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CENTRAL INTELLIGENCE AGENCY
WASHINGTON, D.C. 20505

21 September 1978

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MEMORANDUM FOR: The Director of Central Intelligence

FROM : John N. McMahon
Deputy Director for Operations

SUBJECT : MILITARY THOUGHT (USSR): Some Problems of Military Electric Power Engineering

1. The enclosed Intelligence Information Special Report is part of a series now in preparation based on the SECRET USSR Ministry of Defense publication Collection of Articles of the Journal "Military Thought". This article deals mainly with the production and design of generators for the armed forces. Though gas turbine and gasoline generators have their uses, the diesel generator is best suited to most purposes. Important objectives in this field should be the development of a multi-fuel generator akin to the diesel, and automation of generating units. One-third of the article is devoted to the advantages of nuclear-powered generators, with reference to capacities from 320 to 1,500 kilowatts. Fuel cells, constant power sources, converters, better circuitry, and alternators are also listed among the avenues into which development efforts should be channeled. This article appeared in Issue No. 2 (78) for 1966. [redacted]

2. Because the source of this report is extremely sensitive, this document should be handled on a strict need-to-know basis within recipient agencies. For ease of reference, reports from this publication have been assigned [redacted]

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MILITARY THOUGHT (USSR): Some Problems of Military Electric Power Engineering

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Summary:

The following report is a translation from Russian of an article which appeared in Issue No. 2 (78) for 1966 of the SECRET USSR Ministry of Defense publication Collection of Articles of the Journal "Military Thought". This article, by Engineer Captain First Rank V. Ivanov and Engineer Lieutenant Colonel I. Isakov, deals mainly with the production and design of generators for the armed forces. Though gas turbine and gasoline generators have their uses, the diesel generator is best suited to most purposes. Important objectives in this field should be the development of a multi-fuel generator akin to the diesel, and automation of generating units. One-third of the article is devoted to the advantages of nuclear-powered generators, with reference to capacities from 320 to 1,500 kilowatts. Fuel cells, constant power sources, converters, better circuitry, and alternators are also listed among the avenues into which development efforts should be channeled. End of Summary

[redacted] Comment:

The SECRET version of Military Thought was published three times annually and was distributed down to the level of division commander. It reportedly ceased publication at the end of 1970. [redacted]

<u>Some Problems of Military Electric Power Engineering</u>

by
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At the present time, the overwhelming majority of combat systems and means of military equipment are electrified and automated. For this reason, it is impossible for them to maintain their combat readiness and to function without a reliable and uninterrupted supply of electric power. It may be said without exaggeration that without electric power, armed forces become "blind, deaf, and dumb."

This situation becomes understandable if we state, for example, that in only one motorized rifle division there are more than 300 individual electric power stations and generating units of various types with a total capacity of about 10,000 kilowatts, and an army formation is supplied with about 3,500 items of such electrical equipment with a total capacity of up to 100,000 kilowatts. In this connection, the resolution of the problems of military electric power engineering is a matter of concern to all command levels and staffs and to the control, intelligence, communications, and rear services organs of our Armed Forces.

Constituting the basis of military electric power engineering are self-contained sources of electric power: the power supply generating units (mobile and stationary) and mobile electric power stations by means of which troops, combat systems, and various military installations are reliably supplied with electric power.

In the postwar period, military electric power engineering was in essence recreated. During the 1950's, power supply generating units were standardized: a single system was set up for developing and producing generating units and mobile power stations. As a result, success was achieved in reducing the number of mobile power sources of different types from 200 to 120 types and in setting up their assembly-line production in specialized workshops. It was standardization which paved the way for the rapid quantitative and qualitative growth in low-capacity electric power equipment. Already in 1964 (as compared with 1951), the inventory of mobile power sources had increased by a factor of 8.4 in number and by a factor of 11 in total capacity. These figures convincingly confirm the ever-growing role of low-capacity electric power engineering in the armed forces. Over recent years, the armed forces have obtained standardized diesel electric generators of the AD series with capacities of from five to 75 kilowatts and gasoline electric generators of the AB series with capacities of from 0.5 to eight kilowatts. They form the base on which are established the mobile power, lighting, and charging generators for general troop purposes and also the generators for providing electricity for military engineer works.

Much has been done, but it must be taken into account that within the armed forces there is a steady increase of energy-consuming military equipment systems and installations requiring ever greater individual capacities on the part of power supply sources. If in the past we were satisfied with power equipment of relatively low capacity, today we need self-contained sources with capacities of hundreds and even thousands of kilowatts.

The changing methods of conducting combat actions have also confronted military electric power engineering with new tasks and new requirements. What are the new problems which have arisen in the field of military electric power engineering?

One important task of generator construction is to produce a primary engine, which, together with the electric generator, forms the base of modern generating units. What engines is it the most expedient to use for these purposes?

Among military power specialists there are proponents of carburetor, gas turbine, and diesel engines. Each of these types of machine has its own advantages and drawbacks. For example, carburetor engines make it possible to produce generating units with capacities up to 50 kilowatts, and they are low in weight and not of great size. They can function for an extended time when loads are light, which is characteristic for many consumers. But these engines are distinguished by comparatively low indexes of economy, between-maintenance operating time, and operating reliability. In addition, they are fire hazards.

Gas turbine engines of low capacity have acquired great popularity in recent years. In the US, UK, and France, production of gas turbine engines has reached a high level of technical development and is a new branch of electric power engineering. More and more countries are being included in the development of this field of electric power engineering. Low-capacity gas turbine engines are being manufactured by many large concerns in Italy, West Germany, Canada, and Spain. Already at the present time there are being produced more than one hundred models of multipurpose gas turbine engines with capacities of from five to 1,000 horsepower.

Gas turbine engines are distinguished by simplicity of construction (absence of crankshaft and connecting-rod assembly, valves and timing gear, and cooling system), quick starting under any temperature conditions, small size, and low weight. At the same time, the gas turbine engine, in comparsion with diesel engines, has substantial drawbacks: lower fuel economy, low between-maintenance operating time (about 300 hours for domestic models), considerable reduction of capacity when there is a rise in the temperature of the surrounding air, and others.

The status of the development of domestic gas turbine engines still precludes the production of generators for wide use in the various branch arms and branches of the armed forces, although we know that it is possible, on the basis of gas turbine engines and high-speed generators, to manufacture lightweight generating units with a frequency of 400 hertz, small size and weight, and fast starting (about one minute). It is not possible, without such an engine, to produce a series of new models of combat equipment for the ground forces air defense, where the determinant index is high combat readiness (fast start-up and assumption of load) and low indexes of size and weight.

Proceeding from an evaluation of the advantages and drawbacks of the various types of engines already in existence and of the production capabilities of our country, we may assume that the basic engines for electric generators in the immediate future will be diesels, on the basis of which it is feasible to produce mobile and stationary generating units with a capacity of eight kilowatts or more.

Diesel engines possess a number of fundamental advantages over other types of engines: high fuel economy, long between-maintenance operating time, significantly greater stability against the effects of the shock wave from a nuclear burst, high stability of engine revolutions and short duration of transient processes, higher operating reliability, and less danger of fire.

On the basis of diesels it is possible to produce generating units with flywheel generators and multi-fuel engines which in weight and size are close to generating units with carburetor engines but are superior to them in economy and performance.

In developing diesel engines for military electric power engineering, in our view, work should be carried out in two directions:

-- to adapt existing diesels to operate on different kinds of liquid fuel (diesel, kerosene, gasoline, alcohols, and mixtures of these fuels);

-- to design special multi-fuel engines based on the diesel process.

The development of multi-fuel engines must be considered as one of the most important tasks. The use of multi-fuel engines in generating units will simplify the supplying of fuel to mobile combat systems based on vehicles with both gasoline and diesel engines. The use of multi-fuel engines in combat vehicles, personnel transport vehicles, and special vehicles will make it easier to supply an army with POL. It will become possible to use any available fuel under conditions of combat actions, which will improve the tactical qualities of vehicles with multi-fuel engines, including generating units as well.

The military specialists of the NATO countries attach very great importance to multi-fuel engines. On the basis of orders placed by the military, intensive work is being done in this field. At the present time, development is for the most part in a completed stage, and mobile power sources and combat and personnel transport vehicles with multi-fuel engines are being put into service in the NATO armies. The most extensive work is being carried out in West Germany, where the firms Mann, Mercedes-Benz, Dietz, MWM, Daimler-Benz, and others are engaged in research and development of multi-fuel engines. Great success in this field has also been achieved by the US, France, and Italy. In the field of generator engine construction, there is great hope for the work involved in the development of diesel engines with long-term operating processes and a rated speed of 3,000 revolutions per minute, having low weight and size while preserving a long between-maintenance operating time. Great importance must also be placed on air-cooled engines for mobile electric power stations with a capacity of eight kilowatts or more.

* * *

The increase of combat readiness of combat systems and means of military equipment, the long continuous operation of them, and new conditions of the conduct of combat actions -- conditions necessitating operation of the systems on the move and on terrain contaminated with radioactive substances and toxic agents -- make it necessary to develop automated generating units and mobile electric power stations with remote control. Automation of generating units and mobile electric power stations has become an urgent task of military electric power engineering. Already there are automated generating units for fixed installations with capacities of 12, 20, 50, 100, 200, and 500 kilowatts and automated mobile electric power stations with capacities of 100 and 200 kilowatts. However, this is only a beginning.

In connection with the need to automate mobile electric power stations, the question arises once again of how mobile electric power stations are to be built. As is well known, up to the present, standardized mobile electric power stations for general troop use have been manufactured for the most part on vehicle trailers covered by a metal housing -- so-called mobile electric power stations of "cold" construction. And only certain types of special electric power stations are built on motor vehicles or vehicle trailers with a heated body -- so-called mobile electric power stations of "warm" construction.

Automated mobile electric power stations have a large number of semiconductor elements, sensors, relays, condensers, switches, and other equipment; and the circuits of the automatic equipment are similar in their complexity to the circuits of radiotechnical systems. This equipment requires certain definite conditions for adjustment, regulation, and periodic technical servicing and repair. In mobile electric power stations of "cold" construction, conditions are not created for normal technical servicing. It is therefore better to develop mobile electric power stations of "warm" construction. Their structure and layout provide more suitable conditions for reliable functioning of the automatic equipment and its technical servicing, and also for the overall operation of the power station.

It appears to us that we should develop automated 100- to 500-kilowatt mobile electric power stations for general troop use only of the "warm" construction type, and mobile electric power stations of less capacity -- of both construction types. In this connection, mobile electric power stations of "cold" construction must have a limited amount of automation. Speaking of the automation of generating units and mobile electric power stations, it must be noted that the operating reliability of these means depends to a substantial degree on the training and skill of the servicing personnel.

Analysis of the results of field operation of a large number of non-automated electric generator units of series AB and AD, relatively simple in construction, shows that about 25 percent of all malfunctions leading to shutdowns of generating units are caused by poor quality servicing.

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As is well known, our Armed Forces now have power-consuming systems and installations requiring self-contained power sources with capacities of hundreds and even thousands of kilowatts. The power sources for these installations are, as a rule, diesel power stations. They find wide application because they have relatively light weight and small size, a well-perfected design, a relatively high efficiency factor, and a developed industrial base for their production.

In areas with a good transportation network, the delivery of POL does not cause difficulties; in the immediate future diesel electric power stations will obviously retain certain tactical-technical and economic advantages over other types of electric power stations. As regards remote areas and areas difficult of access, the operation of diesel electric power stations there entails substantial difficulties, since it is obvious that the greater the capacity of a power station, the more fuel, lubricants, and other expendable materials are needed for it. The problem of supplying fuel arises.

Questions of supplying fuel take on great importance even in peacetime, since a considerable portion of the territory of the USSR still does not have a well-developed system of transportation -- the islands of the Arctic and Pacific oceans, the Far North coast, the northeast and east of Siberia, the Far East coast, and certain areas of Central Asia. For these areas it is best to have electric power stations which could operate for many months or even years without being resupplied with fuel, i.e., <u>nuclear electric power stations</u>.

In our view, the moment is at hand when we must establish military nuclear electric power engineering. Nuclear electric power stations have numerous decisive advantages, from the military viewpoint, over other types of power stations:

-- They can provide absolute independence in supplying a given installation or group of installations with power, without having to be resupplied with fuel for an extended time period (up to two years or more).

-- Under conditions of massive destruction and disruption of the power supply, transportation lines, and control, nuclear electric power stations are the easiest and most reliable for restoring the power supply of especially vital installations, since they can be delivered rapidly by air or ground transport to any area, can be quickly put into operation, and can provide for operation without organizing a supply service.

-- The continuous operation of nuclear electric power stations (without shutdowns) can be numbered in many hundreds and even thousands of hours. No diesel power station can provide this.

-- When nuclear electric power stations are placed in protected or partially protected structures, it is easier to set up a system for isolating them completely from the surrounding environment since, for example, a water-cooled nuclear electric power station does not require air input or removal of exhaust gases, and it is consequently possible to dispense with a complicated system of ducts between the power station and the atmosphere. For this reason the viability of protected nuclear electric power stations will be greater than that of other types of power stations.

-- Stationary nuclear electric power stations, in addition to electric power, can also produce heat for local distribution, which is particularly important for northern areas of the country and something diesel electric power stations cannot provide.

For remote and little developed areas of the country, nuclear electric power stations already today are not only economically competitive, but they also surpass diesel power stations in operation with regard to economy and a number of technical specifications.

Research shows that if POL must be delivered to a 630-kilowatt diesel electric power station by air over a distance of 1,500 kilometers or more, a nuclear electric power station is more economical. As an example, we cite the following figures. The diesel electric power stations of the Yakutsk ASSR produce electric power at a cost of 9.2 to 11.7 kopecks per kilowatt-hour. A nuclear electric power station of approximately the same capacity (800 to 1,500 kilowatts) can produce electric power at a cost of 4.1 to 5.6 kopecks per kilowatt-hour. It is known, for example, that the cost of a nuclear electric power station (together with nuclear fuel) is four or five times the cost of diesel electric power stations of the same capacity. However, the operating expenses when using diesel electric power stations considerably exceed those of nuclear electric power stations, and therefore the total expenditures (capital and operating) of diesel electric power stations are either commensurable with those of a nuclear electric power station or somewhat exceed them (depending on the area of location).

It should also be taken into account that, with the very first exchanges of nuclear strikes, large industrial electric power stations will be destroyed or severely damaged; entire power systems may be knocked out, power circuits broken, and power transmission lines put out of service; and thus many important military-industrial complexes and entire areas may remain without power and consequently be inoperative. The supplying of power in such instances is restored the fastest and most easily with nuclear electric power stations, since they, for example, can be transported en bloc by any type of transport and rapidly put into operation.

We consider it necessary to set up, in peacetime, a state reserve of nuclear electric power stations in case the necessity arises to restore the supplying of power to important military-industrial complexes and administrative-political centers and perhaps to entire areas.

And how do specialists abroad evaluate military nuclear power engineering? Quite highly. As early as 1952 the US Army Corps of Engineers, jointly with the Atomic Energy Commission, worked out an extensive "army nuclear program" providing for the creation of military nuclear power engineering in the US. This program is being energetically implemented: stationary, unit-transportable, and mobile nuclear electric power stations have been developed and are in operation; five types of unit-transportable nuclear electric power stations, with capacities from 1,000 to 1,840 kilowatts, have been adopted for supplying the US Armed Forces; and development has been completed of four nuclear electric power stations with capacities of 200, 800, 1,500, and 6,000 kilowatts.

The Americans have set up nuclear electric power stations in those areas where the network of supply lines is poorly developed. For example, the Air Force uses nuclear electric power stations in the state of Wyoming in mountainous terrain, the Navy at Fort Greeley in Alaska and McMurdo Base in Antarctica, etc.

Of the mobile nuclear electric power stations, one with a capacity of 300 kilowatts has been adopted as standard equipment, and another with a capacity of 10,000 kilowatts (planned for installation aboard "Liberty" class ships) is in the production stage. In addition, a nuclear electric power station with a capacity of 3,000 kilowatts is under development.

The scale of the work to be carried out by the US in order to set up nuclear electric power stations is indicated by the following figures. By 1970 it is planned to develop army nuclear electric power stations capable of producing up to two million kilowatt-hours of electric power every day. In terms of 1,000-kilowatt nuclear power stations, this means that 83 or 84 nuclear electric power stations will be operating around the clock. In this regard, the main trend in the establishment of nuclear electric power stations is considered to be the development of mobile nuclear electric power stations, by means of which the Americans plan to have, within the theater of military operations, power bases for supplying power to the ground forces.

To supervise the work for implementation of the army program, the US Department of the Army has an office of nuclear electric power engineering, which consists of six departments; and for training specialists in military nuclear power engineering, a training center has been opened at Fort Belvoir, in which 100 enlisted men and 15 officers are trained every year.

Although the Soviet Union is the pioneer in developing nuclear electric power stations (the first nuclear electric power station in the world was constructed in the USSR in June 1954, with a capacity of 5,000 kilowatts; and the first mobile nuclear electric power station in the world in 1959, of type TES-3 with a capacity of 1,500 kilowatts) and although it leads the world in construction of large industrial nuclear electric power stations, we still do not have military nuclear electric power stations. In 1962 a number of organizations from the State Committee for the Utilization of Atomic Energy worked out preliminary variants of mobile nuclear electric power stations with capacities of 320 to 600 kilowatts and unit-transportable nuclear electric power stations with capacities of 750 to 1,500 kilowatts. But, since these were essentially pioneer projects, their organizers could not take all requirements into account, and the nuclear electric power station variants proposed at that time were not altogether suitable for the armed forces.

This situation has obviously come about because we still do not have an agency to direct, support, and finance work on military nuclear power engineering, to build up experience in developing and operating nuclear electric power stations, and to introduce the results into the troops.

It is not without cause that our military power specialists have a poor idea of the capabilities of nuclear electric power stations, the principles of their functioning and organization, and their operating characteristics. It is self-evident that until such time as there are operating models of nuclear electric power stations among the troops, our military power specialists will be unable to evaluate their strong and weak aspects correctly.

* * *

We shall refer briefly to a few other problems. Military electric power engineering is faced with the task of developing and introducing among the troops non-mechanical generating units with electrochemical generators (fuel cells). Such generating units have a number of important advantages, principal among which are high reliability (there are no moving parts), noiselessness, comparatively light weight and small size, and absence of telltale infrared illumination.

It is also very important to develop special constant power sources. This task has come up in connection with the fact that a number of the newest military equipment means require a continuous power supply (without interruptions of even fractions of a second).

Since many combat systems and military equipment means require alternating and direct current simultaneously, with the alternating current having frequencies of 50, 200, 400, 600, or 1,000 herz or more, the troops must have current transformers and frequency converters. The present state of science, technology, and industry makes it possible on the basis of semiconductor devices to develop static frequency converters and rectifying units with non-contact automation circuits. These must also be developed on a priority basis.

Military electric power engineering is also faced with the task of standardizing connector plugs and the plastic insulation for cable networks.

Actual use of metal connector plugs shows that they are not sufficiently reliable in operation and do not provide the necessary sealing and electrical safety. It is already possible today to produce a cable network and connector plugs which fully meet troop requirements.

And, finally, the interests of military electric power engineering require the development of a series of alternators for turbine and diesel generating units, with speeds of 3,000, 6,000, and 12,000 revolutions per minute, and also of a series of non-contact alternators providing for high operating reliability.

* * *

Even a short presentation of the problems facing military electric power engineering indicates the size and importance of this field of military technology. Its growing dimensions require a new approach to many technical engineering and organizational questions.

Directives of the Twenty-Third Congress of the CPSU regarding the five-year plan of development of the national economy set the task of achieving a superior growth in electric power engineering, i.e., it defined very clearly the priority role of electric power in the future growth of production in our country.

The fulfilment of this task will create significantly better conditions for the development of military power engineering, which is of such great importance in providing for a high level of combat readiness of the weapons and military equipment of our Armed Forces.