dry years has an influence upon the capacity of the dam. To get an idea in this respect, the data for precipitations of all 27 stations were arranged in ascending degree, as (p.160) the dryest year of the 50-year series gets No.1, the next one No.2, and so on. In the graph 4 of Table 5, the serial numbers of the dry years are given for 27 stations which are also included in the series 1935/36 - 1950/51. In one half of the stations, the most arid years are in this period, and in 20 of the stations the following is at least the dry year. In 21 stations, three are included with 10 very dry years, in 18 stations--- three with 9 very dry years, and in 16 stations, three with 8 very dry years, and in 12 stations, three with 6 very dry years.

The unfavorable indices in regard to number and low waters of the dry years in the series 1935/36 - 1950/51, in comparison with those of the 50-year series, are also distinguished by the following facts:- If we assume, even though hypothetically, that we wish to regulate annually by a dam the precipitation of the various stations, with an assurance of mainly 85%, and we compute the required capacity of the dam once by the 50-year series, and once by the 16-year series, for all 20 stations the capacity obtained by the 16-year series is larger than that obtained by the 50-year series.

All this shows that in cases of annual or pluri-annual equalization the 16-year series 1935/36 - 1950/51 is in general features more favorable than the 50-year series of 1901/02 - 1950/51, and it allows that it can be used at the solution of the tasks of regulating the runoff by the balance method, and with a certain safety at that.

With the multi-annual equalization, beside the number of low waters in the dry years, their arrangement is also of great importance. And in this respect the 16-year series is unfavorable. As it is seen on Graph 5 of Table 5, for each station the period 1944/45 - 1949/50 is dry, while only 1947/48 for some stations and/or 1946/47 for other stations is a little above the standard precipitation. Consequently, in the period of six years, only in one year would the dam fulfill its destination, without resorting to its pluri-annual reserve. Similar is the picture also of the data on the runoff of 18 stream gaging stations in Southern Bulgaria, on the rivers Arda, Marica, Iskur, Tundsha, Tepelica, Strema, and their tributaries. As a rule, the period 1944/45 - 1949/50 is arid, with the exception of 1947/48. Such an unfavorable combination of dry years is of little probability, and it is characteristic for a pluri-annual period.

This established fact is also confirmed by comparisons made between the results on the capacity of the Zhrebchevo dam by the balance method, and by the statistical method. With all variants for the average degree of regulation up to alpha ≅ 0.86, the capacity of the Zhrebchevo dam, obtained with the balance method, is larger than the determination with the statistical method, with identical starting data. Only with a degree of regulation alpha ≅ 0.90, the statistical method gives a little larger capacity.

The evidence gives the right to assume that in cases of the pluri-annual equalization also, the 16-year series 1935/36 - 1950/51 is representative, and it may be taken for the basis of computation for the balance method up to a degree of regulation alpha ≅ 0.85, which is also the practical limit.

(p.161) Interesting is the influence of 1950/52 for which we have at our disposal data both for precipitation and for the runoff, and which was deliberately left out for reasons which we explained above. For the entire country, for the runoff as well as for the precipitations, 1951/52 was a dry year. The standard precipitation, computed as the average of the 17-year period 1935/36 - 1951/52, approximates still closer the 50-year standard. The inclusion of another dry year makes the available series more unfavorable, especially in cases of annual and seasonal equalization, and still more it confirms the probability that the series is representative.

CONCLUSIONS.

1. The basic hydrological parameters, standard runoff, coefficient of variation, and distribution of runoff in the year, directly influence the results of the regulation of the runoff by the statistical method, and the determination of their values is a very responsible task.

2. There is ground to believe that the determination of these parameters, on the basis of the 16-year series 1935/36 - 1950/51, is of sufficient accuracy within the framework of the allowable errors.

2. In the series 1935/36 - 1950/51, dry years are included more than the theor-

etical number, some of which are years of the lowest waters in the 50-year series. The arrangement of the dry years is unfavorable from the point of view of the regulation of the runoff. All this gives ground to think that the observations of the 16-year series may be used for the regulation of the runoff by the balance method, moreover with a certain safety (with less degree of regulation).

3. The conclusions made about the representativeness of the 16-year series, from the point of view of regulating the runoff, are acceptable, but they are based only on the examination of precipitations. It is necessary to have these conclusions confirmed by continued study of the runoff, of the physico-geographical factors, and other climatic factors for each individual district in the country.

(p.162) TABLE 1: (LEGEND) (of columnar heads: a- serial number; b- station; c- explanation; d- average of 50 years in mm; e- 16-year series; f- its average maximum in mm; g- its average minimum in mm; h- 25-year series; i- its average maximum in mm; j- its average minimum in mm; k- standard average for 1935/36 - 1950/51 in mm.

(LEGENDS of column C:)- Explanation; alpha: precipitation; beta: deviation from the 50-year standard; gamma: deviation in %.

(LEGENDS of Column b: Stations with altitude in m): 1- Chirpan, 170; 2- St. Zagora, 234; 3- Sliven, 270; 4- Kazanlyk, 372; 5- Shipka, 570; 6- Samokov, 950; 7- Batak, 970; 8- Petrokhan, 1400.

(p.163) TABLE 2: (LEGEND of columnar heads): a- serial number; b- pluviometric station; c- altitude above sea-level; d- period observed: 1- 50-year' 1901/02 - -1950/51; N_o^{50}; 2- 16-year period 1935/36 - 1950/51; N_o^{16}; X e- deviation D N_o^{16} = $N_o^{16} - N_o^{50}$; 1: D N_o; 2: %.

(LIST OF STATIONS IN series): 1- Yambol; 2- Sadove; 3- Lyubimec; 4- Plovdiv; 5- Chirpan; 6- Khaskovo; 7- Pazardzhik; 8- St. Sagora; 9- Perushtica; 10- Sliven; 11- Kazanlyk; 12- St. Dimitrov; 13- Panagyurishte; 14- Kyustendil; 15- Koprivshtica; 16- Sofia; 17- Novoselci; 18- Shipka; 19- Slivnica; 20- Kalofer; 21- Ikhtiman; 22- Dimitrovo; 23- Lydzhene; 24- Buchino; 25- Samokov; 26- Batak-; 27- Petrokhan.

(p.164) TABEL 3: (LEGEND of columnar heads): a- serial number; b- station; c- explanation; d- C_v of 50-year period; e- 16 years' series; 1: C_v max.; 2: C_v min.; f- 25-year series; 1: $C_v$max.; 2: C_v min.; g- C_v for the period of 1935/36 - 1950/51.

(LEGEND of C column:Explanation): alpha: C_v; beta: deviation from C_v 50; gamma: deviation in % .

(LIST of stations of Column b): The same as for Table 1 above).

(p.165): TABLE 4: (LEGEND of columnar heads); a- serial number; b- pluviometric station; d- period observed 1: 50 years 1901/02 - 1950/51; 50 C_v: 2: 16-year period 1935/36 - 1950/51; 16 C_v: 2- deviation D C_v = $C_v^{16} - C_v^{50}$; 1- D C_v: 2- %.

(LIST of stations in column b:) identical with list under Table 2.

(p.166) TABLE 5:(LEGEND of columnar heads): a- serial number; b- pluviometric station; c- number of years of 75% assurance through the period 1935/36 - 1950/51; d- ordinal numbers of dry years in the period 1935/36 - 1950/51; e- drought period; f- rainy years in the drought period.

(LIST of stations in column b): identical with list of stations in Table 2, and Table 4).

-- END OF ARTICLE--

(next page for CONCLUSIONS).

CONCLUSIONS AND RECOMMENDATIONS OF THE FIRST CONFERENCE ON HYDROLOGY AND REGULATION OF RUNOFF.

(Held on 27-28 February 1956, in Sofia)

The Conference, organized by the Technical Institute of the Bulgarian Academy of Dciences, by the Scientific Research Institute of Hydrology and Meteorology, and by the VTO Energo-Hydro--Project, is the first in our country, and as such it had the following tasks:- first, to make a survey of the development and of the status of hydrology and of hydrological science in our country; second, to point out the most important and most essential scientific practical and scientific theoretical problems which are in direct relation to our socialistic construction and whose elaboration is essential; and third, to give, in very general outlines, instructions for the future work of the scientific research institutes and departments in the field of hydrology, all in regard to actively aiding the practice.

The exhibited reports and statements in course of their discussions have contributed to the correct solution of the thus stated tasks.

The report of Comrade MARCHINKOV brought out the most essential moments of the development of hydrology and of our young hydrological science from the Day of Liberation to the present time. The exposition was detailed, exhaustive, and many expressed their satisfaction by the report. A few comrades disputed only the periodization which Comrade MARCHINKOV took in respect to the development of hydrology in our country, and they put in doubt entirely the need for such a periodization. There is such a periodization. It is another question as to the different periods and their characteristics.

The question therefore is not about the periodization, but about the establishment of the separate periods and about their correct foundation. The report reader could not correctly justify the periodic arrangement which exists in our hydrology, when he took not so much the objective as the subjective factors which have influenced the development of the latter. In accordance with this, the periodization depended almost exclusively on the people who were put at the head of the services in the Department of Waters (later Directorate of Waters) at the Ministry of Agriculture. Thus, for instance, he says that for the period 1920-1935, no attention was paid to hydrology since there was no understanding of its importance in the administration of the Department of Waters. Such an explanation is incorrect. The "neglectful at-

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titude" toward hydrology and toward the hydrological studies in this period, and again a little later, is explained by the demands on the water(p.168) economy of the country, in general, at this stage of our social-economical and political development. And these demands have been also restricted.

What was the matter with us, indeed, at the end of the year 1935? The irrigation of a few hundred thousand decares of agricultural area, with a small irrigational system, scaled with regard to the natural distribution of the runoff in the rivers -- water springs and water electrical centrals with a total power of about 49,200 Kwatts, constructed at the course of the water. The needs of enlarged and deepened hydrological studies have not been so large as to stimulate a development of hydrology and of the hydrological science in such a tempo as a few had desired.

Radically different are the conditions after 9 September 1944 when a broad construction started in the field of water economy. The demands on the water resources increased very incredibly, and thence -- also the requirements on hydrology. This, and not the desire or non-desire of one or another Chief or Inspector, compelled the growth of the services on hydrology, in the result of which the Hydro-Meteorological Service was created, uniting the meteorological and the hydrological ones, which is also of great significance for the development of our water economy. At the same time, and for the same reasons, the hydrological science was also originated in our country. In 1946, a special chair was created for hydrology at the State Technological Institute, and in 1952, a course in hydrology was also introduced at the University. A strong impetus for the development of hydrological science was given by the creation of the NII(Scientific Research Institute) for Hydrology and Meteorology at the Ministry of Agriculture, and the Section for Hydrology at the Branch for Water Economy and Water Construction at the Technical Institute of the Bulgarian Academy of Sciences.

The problem of the preparation of the cadres, at the present moment in paper reports, is also important for the development of hydrology and hydrological science in our country since the problem will be solved by the cadres after all. It must be however well considered in regard to our conditions, without enthusiasm and without excuses.

A great interest was also produced by the report:" On the new trends in the field of hydrology"; "The hydrological network in our country"; "On hydrological predictions"; "Employment of the methods for the regulating of the runoff in our

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country", and so on.

The lively discussions on the report on the new trends in hydrology were not a chance event. They went to prove the opposite of what Comrade RADEV outlined, and some of the comrades who made statements along the same report and other reports. The report is therefore superfluous consequently since it had not solved the problem of the new trends in hydrology. A proof of this is also the increased and deepened discussion 2-3 years ago in the Soviet Union which has still not brought to an end, but which fives a certain result which, though it is not publicly advertised, is known to us. The method of mathematical statistics and the genetic method are mutually supplementing each other, and their harmonized use is the most correct approach, such as it was demonstrated in a very nice way in the report of (p.169) Comrade MARINOV under the title "Scientific foundation of the hydrological network in our country".

In the discussion of both Comrade MARCHINKOV's report and of the report of Comrade PAPAZOV, valuable recommendations have been made which will be taken into consideration at the conclusions and recommendations which will be made.

In respect to the report of Comr. MARINOV " Scientific foundation of the hydrological network", it must be said that this report also caused a lively interest. By the discussions which were made it was confirmed that hydrology in our country has made a remarkable stride in advance.

Valuable discussion and recommendations were made by the comrades who took part in the discussions---Comr. L. KRUSTANOV, Comr. ZHIVKO GULUBOV, Comr. GADZHALSKI, Comr. MITEV, and others,-- whose discussions are also to be taken into consideration.

The report on " The Hydrological Predictions", brought up by Comr. RANGEL MINCHEV, considered a perfectly new subject matter for us. With the elaboration of a methodology for the establishment of short-term and long-range predictions, it will work with extra stimulus.

A great interest was also raised by the collective reports of Comrades STELA BENATOVA and RAIKO RAIKOV, which reports have close relation to each other, and the interest in them is evident. The runoff of our rivers on one hand, and the character of our water economy on the other hand are such that the question of regulating the runoff is of substantial importance for the correct and purposeful utilization of our water resources. And the correct regulation of the runoff to a large degree depends upon the approach and the methods which are being used in the elaboration.

Because of this fact that the conditions in our country are very different than those in other countries, the problem of the regulation of the runoff is also more difficult since a series of new problems arise, such as for instance that of the variable irrigational standard, and the variable water-employment in general. In connection with this, it is emphasized by some that the problem of runoff regulation is at the present time slightly, weakly represented at the present conference. This is believed to be due to the following reasons:- first, at a conference like this all exhaustive problems in the field of hydrology and water economy cannot be brought up for consideration; second, with putting additional reports on the agenda, the conference would be prolonged, and the interest in it would have been weakened.

The administration of the Technical Institute of the Bulgarian Academy of Sciences will take into consideration the desire for organizing a special conference on the regulation of the runoff.

From the discussions which were made during the meetings it is evident that the problem which will be placed on the agenda at the following conference are difficult and they shall be seriously worked on.

From the introduced reports of the First Scientific Conference on Hydrology and Regulation of the Runoff, and from the discussions that occurred during the conference the following conclusions andrecommendations can be made:

I. CONCLUSIONS.

1. After 9 September 1944, in our country the water engineering construction started which is big both in dimensions and in tempo. In the course of ten years, the dams K. Kolarov, Studena, Al. Stambolijski, G. Dimitrov, and Stalin were constructed. Moreover, the dams Studen Kladenec, Topolnica, Kyrdzhali, Batak, and others are under construction. A large number of small dams are also constructed or are being erected. A number of irrigational systems were constructed such as:- the Rosishka, the Bryshlyanska, the Belen, the Chervenobrez, the Staro-zagor, the Pyrvomaj, and other constructions are the irrigational systems at Sofia, Vidin, and others in the Duna delta plains, and in the remaining river basins of the country.

The construction of our water engineering enterprises of the planned and complex beginning substantially contributes to the development of the socialistic national economy, and it represents a power for the generalization of the welfare of our nation.

2. The purposeful construction and exploitation of our water resources with the maximum economical effect is impossible without the presence of safe starting hydrological data on the regimen of the water sources, and without the use of suitable methods both at their elaboration and at the water economical studies. The comparatively weak investigation of our country in hydrological respect puts also very serious tasks on the solution of which will depend the purposeful and thrifty construction and use of the water resources.

3. In regard to the methodology for studying the fluvial runoff with the available starting data, the possibility is not always ready for the use of the genetic method, and one is forced to work with the statistical method.

4. In spite of the indisputable advance in the field of hydrology, and hydrological science in the country after 9 September 1944, and especially after 1949, we do not have available in sufficient number neither correct measurements nor observations on a series of hydrological elements, such as sediment, high waters, underground waters, evaporation, etc.

5. What is concerning the research on the runoff regulation must be also mentioned that sometimes the other hydrological parameters are used improperly. On
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the one hand, the endeavour to use the possibility, the balance method, is not always at hand, and on the other hand it must be recognized that for a long time and at many places, the statistical method will remain the only possible method for this research.

6. The consultation also notes down that it must be outlined that on the side of the Hydrology Section of the Water Economy and Water Construction Branch of the Technical Institute, of the Hydro-Meteorological Service at the Ministry of Agriculture, and of the service by the Engineering Hydrology at the Energy-Hydro-Project and the Water Project, a number of hydrological questions of organizational and methodical nature have been solved during the last years which have helped to a certain degree the hydrological practice.

7. It must be still remarked that the present hydrological cadres are not sufficient at all, and above all not highly qualified. This concerns chiefly the low cadres which work on the hydrometric network. Inspite of the qualificational courses for the preparation of the low cadres, they never were able anyhow to acquire the type of qualification which is essential in dealing with the extraordinarily

high requirements of hydrotechnical planning and construction. For instance, some groups and water reader posts exist which are held by people who do not have even an average education.

8. In consideration of the large uniformity in the terrain of our country, however purposeful may be the supporting hydrological network, the runoff conditions and the more concrete genesis of the runoff cannot be anyhow established, unless a stimulus is given by the experimental hydrological studies -- by the runoff landings (squares?). The onset is still insufficient.

9. The practice shows that to answer the specialized needs of some jurisdictions, special jurisdictional hydrometric stations must be organized.

10. An important portion of the hydrological studies must be the study of the underground waters. The latter represent an important part of the equalization of the water balance, and they have great national economic significance.

11. The finished conference gave the chanse a) to discuss problems brought up by the reports and other problems created by the practical demands upon hydrology in our country; and b) to give the direction for the future development of hydrology.

II. RECOMMENDATIONS.

1. Reorganize the hydrometric network on the basis of the given scientific foundation, as:

a) the scientific foundation of the network is further enlarged on the basis of the principles of water balance;

b) the stations excluded from the supporting network on the basis of the scientific foundation, should not be closed until the establishment of the relation between them and the new stations;

c) at the beginning, the stations of longer series and of good observational set should not be closed;

d) the closure and the opening of stations of the same network will be harmonized by the HMS and the interested planning services, while a study at site is made for the purpose;

e) the meteorological network of the supporting hydrological network is enlarged and harmonized according to the river basins.

2. In connection with the perspective for a wider utilization of the genetic

method at the study of the river runoff, sufficient investigations will be carried out on the elements of the water balance.

3. The statistical method will not be formally used, but in accordance with the hydrological analysis.

(p.172) 4. Work must be done on establishing a method suitable for our conditions which could lengthen the short hydrological series as well as a method to demonstrate the representativeness of short hydrological series. The problem must be investigated both on the pluri-annual section and in regard to the intra-annual distribution.

5. Work must be done on improving the hydrometric methods:

a) of the surface waters;
b) underground waters,
c) sediment(silt)
d) snow coverage,
e) evaporation.

6. The importance of the problem of the hydrological prognostication is pleaded, the study of which represents a special interest both from a scientific point of view and form a practical point of view. Special significance for the exploitation at the irrigational systems comes to the long-term prediction of summer runoff.

7. Work must be further done on the precision of the balance and statistical methods at the regulation of the runoff for our conditions. The question must be investigated theoretically, while comparisons of the fianl results, obtained by the two methods in more cases, are made, and explanations of the differences in the results are sought for.

8. In consideration of the insufficiency of the top engineer-hydrologist cadre it is recommended to train annually a few students of the specialty "Water improvement construction" by a specialized plan, while some of the subjects in the instructional program of the specialty of HMS are left out for them, and changed to special hydrological disciplines. The suspended chair for hydrology and meteorology should be restored, and it should manage the teaching of these cadres.

9. In the Technical Institute of the Bulgarian Academy of Sciences, Section on Water Economy, the Sector on Hydrology and Water -economical Investigations should be enlarged and fortified.

10. As to the series of hydrological and hydrometrical problems along which the services are also isolatedly operated by different people, the work should be

also harmonized and distributed with regard to a better purposefulness.

11. The experimental hydrological branch should be developed by opening a (or more) runoff landings. To this problem also belongs the taring of the hydrometric screws, spillways, etc., and other hydrometric equipments.

12. Investigation of the underground waters should begin. On the basis of the research the solution of both theoretical and practical hydrological problems should be laid down. Along with this, a corresponding network should be prepared and established.

13. The science of hydrology should be popularised through corresponding publications:-- scientific, popular, monographic, and reference works, etc. The collected hydrological data in the HMS should be published in yearbooks. Work should be done to publish maps for the modulus of runoff, coefficient of variation, and runoff coefficient for the 20-year period 1936/1956.

14. The Bulgarian Academy of Sciences, the Branch "Hydrology and Water Economy" Research" of the Technical Institute should arrange for periodical scientific conferences on the hydrology and regulation of the runoff.

(End of recommendations)

(Cont. on next page)

(p.173) FROM THE STENOGRAPHIC RECORDS OF THE PROCEEDINGS OF THE SCIENTIFIC CONFERENCE ON HYDROLOGY AND REGULATION OF RUNOFF

(Held 27-28 February 1956)

*** FIRST SESSION ***

(Opened at 9 o'clock by a short address of Academician LYUBOMIR CHAKALOV, Secretary of the mathematical, physical, and mechanical sciences Class of the Bulgarian Academy of Sciences).

Chairman, Corresponding Member LYUBOMIR KRYSTANOV:

– Comrades! Let us go on with our work. Prof. Engineer B. MARCHINKOV has the word. He delivers a report on the topic: "Development of Hydrology and of the Science of Hydrology in Our Country". (The report of Prof. Engineer B. Marchinkov is printed in the present Symposium).

(After the rest period)

Chairman, Corresp. Member, L. KRYSTANOV:

– Comrades! The work of the conference continues. Engineer RADOJ PAPAZOV, junior scientific co-worker in the Technical Institute of the Bulgarian Academy of Sciences has the floor to deliver a report on the topic "New Trends in Hydrology" (The report of Comr. R. Papazov is printed in the present Symposium).

*** SECOND SESSION ***

Sofia, Monday, 27 February 1956

(Opened at 15.30 o'clock)

CHAIRMEN VICTOR SHILEGOV:

– Comrades! Let us start with the discussions on the reports which were read before luncheon. Take the floor for your utterances. If a few comrades wish to ask questions, they may write the questions on slips of paper and send them to the office. Questions may be also asked verbally.

Comrades! The first time in our country, a conference has been arranged on hydrology and regulation of the runoff, and therefore I hold that we should take an attitude to the reports and to the conference itself as a whole, to the effect also as to whether it was useful and whether we should arrange similar conferences in the future.

Comrade Engin. Radi Radev has the floor for his announcement.

Engineer RADI RADEV:

– Comrades! It was a great satisfaction to me what I heard from the report of Comrade Prof. MARCHINKOV on the history of our hydrology. On the other hand, nowhere could we find this material so compactly, nicely, and exhaustively exposed. I believe that the administration will make it a must to have this report reproduced so that it will be accessible for us. Much material can be drawn from it for different purposes.

As to the second report — the report of Comrade PAPAZOV. Truly, I tell you, I remained disappointed. In this report, no actual problems were raised.

The problem on the genetic or statistical methods does not occupy us to-day in general. We do not make a difference between statistical, genetical, or balance methods. We employ the methods which correspond to the tasks and to the starting data which are at our disposal. I was left with the impression that hydrology must make itself a high-class science, enclosed in itself, which does not care or does not account for the practice.

(p. 176) From the report of Comrade PAPAZOV it comes out that the statistical method in general must be discarded from useage. No, Comrade Papazov! We regret very much that the statistical method is not so elaborated that we could use it everywhere where the practice requires it: — with a disturbed regimen.

As to the report I wish to say also this. The idea is incorrect that the statistical and genetic methods are antipoda, which exclude each other. The genetic method is genetic only in those elements which are still open to our knowledge. The statistical method deals with values or events whoch are said to be chancy. Yet, Comrades, they are not chancy. If we call them chancy, we wish to say thereby that we do not know the causes of these phenomena. They are complicated, a chain of events, created mutually according to the Law of Causality. Some of these chains we may break — the geological, underground waters, and all those which we shall call a capture by the genetical method. Thus, more and more, we reduce the complex which we treat by the statistical method. However, for a long time, not to say for ever, elements will be left which will be treated by the statistical method. Therefore, instead of sending the statistical method into exile, I think, one noble task of the hydrologists is to further develop them, to generalize them, and to find for them larger application, because only then shall we get rid of the back-breaking Egyptian work which at the present time we are doing there where we do not have a way by the statistical method to solve the task, and where we are forced to turn to the balance method.

RUSI RUSEV:

– Comrades! This session for me, and I think that also for many, is impressive for the reason that it appears to be the first phase in our country where, before a wider circle of people of science and of practice, publicity is given to hydrology. As for me, this is very important. I believe that it is one step which should have been made earlier. A similar kind of step must be also made in the future; still more, that the successes and the development of our hydrology had been associated to a large degree with its public recognition. This phase today–– attending this conference of hydrologists and of other problems–– is a positive, encouraging step and it should be congratulated.

In our country, a certain underestimation existed of the importance of hydrology. This is also the result of the circumstance that the significance of hydrology had various interpretations. It was held that it is an accessory discipline which does not have anything common with the rest of the engineering diciplines. What are we talking about? Some tell that hydrology is a geophysical discipline, and others, that it is a physico-mathematical discipline––– I tell you about a definition, about an enclosure of its essence. It is essential to clear up this question.

I wish to delay for a few moments on the report of Comrade Prof. MARCHINKOV, and more especially on the question of periodic arrangement (periodization). Comrade Prof. Marchinkov gives a very complete description of the characteristic moments in the development of the hydrological research in our country. He indicates the first period until 1920, the second period until 1935, which second period he characterizes with the appearance of certain new documents, workers, and the making of attempts at embracing, beside the recorded water stands, also still some characteristics. I hold that this second period which he characterizes after 1920, does not mean anything new or substantial in the development of our hydrological studies. Actually, before 1934/35, when the systematic measurements of the water speeds and water amounts started, we had only individual fragmentary attempts at making any kind of generalization, which single attempts were left in oblivion. These are single, disconnected attempts which we cannot use, and I think that this period should not have been designated as the second one. A characteristic period in the development of hydrology in our country is the period after 1935.

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In the series of remarks, which I covered, I wanted to give an explanation in connection with the assertion in the report of Comrade MARCHINKOV that the union of the hydrological and the meteorological services was at the proposal of a Soviet specialist. For the sake of accuracy, it must be said that this was a coincidence. The idea for the unificiation is not one of a Soviet specialist. It had been put on the agenda, and it was discussed in the Hydrological Service while meanwhile the planning arrangement for the unification had been also prepared. The Soviet specialist Comrade only helped us in the solution of this problem. (p. 175)

In a report a question is concerned which is connected with the development of our hydrology -- the question of the frequency of the gagings. In the report it is said that until 1949-1950, when the entire service was created, the gaging at the water-reading stations of the speed of the water volume, and so on, had been periodical by brigades 2-3 times a year. This is namely the weakness of this period. Thereafter, more frequent gagings were introduced. Insofar as I know, I think that even at the present time the question arose about the revision of the number of gagings. This question must be seriously thought over, because with us, especially in connection with the continuous variability of the chart of the deformations, etc., the density of gaging in the water-reading stations is an extraordinarily important element, and I apprehend that it mat arrive at an error if we reduce in advance the number of the measurements, before we could think it over well.

MIKHAIL DUMCHEV:

Comrades! The introduced reports concern purely scientific questions. The report of Comrade Prof. MARCHINKOV concerns the historical development of hydrology. In the reports, however, the questions of practice are little touched. Of course, the comrades did not have such a task.

I shall delay more on the report of Comrade PAPAZOV. In our practice, we do not examine the runoff in a way isolated from the phenomena and the factors which condition it, when we have left the genesis of the runoff out of consideration. In the method which we use, this matter has been laid down as basic. I am in accordance with the declaration of the person, however, who talked before me, that the statistical method cannot be entirely discarded and the genetic method cannot be entirely accepted. With the employment of the methods of genetics, one must start out from experiments. Therefore, we do not have any foundation, any satisfactory study.

Until now the first and basic task at our studies had been this:- that we should study the so-called stable, non-variable factors; such as the average altitude above sea-level, the slope of the drainage basin, the forest coverage, the soil conditions, the geological conditions, and still others. In other words, we should elaborate the oro-hydrographical characteristics of the district.

Thereaftet, we make a more detailed and widened climatical characterization. The basic factors here are the evaporation, the deficit of humidity, etc.

From the practice it is established that the permanent factors--the oro-hydrographical one and the average altitude above sea-level, are proved to be the most essential, the predominating factors. All other factors are in dependence upon them. Also, since it was established on one hand that the average altitude above sea-level is the most important predominating factor of the oro-hydrographical factors, also on the other hand, since it was established that there is a very good relationship between the average altitude above sea-level and the standard runoff, our country may be divided into 9 zones. Thence, the idea for nine graphical dependences between the average altitude above sea-level and the modulus of the runoff, too.

After a test has been made of this graphical dependences, what results they give, what accuracy they have, it was proved that they give very good results; that the error varies between -14 and plus 15% deviations. There may be, indeed, large deviations, but for the data with which we dispose in the period in which we had observations, for the accuracy that is needed in practice they are completely sufficient.

In our work we had also gone a little farther:- there where it was impossible to establish such a relationship and where the graph cannot help, we began to have the services of the formulas of the Soviet literature and we began to use the experiences of the U.S.S.R.

In the Dobrudzha, the basic factor for the standard runoff is not the average altitude above sea-level, but the soil conditions.

The larger the drainage basin, the smaller the runoff, as a difference from all other districts, the runoff is lost in the ground. This is a common coefficient which reflects all the rest of the factors which do not participate in it. It is determined by the ploughable area. For it, there is a derived individual formula. Here also the ploughable area participates as a basic factor. Thus, the soil conditions are basic.

Therewiht, I wished only to outline that we cannot and must not deal with two basic methods in hydrology, and to consider that this one is sutiable and the other one is not, or vice versa. One as well as the other are closely connected, and in the practice we are using them jointly and indistinguishably.

The other thing which is characteristic in our practice--- again in support of this thought is that we have almost thrown away the analytical methods, the correlations, and it may be boldly said, we are using (p.176) almost everywhere only the graphical relations. Of course, there where it is necessary and cannot be without it we are still using the correlations, but we have recourse to them then when it is impossible to use the graphical dependences. This shows that thus or otherwise we are directed more to the genetic method than to the methods of mathematics and statistics.

This is also established so that the coefficient of variation has a very good graphic dependence with the average altitude above sea-level, with the modulus of runoff, and with the average runoff coefficient. From the research which had been made, however, it seems that the relationship between the coefficient of variation and the average altitude above sea-level gives results.

In conclusion, I wish to say that this hydrological conference represents a very good beginning, and I support the point of view that such conferences be organised every year, and if it is not possible every year, then they should be arranged every 2-3 years. Hydrology is an important branch of our science, very necessary for our construction. Comrade RUSEV correctly represents the point of view that our engineer Technical Institute must be thoughtful and must make it necessary to enable more and better prepared cadres to go out into the field of hydrology.

DICHO DICHEV:

Comrades! As to the first report, only the circumstance should be noted that it threw considerable light upon the development of our hydrology from the beginning of its creation until the present days, for the reason of which it represents an interest for everyone who works in this direction.

The second report had for its task to make us acquainted with the problem of the genetic method which is employed partly both in our country and in a number of other countries, mainly in the Soviet Union. In its chief part, this report was concerned with outlining the advantages of the genetic method in hydrological researches. There exists a certain definite relation between the two methods of work-- the genetical and the statistical. It is not easy, however, to take an attitude in this problem-- to say that the statistical method is the best, and the genetical method should be discarded, or vice versa, to say that the genetical method should be accepted, and the statistical method should be completely discarded. Both methods have positive as well as negative sides.

In the report, such a tendency was expressed-- to give a certain privileged position to the genetic method. The practice shows, however, that we are unable fully to discard the statistical method. The genetic method of working, at least nowadays, is in its emryonal stage of development. These methods are too difficult to work with, and for the practice it is necessary not only that a given method be sufficiently accurate but also that it should be rapid. Consequently, when this estimate is made, this should be also taken into consideration.

In the report the circumstance was outlined that the genetic method has been based upon dialectics, and the statistical methid is dialectically unfounded. Is this true? It is not true. The genetical method, form the point of view of dialectics, is correct and nobody will dispute it, but to assert that the statistical method is dialectically wrong is impossible. We have taken into consideration the statement that at least with the coefficient of variation, since the coefficient of asymmetry and the graphs of assurance of the runoff are influenced by chance elements, then the statistical method is not dialectical, but metaphysical.

The circumstance is left out of consideration that the values with which one operates in the statistical methods are the whole-annual runoffs. But the annual runoffs are not chance values, they are strictly founded. Nature has settled them strictly. They are chance-like for us, since we do not know their origin, since it is so complicated, since it is composed of so many elements that we are not in the position to encircle them all, since we are unable to elucidate the origin of all these causes which influence the runoff for a given year, thus the yearly runoff is a chance value. It is however, as I have said earlier, not a chance value. I doubt whether the genetic methods shall give more exact results at the research of individual problems, since at the employment of these methods a profound research work would be necessary with all probability which, practically employed, could make possible alone to give more accurate results.

It is because of this that I think that it is not right that we assume such a categorical attitude, and we represent the genetic methods as the best ones, and the others-- as incorrect and that we reject them.

(p.177) DIMITUR MITEV:

Comrade PAPAZOV spent some time on the statistical and the genetic methods. This is actually a problem which for many years will interest all hydrologists not only in our country but also in the whole world. Also the fact that many of the existing empriical formulas include one or two, and even some five or more elements which condition the runoff, speaks that, actually still very early, the people who are dealing with, or run into, the problems of hydrology, have searched for a solution of these problems through the basic or additional factors which condition the runoff.

From the existing factors-- either for the standard ones or for the high or low waters-- until now, not a single one turned out to be of the needed eminence to satisfy all demands of contemporary planning and of the modern needs in general.

From the report, it became also clear to me that Comrade PAPAZOV is luttle acquainted with that which is made in the so-called jurisdictional organisations, as Prof. MARCHINKOV expressed himself, namely the planning organizations "Water Project" and "Energo-Hydro-Project". Comrade PAPAZOV, and also all the rest who are not of these organizations, should know that these problems are more or less known also in the Water Project and in the Energo-Hydro-Project, and that the genetic method is used by us not in that light in which it is presented here, but partially. There is not a planner of the Water Project or of the Energo-Hydro-Project who would not pay attention to the transforming activities of Man, disturbing the regimen by the irrigational system, by the water structures, by the dams, etc.; or the future changes of the drainage basins in consequence to the forest coverage, the evaporation, etc. We actually strive on these problems and we are waiting that in the future, by our institutions, by the Bulgarian Academy of Sciences, some kind of instruction will be given.

In the practice we are working with those formulas which include more of the factors that condition the runoff-- we move along the same pathway which Comrade PAPAZOV drew up. However, we are always dressed and ready-- as also the hydrologists in the U.S.S.R. and in the rest of the world-- to a nebulous picture, to an an uncertainty arising from the fact that the runoff is a product of complicated phenomena of a great number of factors which give reflection (reflect) upon the dimension and the distribution of the runoff both in time and in place.

As to the genetic method.- I do not see, byt taking into consideration our material basis and discussions which were carried out in the Soviet Union, that we will start out in a short time along this way, and it might be a long time before it comes to this. However, with the presence of the requirements at the planning and construction, I do not see either along the genetic way, how we would reply (would have replied) all those problems which at the present time, in this very moment, we the planners recognise and without which we are unable to move ahead.

As to the statistical method.- I do not see how we would have been able to reject it and not to work with it, and to prefer one way which we do not know where it shall lead us, which is not explained for us, and for whose explanation many and many data are actually necessary, and then by all parameters which condition the runoff.

But let it be known-- and I think that Comrade PAPAZOV should have emphasized this clearly-- that we do not use the statistical method blindly. In the engineering hydrology, we are using the statistical method after a profound analysis of all basic materials and factors which are of influence upon the runoff.

Actually, the statistical method, and more specifically the graph of assurance of Pearson-- third type-- have their defects. However, in what do these defects consist? You all know them. The defects in this curve are exactly in those assurances which are not frequently used and which the planners are rarely in need of. And with the situation that we are unable to solve the problems by an other way, with those weaknesses we shall continue to work, and above all by those methods-- as long as we shall not be able to have more material and more knowledge at our disposal.

Is not ~~it~~ the analogy which we are using and which is also specified in the world literature, is it not built upon the genetic method? Who is it among us planners who could take an analogous basin, without studying the meteorological and oro-geographical characteristics, without having demonstrated the conformity of these two basins in every respect? Aren't all graphical relations which were deduced in engineering hydrology, all studies which have been made, do not they work, and will continue to work, aren't they genetic ways, genetic methods? Estab-

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lishing(p.178) the relationship between the climatical, oro-geographical elements-- on one hand, and the runoff-- on the other hand, isn't this a genetic way? YES! But inspite of all these studies, we all have still not come to any permanent, solid conclusion by which we would say: " This is the road, on this road we must proceed!". In conclusion: - the application of the statistical method, by which they are working at the present time in the Water Project and the Energo-Hydro-Project, is sufficient and correct for the practice, and it is the only road on which we can move ahead as long as we shall not have the material basis and sufficient amount of gathered data and means to enable us on a reverse pathway to demonstrate the preeminence of the genetic method and to set out on that road!

LYUBOMIR KRSTANOV:

Comrades! The report of Prof. MARCHINKOV is very useful, at least it gives the idea for us what the development of hydrology had been in our country-- not of the Bulgarian hydrology as a science, I should say, but of the hydrometric gagings, since this is in essence the development of the network-- as to the science one cannot talk about it. The gagings that were made, and the accumulation of the data all together is not the science. Of course, it is useful how this thing has developed, but I think that it is still early to talk about periodization. I do not know what significance it would have substantially.

This is personally my opinion, but not the opinion of the Hydro-Meterological Service.

I do not know what opinion I could give as to this division into stages. A science is divided into separate stages when between the stages a qualitative difference exists as to achievements. But here we do not have special achievements. I think that for the start of our hydrometrical gagings the year must be held in which a unified network had been established in the country. This is the year 1949, after the coming of the Soviet specialist ELISEEV. From there on begin the partial hydrometric gagings with the unified method and with standard instruments. From there did substantially start the collection of more sacure data on our country. Before this, of course, there had been also other data which will be also used, but we should not hold that for any special period and should not slit it up into 3-4 periods. This is my opinion.

As to the second problem-- about the statistical and genetical methods.- What about the fact that in every branch of geophysical science where a phenomenon cannot be detected by a single experience, the accumulation of many data is necessary which must be elaborated! Naturally, here the statistics will also play a role, at the elaboration of these data by the statistical methods, the characteristics of the phenomena will be received, but these characteristics of phenomena are not the physical characteristics of the phenomena; they do not speak of the origin of the phenomena; they do not speak of their physical connection with other events, inspite of the fact that they characterize them to a certain degree.

ONE OF THE AUDIENCE:

They contain them.

KEJSTANOV:

Yes! These characteristics are invented by Man. You may create for instance not only a modulus of the runoff, not only a coefficient of asymmetry and of variation, --you may create also a number of other statistical characteristics, if they are handy for the characterisation of the phenomena. This, however, does not tell about the physics of the phenomena what the genetical method is looking for. If we wish to find that physics by the statistical characteristics, then we shall fall into formalism. And that we should not fall into formalism, we must employ methods which give the relations between the elements. This is the genetics. In substance, the true physical methods for research of the geophysical phenomena--- they are the genetic methods. Of course, they determine the phenomenon not only qualitatively but they give also the possibilities to their safer prediction than the statistical methods. This is alltogether an evident work, this is the most intelligent work! Because of this work, namely, it is based upon the fact that, together with the statistical elaboration, with the obtaining of the statistical characteristics,-- with the geophysics it will be already a method, since it is the principal situation; it will be a permanent method when we have a combination of data-- together with this method also, the physical reciprocity between the runoff and all other factors will be sought for, which determine it:- precipitation, evaporation, infiltration, underground waters, etc., when they are also measured. Substantially, you may not run away from this thing:- on one hand, you measure the runoff, and on the other hand you measure all these factors which determine it; you measure it and again you determine statistically these factors. So, (p.179) you will make a connection between the two sides which you get, to actually enable you to reach the foundation of the physical existence of this phenomenon which you are studying, in one word-- the runoff.

This is the question. And it originated in the Soviet Union since at the time, it seems, a deviation was made in one side-- it may be a few of the researchers have started to give physical explanation of the phenomena only through the statistical characteristics. This is, of course, formalism.

PETUR PENCHEV:

Comrades! I did not have the chance to hear also the second interesting report which was today introduced, that is why the remarks which I shall make will be more on the report which Comrade Prof. MARCHINKOV brought up.

In his report, still at the start, the question was raised about the development of hydrology. It was outlined that hydrology has been developing a long time in the technical specialties. Comrade Prof. MARCHINKOV also outlined some attitudes of VELIKANOV and CHEBOTAREV concerning the question what kind of discipline hydrology is. It is outlined that in the past, hydrology on one hand has been defined as a technical science, and on the other hand-- as a physico-geographical science. It was also outlined that hydrology in the modern stage of its development has already reached so far that it has its special objects, its own methods, and that it is developing as a wholly independent science.

But, from the sentences said, it is evident again that hydrology has developed in close relation to both the technical sciences on one hand and to the physico-geographical sciences on the other hand. I am pleased that our present conference gives a chance to the Comrade hydro-engineers who are predominantly the majority of the audience to meet also the physico-geographist comrades for whom the present conference is also of great interest.

I have to tell you that one of the defects for us, physico-geographical people, in the latter part of the report of Comrade Prof. MARCHINKOV was that he did not enumerate where at the present time hydrology is taught in our country, where the cadres are prepared who could be engaged in hydrology. It may be that to the comrade hydro-engineers, with whom we had no sufficient connections, it has not been known that at the Sofia University, at the specialty of physico-geography, hydrology is also taught, and that it is represented with sufficient number of disciplines.

I shall tell you only with what "horarium" (classes) hydrology is represented in the specialty of geography. The physico-geographers at the Sofia University are classified into two profiles. The students in the fourth and fifth years of their following in these two profiles will study entirely different disciplines:- general hydrology with a horarium of 3 hours weekly in 2 semesters; hydraulics, two hours weekly, 1 semester; hydrometrics, also 2 hours weekly, 1 semester; methods of elaboration of the hydrometric data, hydrology in Bulgaria, hydrology of the land, --you see what kind of different disciplines. Beside this, they also listen to a number of climatological and meteorological disciplines which indisputably contribute much to their preparation when they will work in the field of hydrology in the separate juridcitional services.

I should like to finish with one appeal:- to have in the future a closer collaboration between the comrades hydroengineers and the physico-geographers to be able actually to clearly establish the laws in relation to the physico-geographical foundations of the runoffs in the different parts of our country and to be able to predict safer the hydrological phenomena in our country.

VOICE FROM THE AUDIENCE:

And with the meteorologists!

PETYR PENCHEV:

Yes, of course!

IORDAN ENEV:

Comrades! The questions raised in the reports of Comrade Prof. MARCHINKOV and engineer PAPAZOV stimulated a particularly large interest among us. Of great importance for our hydrological practice is the problem on the employment of the genetic method at the research of the river runoff.

I want to spend some time at one of the questions raised in the report of Comrade engineer PAPAZOV---at the problem of the influence of the vegetal cover and more specifically-- of the forest on the size of the river runoff.

The influence of the vegetation and especially of the forest , as it has been established by the eminent Russian and Soviet scholars DOKUCHAEV, OTOCKI, VISOCKI, TKACHENKO, KASATKII, RUTKOVSKI, NESTEROV, ZHILKIN, MOLCHANOV, and others, is of great importance for the regulation of the water runoff.

On the land surface three types of vegetational forms of the vegetal cover are met with.

(p.180) FIRST-- forests which may be of very different nature and form of forest economy conducted on the area covered by them-- as it begins from the high-stemmed coniferous trees and the broad-leaf plantations, and it reaches to the fungus-covered brushwood and shrubbery.

SECOND-- natural and artificial pastures and meadow formations.

THIRD-- agricultural plantations and cultivations.

The different vegetational forms show different influence upon the runoff. The greatest and the most permanent influence upon the surface runoff is shown by the forest, at least it represents the greatest accumulator of organic material, permanently and continuously occupying a given territory and directly acting on the water runoff.

The hydrological role of the forest, as well known, is manifested in four directions:

1.- in the enlargement of the moisture circulation on the ground surface, conditioning the climatical damping role of the forest;

2.- enlargement of the reserves of the underground waters and enalre large-ment of the sizes of the underground runoff-- the water protecting role of the forest;

3.- lowering the peaks of high waters and lengthening the period of the running-off of the waters-- the water regulating role of the forest, and

4.- decreasing the swamping of the ground-- ground and underground dyring role of the forest.

The water containing capacity of the forest depends upon the size of the stemmed portion of the individual trees, on the size of their leaves. Besides, the water containing capacity of the forest depends upon the age of the underbrush, on their wooded type, on their density, on the manner of the forest husbandry, on the form of the coppice-- naked, grouped, permanently seeded and so on, on the annual season-- as to the broad-leaf forest, on the arrangement of the underbrush in echelons(stories), on the presence of coppice in the forest, etc.

VISOCKI, when he examines the individual elements of the water balance of the forest ground, he says that the sum of the precipitations is equal to the surface runoff, the underground runoff, the physical evaporation and the transpired evaporation, and it is fixed on positive and negative elements of the water balance.

In connection with this, he outlines the great importance of the forest management practice which will be directed toward the enlargement of the positive elements of this balance and toward the reduction of the negative elements.

The positive elements of the balance for the national economy are the underground runoff, and the transpired evaporation, and the negative elements are the evaporation of the humidity from the surface of the ground, and the slopes of the wooded areas, and the surface water runoff. However, the positive elements of water balance have in the formula directly opposite results, namely-- the enlargement of the underground runoff contributes to the improvement of the water regimen of the rivers, and the enlargement of the transpired evaporation--to the decrease of the underground runoff. The decrease of the underground runoff does not help the improvement of the climatic role of the forests and the enlargement of the wood growth itself.

At the estimation of the different forest economical measures, we should start out from this-- whether it increases the water protective and water regulating role of the forest. In our country, with the exception of individual articles by engineer KUSEV, of TODOR TODOROV, of IONKOV, and BLISKOVA, we do not have a systematic and profound research of the hydro-meteorological role of the forests.. And this is especially urgent to be done for the waters in the drainage basins of the already constructed dams or of those under construction, and for the field-protective forest belts in the Dobrudsha and elsewhere. For this purpose, it is necessary, at numerous experimental areas and observational points in the different forest districts of the country, to carry out investigations in respect to the water protective and water regulating role of the forest. It is also urgent to create forest-stations conducting experiments in our country, for which at the time Academician VISOCKI also raised his voice. The problems should be also constantly studied in regard to the influence of the types of forests, the structure and the echelonage of their underbrush upon their water protective properties. It should not be forgotten that at the research and the performance of scientific productive experiments, the influence of the various types of cuts should be determined upon the water-protective and water-regulating property of the forest (cut...Bulg. sechi).

In conclusion, it must be outlined that the solution of the different scientific problems, connected with the hydrological role of the forests and with the field-

-protective forest zones in our country, must remain on the basis of the general problems, for the solution of our socialistic construction assigned to the hydrological and geographical sciences in our country.

(The session was closed at 18.30 o'clock.

(p.181) --- THIRD SESSION ---

(Sofia, Tuesday, 28 Febr., 1956)

Opened at 9.15 o'clock.

CHAIRMAN PROF.B.MARCHINKOV:

I give the word to Comrade MARINOV who will bring out a report on the scientific foundation of the hydrological network in the People's Republic of Bulgaria.

IVAN MARINOV:

Comrades! Before starting the substance of the report "Scientific Foundations of the Hydrological Network in the People's Republic of Bulgaria", I wish to make a reserve which consists in the following:- the work on the foundation of the hydrological network in our country is bulky enough, in size about 100 pages. Here, before us, I do not have the chance to read the whole.....

PROF.DIMO VELEV:

...And Glory Be to God!

IVAN MARINOV:

...material. Therefore, I think to bring out only those basic situations which have been laid down in the foundation of the network, the principal things. And if there are certain details which you wish to hear they can be cleared up under the form of questions and discussions(Reads the report).

CHAIRMAN PROF.B.MARCHINKOV:

There are 15 minutes for rest.

(After the intermission)

CHAIRMAN PROF.MARCHINKOV:

Comrades! The second report: "On the Hydrological Predictions", will be read by Comrade RANGEL MUNCHEV, taking the Hydrological Department at the Scientific Research Institute for Hydrology and Meteorology.

RANGEL MINCHEV: (Reads the report on the hydrological prognostications).

CHAIRMAN PROF.MARCHINKOV:

You have the floor for discussion.

RUSI RUSEV :

Comrades! The need for the foundation of the hydrometric network in our country had become rather urgent. It is correctly noted in the introductory words of the report brought out by Comrade MARINOV that in a large portion of the time while our network had been created there have not been sufficientlyscientific and reasonable premises for their construction, and for this reason the construction of the network had been more on the basis of current needs.

I think that we should spend more time on this problem, provided that thereby we shall contribute to a still better elucidation of the preparation of the experiments about the good foundation of our hydrometric network.

And so, the experiments are necessary, and it is further necessary in my opinion that periodical check-ups of the network should be made because a test, a checkup is not something once and for all finished, a test after which we may say that there are no new elements growing which could impose upon the estimate of the work in our stations. And especially at the present time when the work of the hydrometric network is comparatively much fortified, with larger envelopment, of course, in the light of the wider and profounder explanations of the elements of whatever nature they may be, always newer and newer foundations will be laid down. But that what has been made--- I am generally very much satisfied with this report--- is very good in my opinion.

It is worthy the trouble, however, it would have been much better if a slightly different foundation and proof had been added to the basic premises laid down in the report-- namely, that is the question about the foundation of our supporting network of stations which enter into the hydrometric network. In the Soviet Union, and even at other places, the following classification is made of the stations:- supporting stations, supporting section, first-sectional stations; operative stations and experimental stations. I shall spend a little time further on them.

The foundation which is ladi down in the report contains a very valuable thing, and we must connect it with yesterday's report on the genetic methods. We heard that all considerations which have been taken to make more precise the given stations as supporting stations, substantially lead to only... that at observation by the so determined stations we succeeded to include the genetic elements, the influence of the individual factors. In my opinion this is one of the most essential things, which must be emphasized in connection with the report on the foundation of the stations, and it is the most positive side. We cannot imagine today that, by a different method, if it would be suitable at the foundation of the supporting network, it could be more correct than the method which was presented here. I find that this method of foundation is completely correct. Indisputably, there are therein a few works of unequal weight. One could talk about them, one could make remarks, but the basic thing, the essential thing is that all factors have been taken into consideration which influence not only the runoff but also the regimen of the runoff which is very important at the study of the hydrological elements.

Finally I think that of all enumerated factors and elements which have been taken into consideration to be the foundation and to demonstrate the purposefulness of the network, those concerning the volume of precipitations, the temperatures, and the evaporation or the deficit of humidity, hardly may become, especially in our country, authoritative criteria; I personally doubt it, I even do not find that they could becomes such criteria -- in the determination of the purposefulness of the stations. On the contrary, we should acquire these elements vice versa -- through our stations. It is very true that the distribution of the network is in conformity also with the density of the river network; the density of the hydrological network is conditioned. Moreover, beside all other, also by the density of the river network, since the latter is a factor which will influence the runoff.

MIKAIL DUMCHEV:

Comrades! On the importance of the hydrometric stations and the data from them I have nothing to say. I wish to call attention to another question --- the question of operative stations. Here, the opinion was expressed that the operative stations whether they have different tasks are not so important for production. But the thing is not so.

I agree that at the elaboration of the hydrological network much endeavour was exercised, and it was made good and useful. However, it cannot be also harmonized with the following: -- that which was made in regard to the needs of the construction was little. Our perspectival plans in regard to the electrification and amelioration have not been taken into consideration. But these things must be provided for. What is found? In Southern Bulgaria our water resources are concentrated, but there the data are not sufficient. On the contrary, in Northern Bulgaria where the construction will arrive 15-20 years later the stations are almost sufficient. But we look equally at the two parts, at Northern and Southern Bulgaria. This is wrong. One very important factor has not been taken into consideration-- the perspective.

The other thing which made impression upon me and with which I am not in agreement is the loose solution of the problem about the closre of the stations. I think that here we should become more attentive; especially in regard to the long-established stations where we have 10-15 years' observations. Some of these stations may have not been well founded, but the fact that we have data indicates that it is a fortune which should be used. To close them, to stop their existence, to thus annihilate a valuable thing, to get rid of a thing that is alive!

The stations, in my opinion, may be closed only when they are unsuitable and if there are other important factors, geological and others which unfavorably influence , and when their data are not accurate. It is said that in Rila and along the Mesta there are rather many stations. Just the opposite, along the Mesta they are not enough. We plan there this and that an expensive structure-- they cost many billions for our country-- that is a must to open still more stations. They may be, of course, operative, and not supporting ones, but this is an affair of the hydrometrical service.

Another thing which must also be considered in the future is the combination of the pluviometric stations with the hydrometric stations. In our work, gaps are frequently met with, even hopeless situations, on account of this lack of harmony.

ILIA GADZHALSKI:

Comrades! I shall express myself as to the first report, since for the second one, on the predictions, I have not made up my mind.

At the first time I heard the scientific foundation of our hydrometric network which is important for all branches of the national economy. For me, it is clear that the word was about the foundation of the supporting network. Every other network which lasts a short time is founded by another method, and not along the indices for the supporting network, since it serves concretely given aims.

In the foundation there are also imperfections; I think that in the formation of the runoff great influence is exercised by the agrotechnics of the land. This factor also should be considered. The other reporter should answer whether it had been possible to cover it. It should be also taken into consideration that with 50 million decares, of workable area the runoff is not the same as if the area were not workable. Of course, there are details, but these details again, more or less, influence the runoff. (p.183) It should be however well thought over what the supporting station is. Personally, I think that every introduced irrigational system which is an age-long structure should have at least one supporting station. This indisputably must be made more accurate by the responsible jurisdictions.

Simultaneously, I must emphasize that the realization of such a network is connected with certain capital investment-- personal, and materials which the HMS does not have, and it should be helped.

In connection with the water resources in our country I would wish that in the future a network be singled out for the study of the underground waters. This problem is also difficult, but one has also to work on it, because the underground waters are as important as the surface waters.

What is the most valuable in the report of Comrade MARINOV?-- That it has only transpositions, and it provides for new stations. This is namely also the effect of the scientific foundation-- withe the same means, with the same forces, with the same materials, with the same stations to be able to obtain the possibly best and safe data. Indisputably, a serious question also arises here-- the transposition of the stations. This question is important and if I have such a recommendation-- the exchange of a station must be well founded. I do not stand for the attitude that it is not necessary to exchange. As soon as we are convinced that its site is not there but somewhere else we should not be afraid of transferring it. The scientific foundation is namely for that--that we have each separate station well founded.

But at the same time we should also add that this is not perpetual, and there is nothing perpetual. We should take into consideration a certain period of years-maybe 5-10 or 20-- but after the new conditions have been created, the new changes will sure follow, though even to the supporting network. So that the supporting network will always have changes; whether they will be small or large-- this is another question. It is clear, here the reporter raises the question so that the supporting network must have sufficient foundation, that it be dynamic and in a given moment it might change more or less. That in the future this change surely becomes smaller

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where it is on a scientific basis.

I think that the foundation may be accepted as principally correct. The network must be accepted as the latest, the best founded in scientific respect at the present time in our network.

PROF. ZHIVKO GULUBOV:

Comrades! I wish to express myself on the report of Comrade MARINOV on the criteria for the support of the hydrometric network in our country, on its reorganization, etc.

I think that Comrade MARINOV has laid down sufficient hard work, has coped with a certain basic, statistical and graphical material, has tried to make a common conclusion, and gave a conclusion of the problem with first approach to the set problem -- namely, the reorganization of the hydrometric network in our country.

I think that there is a weakness in the premises of the entire work -- that he, as also the other comrades, expressed themselves not sufficiently clear, not concretely as to what is really the supporting network and what are the criteria for the correct selection of this supporting network. He mixes up the supporting network of the network of the supporting stations with the operative and other stations, he takes them as one, and applies to all these types of stations or types of networks one and the same criterion. This is a weakness of a (meteorological) methodical character which naturally cannot be straightened out.

I think that the supporting network is the network which reflects, let us say so, the basic lines of the hydrology of the country. In the supporting network, above all, those wekanesses must be reflected in the regimen of the rivers which are due to the special differences in this regimen, i.e., of the geographical nature of this regimen. A correct premise of the question on the reorganization or the selection of the supporting hydrometrical network is closely related to the question on the hydrological district subdivision of the country. We are not able to create a supporting network without having a preliminary idea about the wholesale lines of the hydrological subdivision of our country into districts. Also here, the question was namely not correctly related, and the criteria were isolated both for the supporting network and the remaining types of network, which in my opinion is not correct.

The second is a methodical weakness -- it is that Comrade MARINOV spent his time exclusively on the annual runoff, but ignored the question of the intra-annual distribution of the runoff. If it is suitable from the point of view of the intra-annual distribution of the river runoff, which determines both the hydrological districts and the hydrological regions, it will be seen that the criteria actually must be others for the approach to the reorganization of this supporting network.

(p. 184) The whole question on the hydrological subdividing -- a question which slightly is also concerned with this profile in our country both in the HMS and in the other institutes -- is a defect in our work. I think that we have sufficient material to give a hydrological subdividing of a first approximation in our country which shall serve as a basis further on for the determination of these stations which at the present time are in existence, and their declaration for supporting stations. We know so what is the supporting station. This is thus a first-rate hydrological equipment, a special attention, maintenance of suitable personnel, the provision of a high technical level.

Please recall that KOCHERIN, at the end of the 30-ies, created his hydrological charts for the European part of the Soviet Union on the basis of only 30 supporting stations. Really, there the relief is plain, but, all the same, the result of these charts which touch upon the mountainous regions, the Ural and the Caucasus, did not differ much from those new charts which at the present time are available in the Soviet Union as a result of a longer period of observations and of a better network. Only from 30 stations, KOCHERIN was able to create his charts of the runoff coefficient, and for the runoff modulus, and it is so as they are also today. It is clear that to select these stations, here the entire physico-geographical complex has been analized, and that not by the method which Comrade MARINOV recommended to us, namely by the genetical method, by the complex research of the district, and not by the research of the components and his laying down one over the other over the whole place.

It is clear that the physic-geographical complex is a complicated combination. We are unable to entirely describe it, but we should analize it. How shall we analize it -- whether without an account-giving of the geographical specific in a given district, without giving account of the different factors which determine the whole nature of the land formation, of the regimen of the runoff, or likewise if we pay pay attention to this specific and if we make an analysis again by the way of Comr.

MARINOV, yet good differentiation is not made about the individual specific peculi-
arities, namely in reference to the specific peculiarities of the separate regions.
Of course, in the first case we are falling into a deficiency-- that we give equal
weight to all physico-geographical components of the runoff of the river. Indeed,
finally Comrade MARINOV makes one remark that he is giving different weight to the
different components, but-- on the basis of which data does he give different weight
to the individual components, or to the individual factors of the river runoff,
after he had projected them on a common chart, and after the specific of every single
factor has been deleted in correspondance with where it has been found in this
country? It is evident that this equalization of the factors, with loss of the spec-
ific difference between the factors in accordance with their specific locations,
local combination,- will lead to a certain mechanistic setting of the problem. Other-
wise, the problems is basically correctly stated-- analysis of the separate factors,
but the approach is wrong at such a wholesale, general investigation of the prob-
lem, aside from the specific of the individual geographical region.

That the study of the physico-geographical conditions or of factors of the run-
off is necessary-- this is evident also from the discussions of all the comrades
here. In spite of the fact that yesterday a mood was created against the so-called
genetic approach to the problem, a slightly negative attitude, which is easily ex-
plainable since the comrades pratitioners have a need for numerical data which will
characterize the runoff at once, and such numerical data is acquired by them by
means of the method of mathematical statistics, yet, and this thing is apparent,
in the premise of all lies the geographical specific of the river runoff. This is
a basic situation which in general both the practitioner and the theoretician
have to cope with in the field of hydrology. This geographical specific, however,
is regionally differentiated, and the approach to its research must be regional-
ly differentiated so that at the same place it should be established by what way
the different components may enter into mutual relationship and by what way they
influence the surface runoff.

For instance, if we take the hilly plain of the Duna, its eastern section which
was involved in comparatively recent years in a regional empire-destroying eleva-
tion, in a geological sense of the word, in anticlism,-in this region a number of
physico-geographical processes develop which reflect upon the runoff, and they do

so perceptibly both on the modulus and the coefficient of the runoff. But these peculiarities may be revealed by analyzing the corresponding region. By establishing the specific peculiarities of this region, as the basis of the problem on this imperiogenesis, by the formation of the drak-gray forest soils in the top horizon, by the(p.185) formation of the exposed black earth in the lower horizon of the peculiar vegetal association, namely mixed oak forests-- all this tells that here some relationship exists actually between these peculiarities, between the regimen of the runoff, the coefficient of the runoff, the modulus of the runoff, the soils, the morphology. However, this is complicatedly established at the same place by analysing landscape-wise the individual peculiarities which in cases also determine the separate factors, determining the regimen of the rivers or the surface runoff. I know that some comrades will object that very detailed researches are needed for this; the practice is quick, the practice has a need for quick data, the peak is at the door, as it is said, and we must hurry. However, in spite of the fact that it had been ten years, the HMS had not taken any steps for such a study of our country in regard to the regimen of the rivers, in regard to the establishment of the laws of formation of these regimens. And XXXX such an investigation of the problem which type MARINOV is recommending us is only due to the circumstance that this thing is needed to reorganize our network as soon as possible, and that in such a way, with equalization of the criteria for the entire land, in other words, with attaching equal weight.

On the other hand, I think that a series of components, a number of factors of the runoff are not taken into consideration, or some are torn out from their connections where they should be taken into consideration. They happen, for instance, with the density of the valley fairways. It is not right that we rely upon the density of the river network, on the density of the plains and the valley fairways which create the runoff. This which is indicated with blue color on the map, does not assure us that there will always be water. We must study the density of the valley fairways, of the entire fairway network by which the runoff appears at the time of the precipitation. Namely, this question on the investigation of this density of the river network was torn out by Comrade MARINOV from its natural place when the relief is separately examined, when the geology is examined, where the things are in a closer relationship, and the coefficient, obtained as weight on this factor, should be more precisely made, more elucidated if all these things-- geology, morphology, density of fairways,--are united as one common factor, but they are not considered as a few special factors torn out of connection.

Moreover, we consider it also a deficiency that he does not pay sufficient attention to the snow retention. This is an important factor in the formation of the river regimen, and especially at the intra-annual formation of the river regimen.

On the other hand, in his foundation, Comrade MARINOV should have taken into consideration that which Comrade GADZHALSKI also said--- also the tillability of our land, which territories and how are worked up, with what are they planted, and so on. This shows a certain influence upon the regimen, especially in the plains regions.

Not sufficiently was taken into consideration the equalizing action of the existing and of the planned dams either. The equalizing action of these dams might create a basis for the removal of a few stations as being already simply unnecessary.

I think also that for the present status of the problem the experinec of Comrare MARINOV is sufficient, and that it may give the sending-off lines (starting lines) for the elaboration of the problem, particularly for the reorganization of the hydrometrical network in our country.

If some recommendations are here taken into consideration which had been made on the part of the discussers, somewhere a few improvements could be introduced, somewhere improvements could be made to that proposition which Comrade MARINOV has made to the effect that we could approach that desired status of the affairs when we shall actually have a sound supporting hydrometrical network which will give us the chance to correctly estimate the peculiarities of our runoff and the causes for its genetic distribution. (Applause).

ENGINEER DIMITŬR MITEV:

Comrades and Friends! We have also heard the third report. With satisfaction it should be remarked that it distinguishes itself by its essence and by the method of investigation of the problem from the former two reports. The problem of the hydrological network should have been considered long time ago, since it is inseparably connected with our practice-- with the evolution of our water economy. But independently from this, that we have delayed, we must account for the report as a great achievement(we should consider it as a great achievement).

I think that the foundation of the network is satisfactory in general lines, even very good. If we put the question yesterday, by which way we should go -- the genetical or the statistical way -- the today presented report shows us that the comrades of the HMS have thought about this problem.

The have taken under consideration the precipitations, the temperature, the deficit of humidity, the area, the slope of the area, the forest coverage, even the density of the river network, and other factors, and I think that we would not be able to wish more at this moment.

(p. 186) In the report, the weighing of the different elements was not treated, and an equal weight was given to them. But I doubt that at this moment in this status of the things we could have solved the question so as Comrade GYLYBOV calculates. At the beginning I was in agreement with him that this is so. Actually, something could be achieved here, however, since the thing would need much more time, it may be also partly our, of the planning organizations, help, especially in regard to the distribution of the runoff in the year, in a multi-annual period, since we have come across these problems, and, at many places we have already looked for its solution. It must be remarked that such questions in our country are satisfactorily solved, namely by the line of the hydrological subdividing of the country.

Here, a few comrades discussed the problem about the closing of existing water-gaging stations. Actually, there are such stations which also point out their foundation. But the fact is that our water gaging stations are few in number, stations from which we are collecting data. And if we quickly would decide this question on the closure especially of the stations of the supporting type, I believe we shall commit an error. Here, undoubtedly it is necessary to think it over very maturely, very profoundly. I do not share the opinion that we have to proceed at once to the closure of the water gaging stations.

As to the question of the disturbed regimen, I wish to discuss it. Most of the water gaging stations in our country do not give us satisfactory data, good data. The cause is namely in the disturbed regimen. What has been made by the HMS until now to enable us to use these basic data in such a form in which they are namely necessary for us?? I have made the estimate --- and now at this moment, before taking this place, I have made it -- that approximately 70% of our basic supporting stations, our stations of long-range observations, have a disturbed regimen. By what?

Mostly they aredisturbed by finished establishments, by dams, by reservoirs, and by pools for gravitational irrigation. In this respect, I think that the HMS could have made something, and if it has not been made, something should be made in the future.

I agree fully with the statement of Comrade MARINOV that steps should be taken in the future about this problem. But it is not only a question to persuade, to convince us, but steps should be taken at once, because the tempo with which our amelioriative construction is being built, and generally our water exploitation, is rapid and it cannot wait longer. We cannot stop these problems any longer.

(Session closed at XXX 13:15)

* * * FOURTH SESSION * * *

(City of Sofia, Tuesday, 28 February 1956)

(Opened at 15 o'clock)

CHAIRMAN PROF. DIMO VELEV:

I ask those who have to discuss the morning introduced reports to take the floor. I also request that in these discussions we should be essentially objective.

Comrade Staf Stefanov has the floor.

STEFAN STEFANOV:

The problem of the hydrological predictions is unconditionally a basic and important problem of the hydrological science.

In analogy to the meteorological prognosis, or to the forecast of the weather, which represents a part of meteorological science and a part of the hydrological science, at the present time the practice has called to life also the predictions on the status of the rivers, oceans, seasm lakes, etc. Undoubtedly, this problem is new and important in our country. But this question cannot be so separated, or developed independently from the general prognosis of the weather. That is why its place is particularly at the institutes for prognosis of the weather, and at the prognosis of the weather alone as long as it has general contact points.

As the meteorological prognosis, the hydrological prognosis may be also divided by the validity of time, by periodization, into three basic topics -- says Comrade MINCHEV. I wish only to add that the predictions may be short-range, not longer than for one day or for a few hours. The need of special operations, to mention

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only the transportational, military or other operations, entirely demands the short-range predictions, i.e., up to 24 hours.

(p.187) Comrade MINCHEV says that the prognosis for 20 days is short-range for the large rivers, for the large basins. That is so. But they are conditionally short-range, or, as we call it, predictions for a certain period, or predictions of a period. This division of the predictions into short-range and into long-range periods is conditioned by the peculiarities of the atmosphere. Consequently, during the past 20-30 years, it was established by the meteorologists that the peculiarity of the atmospheric processes is such that they may go on more or less in the length of some days, of 5 to 7 days or up to 10 days sometimes. Consequently, this period will condition the forecasts of 5-10 days or it works perfectly true.

The other predictions which are for longer period or long-range ones, let us say for a month, a season, a year, etc., are predictions which may be turned out coming true in more than 70-80% of the cases. But a prediction, which does not come true in more than 70-80%, does not deserve attention. Each prediction must have an assurance of at least 80% or more.

The need of hydrological predictions creates special offices in a number of states, and first of all in the Soviet Union where such a hydrological prediction is very well founded. Thus, at the present time, at the Institute for Prognosis there is a special department for hydrological predictions. These predictions are made for long and short periods of time -- daily and monthly.

The predictions which are daily, or for a period of a few days, must be tied up with the basic, the general prognosis of the weather. And therefore, in 1930, the hydrological prediction had been added to the Weather Bureau in the Soviet Union, and at the present time it is in the Institute for Prognoses in the Soviet Union. Thus, it is not developed, and cannot be developed, separately, but it is directly, immediately tied up with the general prognosis of the weather, or with the p[illegible]-processes which are in the atmosphere.

But it is known that the condition of the rivers, the condition of the river-bed processes generally is a problem of observations which are taking place in the atmosphere for shorter or longer periods of time. Thus, for instance, what cyclones and, or anticyclones will pass over a country, what barometric formations there will be in a country, these barometric formations will condition the development of the runoff, or in other words they increase or reduce the runoff.

Thus, when the hydrological prediction is made, it should not be made only when the high water appears, or that we follow the passage of the water, but the conditions should be pointed out generally at which this high water may appear, at what combination of the atmospheric processes, or in what way it may appear if these processes will take place.

I our country we had a series of examples for this. Thus, for instance, you know that during January of the past year in the valley of the Arda river a large flood had occurred which produced not a little damage. Before less than 20 days such a phenomenon took place again in the same district.

Consequently, the prediction of these processes may give the chance to take certain steps in one or the other direction. In such a case this prediction may be given, it may be related and may be used over the background of the development of the weather, over the prediction of the development of the weather.

Undoubtedly, it must be said that the predictions which may be given on this basis, they are entirely qualitative, but for the hydrological prediction quantitative predictions are necessary; to say it precisely, let us say, the amount of precipitation, the height of the flood peak at a certain time, and so on, to make it possible that appropriate steps can be taken.

What should any hydrological prediction contain, and what should be in it? Undoubtedly, it must contain the water stands, or the level of the water, the discharge of the water, the river-bed processes, the drifts, the temperature of the water, and so on.

A basic prediction in our country must be considered the prediction for the Duna stream, since our rivers are not of the order of the rivers in the Soviet Union, or in the other countries. The Duna stream has in many respects a great importance for us, and in such a sense, great attention must be especially paid to the Duna river also by the hydrological predictions. But, it is necessary therefore to know and to continuously study and directly study the atmospheric processes at a large scale, which develop in the basin of the Duna river, thus the change in the gagings (water stands), and to connect these stands with the changes that may enter into conditioning the level of the water of the Duna river.

To me it is worth while in this respect especially that the hydrological predictions should be tied up with the meteorological predictions. The hydrological prognostics must(p.188) recognize the synoptic processes or the development of the processes in the atmosphere, the circulation for short and long periods. In our country, the hydrological service, without our being specialist hydrologists, has to a certain degree solved in general , schematically, the problem on the prediction for the Duna river.

And here it must be emphasized that the prediction of the condition of the water must be given at definite moments, and in general in a direct way. There are situations when the water of the Duna river may be so small, so low that the ship floating is made difficult, and this is at moments when in the entire basin conditions of dry-up(drought) are created, conditions of large discharge of water and of no tributary waters, when very dry and very hot air masses are stationed over the basin which masses take away anew large amounts of water from the entire basin and reduce the tributary of water along the same basin.

The hydrological prognosis of the Duna river is such that it must also embrace the winter period when along the river other phenomena may also enter:- icy phenomena-- when there is ice movement, or the water of the river is entirely frozen, etc.

Particular attention should be paid in the hydrological prognosis to the temperature of the water also, and to the moment of the icing of the water which moment should be related to the water amounts since the practice alone indicates that the Duna river will freeze entirely differently at different moments and in different periods of time.

GENCHO STAINOV:

Comrades! The report of Comrade MARINOV was very interesting, also the way in which he raised the question on the creation of the supporting network of the run-offs of our rivers.

I wish however to call attention that, though the present supporting network has been made with regard to many factors, such as precipitations, temperature, etc., according to my opinion there are certain omissions therein which I think that they should not be closed. As an example, the station of the Mugleaska river should be specified at the village of Mugla. Indeed, this river, a little further at Tenesdere downstream, is lost in the karst-type region, and therefore it can be questioned whether it is necessary for us to observe a river which is lost further on.

However, the plans for the use of the Vycha provide that the waters for an irrigational canal for Mugla should be taken from there.

That is why I think that such a station as the one at Mugla should not be closed but it should be kept.

Another thing to which I wish to call attention is that all factors were considered, beside maybe the most important factor, namely the action of Man. The hydrometric stations, situated above the dams, have a certain relation to the natural conditions which create the runoffs in the rivers. We can relate the runoff to the drainage basin, we can measure the coefficient of the running-off, etc., generally all these relationships, the modulus of the runoff, etc.

But, downstream, below the dams, the situation has changed already. Yet, the dams have been already constructed along most of our rivers, and some more will be built.

I am asking:- what will the runoff show us, for instance, at the station Hurilo when the Stalin dam does not let out any water downstream? Or what shall the stations indicate for us along the river Tundzha, or the river Rosica, downstream below the erection of these dams, where the waters are distributed for irrigation and very small portion of it is squeezed back into the rivers?

I am not for the closure of the below-the-dam stations, because all of them again indicate something. We must make an estimate for what purpose the stations are serving us, which stations are located by the dams downstream along the flow of the river whose runoff is regulated? Thus, as long as the stations above the dams have a certain relationship to the natural conditions which create the runoff, in the stations below the dams the regimen of the rivers is profoundly disturbed by the interference of man.

You have taken into consideration that if we will irrigate in the near future 10 million decares, at least 5 billion cubic meters of water will be separated for these from our rivers. And five billion cubic meters of runoff will wholly disturb the picture of our runoff regimen.

In my opinion, the stations above the dams, in relation with the developing water economy in our country, should be made denser. Particularly, no cancellations should be made in the mountainous areas, but rather, further stations should be opened there to still further clarify the situation of the runoff in this region in relation to our water economy.

And what concerns the stations below the dams, we should look at them with critical eyes, and we should see what lessons we could find from their testimonies, since they(p.189) do not have that importance at this time which they would have if we would possess a water economy and a transfer of the runoff.

Another matter to which I wish to call attention is that it is not important for us to have stations, but they must be well provided and they should be able to catch the runoff (measure the runoff) well.

From 1949 until today, when the Soviet specialist Eliseev arrived in our country, our hydrometric service was set upon very sound bases, the stations were well selected, the river beds at the stations have been regulated, repaired, and an even flow was obtained, steady beds were sought for, strengthened bottoms were made for the rivers, at many places hydrometric bridges were constructed, and it may be said that the ordinary waters, the low and average waters are very well and reliably caught.

But I doubt whether the storm floods in our rivers are also caught correctly at the present time. In the lower courses of the rivers as the Marica, Iskur, and others, a flood wave will last many hours, and sometimes days, and it may be caught, but in the mountains the high-storm peak will frequently stay for less than an hour. And for this short time, the observer rarely can get out to gage, or the hydrometric corporal is rarely able to go out and to make his gaging. And also, at the peak waves, with a hydrometric screw which must stand very vertically, or very close to the vertical line, and as long as the gaging is being made, the peak will pass and depart.

Generally I believe that the hydrometric service must think over the improvement of the methods for observation of the flood peaks in our rivers.

ANGEL CHUCHULEV:

Comrades! I find appropriate and useful the recommendations of Comrade MARINOV concerning the closure of the operative water gaging stations. I think however that for the closure of these water reading stations we should not do anything as long as the opinion of the Energo-HydroProject and of the Ministry of Electrification is not obtained.

Another matter which impresses me is that along the basin of the Struma river no water reading stations should be established. For instance, we have the water gaging station of the Marica river at Brichebor, and we do not have one on the neighboring Manastir river whose water amounts could be gaged by the same man.

Furthermore, on the river Blagoevgradska Bistrica, we have a water gaging station at only one town, and we should have such other stations also higher up at Kartala where the forest administration is, and there are always people available who could service it.

The same situation exists also in Sandansla Bistrica. At Lilyanovo and at Popova Lyka we have stations, and higher upstream we have no water gaging station though there is also a forest administration and during the entire year we have people who could read the water amounts. And we need data on the water amounts both on the high-mountainous rivers and on their tributaries in order to be able to correctly dimension the structures and to correctly erect the power constructions. Therefore, as Comrade MARINOV mentioned, and we also have established as facts, the water gaging stations before 9 September 1944 only served the agricultural (rural) economy, and they have been looking out for the accounting of the low-standing of water, bot not for the high-level waters, and the minimum water amounts which are necessary for the irrigation of the areas, since they were irrigated with running waters.

My wishing is that these water gaging stations which are not operative should not be closed. As I have said, subsequently they will drop off by themselves. For instance, the station Batak, after the Batak dam will be built and the waters will be deviated from the Byala river and the Cherna river, it will drop off by itself, and will be closed, as also the other such stations along the Arda river. After the water engineering structures have been erected, they will drop off by themselves.

When we have the water reading stations along two rivers close to each other, I think that it is not purposeful to close them. For instance, such is the water gaging station No.18 at the Hydroelectrical Central Vycha and the water gaging station at the stop Kadievo. Out of the two water gaging stations, one in 1950 showed that in a day 500 cubic meters in a second have passed by, but the other did not show anything. They must stay to remain also as controls of the water gagers themselves. There are not large amounts to spend, but they will serve as controls one for the other.

(over)

IVAN MARINOV:

The problem of the hydrological prognosis in our country, Comrades, is actually a real problem. As it was outlined in the report, the predictions are (p.190) very different. They may be divided by term, by contents, by objects, by accuracy, etc. We of the HMS believe that about the problem of WHICH predictions are necessary and actual for our practice the comrades will speak up so that we will be able to direct our attention exactly thereto. We stop chiefly at two types of predictions:- the long-range and the short-range, and at the long-range predictions especially at the predictions for the Duna river.

Comrade Stefanoc outlined what its importance is for our economy, especially for our shipping, when particularly he mentioned the predictions about the icy phenomena of the river.

We think that it is not necessary, at least at the present time, to keep our attention on the short-range prognoses for the rivers in the interior of the country, and to dissipate our sources. As to the rivers in the interior of the country we should not pay great attention and we should work on the long-range predictions. And why is it that we direct our attention exactly thereto? Because we think that with the help of the long-range prognoses we shall be able to render concrete help to our economy. And in what does this help consist? It consists in its making possible to give preliminary indications to the exploitational organs of our dams and irrigational systems about how to manipulate with their water reserves which they have in the dams, in the small water reservoirs, and so on. Therefore, the attention in the institute is justly directed to these two types of prognosis:- the long-range predictions for the icy regimen on the Duna river, and the short-range predictions for the rivers in the interior of the country.

I think that it is not necessary for me to delay on the nature of the predictions since Comrade MINCHEV has explained this problem. Nothing more should be said about it. The methods are known, and nothing else remains for us, except to be directed by these known methods in our actions in regard to the predictions.

CHAIRMAN PROF. DIMO VELEV:

We go over now to the following point of the agenda: "Determination of the hydrological characteristics at the regulation of the runoff". Comrade engineer SHELI BENATOVA has the floor to bring up the report.

REP.SHELI BENATOVA: (Reads the report of the above topic).

(After the rest period)

CHAIRMAN PROF.DIMO VELEV:

Comrades! The session continues.Comrade engineer Raiko Raikov has the floor for bringing up his report.

REP.RAIKO RAIKOV:(Reads the report of the same topic)

CHAIRMAN PROF.DIMO VELEV:

The floor is of Comrade Davidov for discussion.

ENG.D.DAVIDOV:

I shall keep myself more specially to the problems in the first report,brought up by Comrade(lady) Sheli Benatova.

The entire report is to tell about the employment of the methods which are known in the literature, in the practice, especially under the conditions of Bulgaria. I think that,at the solution of such a task,the reporters should have taken into consideration the entire collected experience in this respect, and not only the experiences collected by themselves personally as authors of these reports, and also the experiences of the Energo-Hydro-project.

It is certain that also in the Water Project planning organization there are certain successes in this direction which successes are reflected both in the technico-economical reports "Marica","Tundsha","Arda, and in an article published in the review of "Hydrology".

The basic problems which were presented in the reports are two. The first is about the results of the serieses which are used in our hydrological researches. The second is-- whether at the regulation of the runoff we should use the statistical method or the balance method.

I think that the raising of these questions is senseless(thoughtless) because, as in hydrology we are using genetic and statistical methods in accordance with the circumstances,and with the data which are at our disposal, similarly also in the water economical computations we are applying one or the other method,in accordance with the data which are available.Essentially,the reporters have also tried to make this analysis-- which method to use, and with such a conclusion the first report ends that the balance method may be used if we have 16-year serials and the representativeness in all relationships. But from the other report it follows that at this serial and at this consistency the balance method may be used.

I wish to say two words on the representativeness. The representative character of the hydrological serials has three sides. The first side is a representativeness in regard to (p.191) the statistical parameters, asymmetry, and other similar parameters; the second representativeness is in respect to the runoff in the year, and the third representativeness is of the runoff in regard to the alternation of the years, i.e., the annual distribution of the runoff.

The question about the representativeness of the observations is a basic one and it had been solved long ago by our own practice.

I do not share the opinion of the reporters in regard to the representativeness of the runoff by its annual alteration, namely, that one 16-year long serial is representative. It is not representative for the reason that for the hydrological characteristics different lengths of the data are required. Thus, for instance, for the standard of runoff, since the standard represents a characteristic of first order, a complete accuracy is necessary, for instance with 10-15% error. For the coefficient of variation, which is a highly substantial characteristic, observations of 20-30 years are necessary, and for the coefficient of asymmetry of the third order, observations from 100 years upwards are necessary, and even they are not sufficient. It is the same thing also with the intra-annual distribution of the runoff.

The intra-annual distribution of the runoff is a characteristic which we may take as a characteristic of the first order, and it is sufficient to have a series of 16 years or 20 years to enable us to establish with sufficient accuracy the most probable characteristic percentage of distribution for a given assurance as long as the yearly distribution of the runoff which has an importance at the annual dimensioning of the dams is a characteristic of the second order, which we may not deduce from such a short series. That is the reason that the estimate which the comrades make, namely, that ONE 16-year series was proved representative for the runoff by some lucky chance, in my opinion is not credible.

For supporting their conclusions, the comrades gave a few examples of the KYRDZHALI dams, of the Topolyane dam, and the Tundzha cascade. And from these examples they drew the conclusion that the balance method is recommendable, and that the statistical method gives considerable deviations and errors. At the present time, I do not wish to put myself in the position of the devil when he reads the gospel,

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however, from these examples I again deduce the conclusions that the differences are insignificant. Thus, for instance, from the first example on the Kyrdzhali dam, the authors themselves say that the difference between the balance and the statistical computation is only 10%. They say also the same about the Topolyane dam.

ENGINEER KALCHO IVANOV:

Comrades! The two reports are also sufficiently important for the elucidation of the correct trend in our water engineering plannings.

The Comrade Davidov spent some time on the first report. I shall confine myself to the second.

The preceding speaker has very easily repudiated the representativeness of the 16-year series. In my opinion, this is not right. The comrade lecturers have worked, and indeed they did plenty. To calculate these creeping series is a rather bulky work and they again arrived at some definitive conclusions. It could be more correctly said that they should widen and correct a few statements in their work.

Hence, we shall delay on this, in reference to a few principal statements.

To use the precipitation for demonstration of the representativeness of this 16-year series, the coefficient of correlation for the relation between the runoff and precipitation is used. I think that it is not enough of 5 or 6 stations only, first and second, the physical sense of this relation must be also sought for. Hence, in case of a well-solved correlation coefficient, it may be frequently physically demonstrated that the relationship is not sufficient. This is one statement.

Another. For a more complete and more accurate analysis, I thin, it is necessary to apply the precipitation maps. In spite of the fact that this is a difficult and very voluminous work, it must be done. Why? Because a pluviometric station gives only the characteristics of the district adjacent to it in a given definite radius of action. However, it does not give the characteristics of the entire drainage area. This concerns particularly the larger drainage areas. For a few small areas it may coincide, but with the largerones -- no.

I also think that it is more correct to take in addition to the stations in South Bulgaria, the stations in Northern Bulgaria also, to have the entire Bulgaria elucidated as to the representativeness of its hydrological series, to make it eventually possible to prove that it had been done and that it had been well chosen.

Really, in these reports a little optimism is blowing gently in respect to this

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series. I think that it is further necessary to lengthen the research of a (to a) larger period(p.192) which may be proved to be more representative and for which we have more and still more data, that we say it may reach a 20-year period.

I also think that attention should be also paid to the fact that the curves of assurance for 16- and 50-year periods are also used. I think that it is good to do so to see what relationship is obtained.

CHAIRMAN PROF. DIMO VELEV:

The floor is of Comrade Rangel Michev.

RANGEL MINCHEV:

I shall speak only of the correlative ratio which the comrade lecturers have used for the determination of the representativeness of the series.

The comrades have wished first to measure the correlative ratio between the precipitations and the runoff, when this correlative ratio has been used by them for the intra-annual distribution of the runoff. Such a ratio between precipitation and runoff, in regard to the intra-annual distribution, does not exist. This which they have measured must be noted that it is entirely chancy, since I had made a daily analysis of this relationship-- daily, and not monthly, or and by seasons, but daily analysis of the relationship between the precipitations and the runoff which was necessary for the prediction for all stations of the drainage basin of the Marica river. It cameout that such a correlation and identical relationship does not exist. That which they have made, concerns more the mountain stations where during the summer season the rains give a runoff indeed, but for the middle-altitude climatical stations and the plains stations such a relationship does not exist. The precipitations during the short spring and the summer, and a greater part of the fall, do not give any kind of runoff. Consequently, if we count upon such a relationship between precipitation and runoff, we may be misled. Hence, there is no determination of the representativeness of the hydrological year either, in respect to the intra-annual distribution, since the correlative ratio between precipitations and runoff is irreal. When one starts out from a thus determined representative year and if one works with the balance method, there is surely an error to be made. In such a case, it is preferable to continue the work by the method of mathematical statistics, instead of working with the balance method, by counting upon the representativeness of the hydrological year of a 16-year period and upon the correlative ratio between precipitation and runoff.

ENGINEER KAISHEV:

Comrades! The problems in regulating the runoff are very important. It is well known that both in the USSR and in our country two methods are chiefly used for regulation of the runoff, namely -- according to the presence of the data -- the balance (tabulated or graphical) and the statistical method.

The essential imperfection of this scientific conference is the circumstance that in the reports it was assumed that these problems are to be treated in a general way, instead of introducing two reports -- one, surveying the balance method basically and profoundly, and the other -- the statistical method.

In such a way, in each report the latest achievements in the world literature and in the practice in our country would have been examined, and also the scientific elaborations on the regulation of the runoff made by Bulgarian engineers. Then, the present conference could have turned out with more concrete conclusions.

The other deficiency was that there were no reports prepared on the irrigational standards and on the method for their computation, neither was there any on the economical foundation of the computation or on the acceptable volume (capacity) of the water reservoirs. This complex of problems is continuously tied together, and it is impossible to consider them torn apart. I do not have to stop on details at all of the in my opinion unexplained, unclarified questions, first because I ded not have enough time to prepare a suitable calculative material, and second, because it would seem that it is a co-report.

In the introduced reports, there was a number of statements which are uncontested, but there are also such to which serious objections could be made.

It is right that according to the availability of the hydrological data the method of computations is also selected, but the method for a percentual distribution of the runoff for the characteristic years must be chosen more carefully, and that the phase method, pointed out by POTAPOV, and also the variant proposed by NIKITIN, deserve greater attention on the part of the engineer hydrologists.

I do not know whether the comrade reporters have elaborated their examples also by the percentual distribution, proposed by engineer G. KRAFTI, which will also give very good results.

On the reports the following remarks can be made:

1) An example was not given how the balance method is used at the present moment, since the time when its application has started in the water economical group (p. 193) of the Energo-Hydro Project, the original medley of the balance and the statistical findings had been employed.

2) As a proof against the use of the statistical method the elaborations of the TED "Tundzha" of 1953, and those for the dams Georgi Dimitrov and Zhrebchevo, completed by the planners of the Water Project, have been used. It should be told that actually the then planners (e.g., Engineer Kaishev) admitted errors, when they had used the method for a full-year equalizer for computation of a seasonal equalizer, what after all the Georgi Dimitrov dam is. In consequence of this, by the correct use of the method of the curve of assurance of the revised summer water amounts, almost identical results were obtained by the balance computation. The data are on TED Marica and Tundzha from the year 1955.

I think that, with the use of the provisionally admitted errors, it is impossible to discard the use of the statistical method, created and used successfully in the USSR. This is a basic weakness of the report. It is another question if whether the comrades had used their own elaborations and comparisons .

To the reporters it is well known that in the use of the statistical method in our country a large step had been made in advance, and that scientific elaborations of our engineers are available which deserve attention, and they should be introduced and they themselves should have used them for deduction of the finished conclusions.

3) As a red thread, in both reports the tendency is laid down -- whether the data are enough or not, to use the balance method. The reasoning related to the hydrological elaborations is naturally aiming at the same purpose.

After a detailed analysis and criticism of the reports, Comrade Kaishev makes the following conclusions:

1. I share the understanding that the present hydrological series in our country in the majority of cases increased in value in respect to the standard runoff up to 10%. The same holds also tru for the coefficient of variation.

2. The hydrological series of 1936/54 is not representative in regard to the alternation of the arid years, since the deficit period 1945/52, as to duration and volume, happened to occur but once in 50-57 years by a number of stations which

have long-range observations.

3. The method of computation of the regulation of the runoff has to be chosen according to the availability of the hydrological data as a very detailed analysis is made on the same data.

The balance method will have a rather limited application in our country until the data collected are sufficient for its successful use.

4. That a greater research work should be deployed at the application of the statistical method which at this moment is the most applicable to our data.

5. Still during this year, a scientific conference should be organized and it should be specified that it be dedicated to the regulation of the runoff, when reported will be also prepared on the variable irrigational standard and on the economical effect of consumption.

ENGINEER SLAVI GRIGOROV(FROM Water Project):

I wish to throw some light upon the problem of the balance and the statistical method, with the desire to dispute somewhat the question, because as at the present we are standing at two corners of the hall, so I have been always standing and have been disputing.

The formula which Comrade Benatova quotes in her report on p.7 was $beta_1 = K_{mi} - K_1$; but the formula of TROFIMOV, which we have been widely using has the following form: $beta_1 = d_e k_m - k_1$.

Look at the formulas, and you shall see that they are analogue. But this is the same statistical method, since later it is said:- by the same method all modulus coefficients of the volume(amount) have been computed, and 75% assurance was chosen. Consequently, the curve of assurance is constructed for the modulus coefficient of the inflow, and 75% is obtained as long as the modulus coefficient of the runoff must be taken in accordance with the assurance of the inflow. The value of this formula is that the correlative ratios are taken into consideration, namely not expressed in any coefficient of correlation, with the direct participation of the value of the inflow of the irrigational standards. So that I think that we take away the quotation marks from the balance method, and we should call it the statistical method, which it is substantially(Applause). The inconvenience of this method is that it cannot be used in cases when there is a series of years.

I wished to say a few words on the balance method also. As its name indicates, and as it was said on the first pages of the report, it consists in a direct juxtaposition(comparison) of the inflow and the consumption, with an accuracy what we desire. We may make it by years, by months, by decades, if you want also by days, but (p.194) by directly comparing the tabular computations from end to end, as many data we have-- and the more we have the better.

The genuine balance method has not been actually used in our country, Comrades! Nobody has used it, and there is none to use it since it is very unsatisfactory, first, and second, many comrades stated:- we want speed in our computations, why should we be slowed down by such a slow method when there is a quick one.

The past year delivered the TED for Southern Bulgaria in which 60 dams participated. Let us imagine for ourselves the ideal situation that we have data everywhere. Everyone may visualize for himself the enormous work of computation by the balance method. 50-60 dams, put them each by two variants of the dam, by 16 years, and when the precaution has been taken that the sketching of one dam for one year contains 800 numbers, which are made by 400 hours, you may have an idea what an enormous work it is, what an enormous Army of planners must be engaged to get the figures. But this is not necessary, because science has given you a method which makes the work easy.

ENGINEER GEORGI KAUKOV:

Comrades! By an accident, yesterday I was not able to attend at the reports. I have listened with attention to the reports which were read today. I also listened to the critics. I understood that there is no bleeding. Up to the present moment I did not know it. It is very natural for me, the critics did not stop today, comrades! The critics will continue as long as a positive attitude has been already taken.

At the most he will say that the initiative of this scientific conference should be congratulated. This initiative must also continue in the future, since the results of these sessions will be good without doubt. We shall always see two courses which will be in conflict. This is useful since when there is conflict then the truth will be disclosed, then there is advance and progress.

I wish that all of you be engaged in the field of hydrological science. I congratulate the young colleagues who introduced here the reports, and I wish them to continue working, as also I wish it to all of you that you should serve as an example how we should work in the future--with seriousness, with laboriousness, with

with profoundness,but most of all,Comrades, it is that should conceive a liking for your specialty(Applause).If you do not like your specialty,there are no results which you could obtain.

Now,I shall say something else.I am not only an engineer. I have followed and finished also mathematics.At my younger years I thought that everything can be clothed in mathematical formulas.The water runoff,the river regimen,and even more the underground regimen,the underground runoff,are depending upon many factors.But since there are many factors--and at the prdsent grade of development of our science you may hot comprehend all factors-- your mathematic formula will stay with a question mark.

The balance or statistical method? The practice forces you one way today--or another way tomorrow.The practice itself shall orientate you,and you shall continue your work.

I am XXX satisfied with the announcement of Comrade Krystanov.He says that we have always kept a connection with the practice ,and will continue to keep such a relation.

I shall add still another thing.The engineer must keep a connection with all specialists-- not only with the mathematics,but also with agronomics,with meteorology,with geography,with geology.In the beginning when we had started to work,our science was not yet developed.After all, we had kapt a connection with meteorology, with geography,with agronomy,with the science of soil spaces, and I will tell you, we kept a relationship even with the physicians.You would perhaps say:-- wherefrom the connection with doctors? We kept a contact with the doctors in regard to the malaria,the swamping,and we have listened to all of their opinions, we have discussed them,and somewhere they have been true.

I tell you this also:- the engineering practice and the engineering science must strengthen its relationship,their mutual relationship; they must strengthen the relation with the other disciplines,too,with the other specialties(Applause).

I wish to say a few words about another question,too,--in regard to the hydrometeorological service.All of us have heard that this is the basis of water economy.Naturally it is so.We heard from Comrade MARINOV that a few more supporting stations have been weighed for closure.This question is clear.Only I want to say that one should not hurry with the closure of the stations.The given stations may be superfluous at the moment,but they should not be closed since one station which we would close today may be necessary to open tomorrow again,since some(p.195) other biological factor may require to open it. I have spoken also somewhere else on this question.Not so long ago we had such an example at the examination of a dissertation when the biological factor was also outlined.Never until now have I thought of the biological factor in the "colmatation".But I saw that the author is right. Consequently,a station should not be closed at the present time when tomorrow, on account of a few factors-- and the factors in the hydrological service are many, you have nothing to cover it maybe even after 100 years-- it will be again necessary to open it.The connection with the practice should be of use for our rapid construction.This will improve our mathematic formulas, it will empirically help you and will direct you to the method which you must employ in your service:-- the statistical or the balance.

I think that from these reports and from the discussion we shall get lessons and we shall have better results tomorrow than today.

This is what I had to tell you as the eldest among you, byt maybe also in Bulgaria I was left only to adorn (enjoy) still a few years(Applause).

PROF.BORIS MARCHINKOV:

Comrades! A close relation between the precipitations and the runoff does not exist.For this reason,the correlative ratios are not close. It is only a rough approximation.There are the old classical formulas of KELER which were created for Central Europe,and which give approximative results. Such formulas have not been established for our country.With our climatic regions these ratios are still weaker than the ratios which have been established by Keler for Central Europe.

I was impressed that the stimate of the closeness of relation has been always established only with the aid of the correlation coefficient,always when the correlation coefficient was made and the coefficient was established, regardless that the error of the same correlation was also determined, and I make the conclusion that the percentage deviations of the same values must be also computed,which values enter into the correlation, and the values which we will have thereafter, the truth of regression.

With a correlative coefficient 0.998 with 2-thousandths' difference-- indisputably the relation is extraordinarily close-- percentual deviations of the separate values are obtained which values enter into the correlation with 3-4-5%, and there are also values with 7%. Of course, the mean error is very small, particularly if it is taken with a plus-minus sign in the correlative error of the quadrate. However, the separate values in the correlation have a considerable error. You may visualize it for yourselves at a correlative coefficient, which we have, 0.54, if we undertake such a computation to calculate the separate deviations of the individual members of the series of the truth of regression, what will be obtained. I think that it is not proper to prove the representativeness of the 16-year period or of 18 or 20 years' period. The question is to find a way, a method. And as you see, in the plan of the Hydro-Meteorological Service, this question was put-- since we think that the representativeness of the series/ such is the topic raised in the current year/ will necessarily lead to the prolongation of the series.

So that the question is not that we search for the representativeness of the 16-year period, since, again from the hydrological point of view, the 20-year series is small, but that we should search for ways and method to prolong the series. Such methodology may be found.

Of course, at the elaboration of the methodology, the question arises to include two more factors:- the temperature, the deficit of humidity, and a series of other factors which until now have not been used, and which perhaps may be used under our conditions. Such experiments were completed in Soviet Russia. Along the same way, we think, we should also progress.

On the other hand, the problem arises, too, for the "creeping" series. This question interested me for a long time. Even in connection with this question it is necessary that the formulas be transformed since you know what enormous computations are there with the research to finish the "creeping" series, and up to this moment I continue to be interested in the research of a certain definite number of the series. In spite of the abbreviations which I have obtained with the simplifications of the formulas, again, you know very well, what troublesom is the computation to finish. And moreover, the provision of long serieses is also very difficult. I was successful to compose such a one only by the present Soviet management where there are 35-50-60-year serieses-- since we must have the basis with which we shall compare. A certain number of serieses have been also provided in Hungary. I was given about 20 series with 70-year observations. During September 1955, the Hungarians celebrated the 70th year of the foundation of their hydrological service. They have hydrological data for a period of already 70 years.

(p.196) I think that we must take into consideration this, and we must be directed to the prolongation of the serieses. Much is risked in my opinion that we give representativeness to this 16-year period, since we lack the required basis. We do not have long sets. Our set which we have for the river Tundzha and the Tepelnica river is a series of 22 years. Again, because of the unqualified character of the observations, these sets are unable to serve as the basis for comparison, in order to enable us to work by the method of the creeping serieses and eventually to prove with them the representativeness of the 16-year period, still more so because in the water economical studies, beside the general characteristics which are asked at the representative identity of the arithmetical means, of the average coefficient, the criteria are also requested for the alternation of the years. The alternation of the years is extraordinarily important at the water economical studies. This has been already outlined here.

So that from the present observations, from the present research of the creeping serieses it is not indicated what Comrade Raikov's report contains. The causes of this are the following. Above all, there is no analogy, no parallelism between the runoff on its course and the precipitations. This has been outlined.

On the other hand, stations are taken separately. At the water economical studies, we do not have anything (we cannot do anything with isolated stations, we must work with the volume of the irrigated field.

As a certain approximation, individual stations also may be taken only in the case that these stations, their precipitations are not deviating much from the variation of the general precipitation, which we have over this area, which holds good however for the small area, or again, we may have large deviations in the case that they are very uniform precipitations in the entire drainage area.

I must say also that in the research of the creeping series it was established that the data in the literature, including also in the American literature, the standards of Binet for the errors of the arithmetic mean and the coefficient of variations, are approximately analogous. You have read, and you surely know the example of Tusula in the review "Hydrology and Meteorology". In the use of the method the value is therein that it gives the average deviations. With the use of the method of the creeping series,we get the idea for maximum deviations, which may be obtained when we use a short series--5-10-15 and 20 years.This thing is illustrated by an example.It is possible to have also a curve executed of the distribution,by which it can be seen how the errors are distributed.Consequently, in the use of this method the new feature is that the average deviation is obtained,which does not interest us at the planning,but we must know what the possibilities are of the maximum deviations, or still better-- of the distribution of deviations.

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(p.198) SCIENTIFIC CONFERENCE ON HYDROLOGY AND THE REGULATION OF THE RUNOFF.

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