Belarusian State University
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UDC

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Modeling of electromagnetic radiation shields based on charcoal for technical tools of information protection

Essay in Engineering Science
with the speciality 1-98 80 01 Methods and systems of information protection, information security

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Minsk 2016

CONTENTS

GENERAL WORK DESCRIPTION

Purpose and tasks of research

Research purpose consists in development of structures of electromagnetic radiation shields, which are based on new carbon-containing material – charcoal, and in the study of the influence manufacturing modes have on the coefficients of attenuation and reflection of electromagnetic radiation.

According to the purpose set, the following tasks have been stated and completed:

– the analysis of modern methods and means of detection of military machinery and special technologies, means of camouflage against optical, radar and heat reconnaissance was carried out;

– the structures of electromagnetic radiation shields and modeling of electromagnetic wave distribution in homogeneous materials were considered;

– main methods of charcoal powders impregnation with water-containing components and the equipment evaluating interaction of the shields with electromagnetic radiation were defined;

– methods of manufacture of protective electromagnetic radiation shields based on shungite-containing enamel paint were developed;

– the influence of composite coatings composition based on powder charcoal on electromagnetic radiation was studied.

Connection with the priority areas of scientific researches and with real economy demands

Topic of thesis research complies with:

– p.13. "Human, Society and State Security" of Priority Areas of Scientific Researches of the Republic of Belarus for 2016-2020 approved by the Resolution of the Council of Ministers of the Republic of Belarus No. 190 of March 12, 2015.

An essential task on development and justification of usage of new carbon-containing materials (charcoal powder), methods of its modifications by means of impregnation was stated and completed in this thesis. There was shown prospectiveness of usage of relief cellulose pyramid-shaped underlayers with efficiency up to –10 dB in frequency range of 0.7–17 GHz.

Scientific novelty consists in the established regularities of change of electromagnetic waves attenuation and reflection coefficients. These regularities are characterized by resonance on the frequency of 7 GHz.

Theoretical relevance of the thesis is that an approach to construction of efficient electromagnetic radiation shields containing carbon and water components was suggested in it.

Practical relevance of the thesis consists in the development of new electromagnetic radiation shield structures, which are characterized by low cost, and in the possibility of their usage in the systems of information protection and environmental security.

Points submitted for defense:

– experimental justification of charcoal powder usage and methods of its modification by means of impregnation for manufacture of electromagnetic radiation shields;

– experimental justification of coatings usage on relief cellulose pyramid-shaped underlayers with efficiency up to –10 dB in frequency range of 0.7–17 GHz.

Personal contribution of the degree-seeking student

In jointly published works, setting of purposes and statement of research tasks, choice of development methods, participation in the analysis of modern methods and means of creation of new structures of electromagnetic radiation shields and providing objects security, as well as in processing, analysis and interpretation of the obtained results, formulation of conclusions belong to the degree-seeker.

The main co-author of the published works is research supervisor, Doctor of Engineer Science, Professor L.M. Lynkov.

Thesis approbation and information about the usage of its results

The main points and results of the research were reported at scientific and research and practice conferences of different levels: XIII Belarusian-Russian Scientific-Technical Conference (Minsk, June 4-5, 2015), XIV Belarusian-Russian Scientific-Technical Conference (Minsk, May 25-26, 2016).

INTRODUCTION

An efficient method of information signals reduction is shielding of their sources that consists in limitation of electromagnetic waves distribution to a certain area of space by means of scattering, re-reflection of electromagnetic vibrations energy and its conversion into heat energy in shielding materials with resistive, dielectric or magnetic losses.

The analysis of existing EMR shields structures shows that efficiency of shielding devices is determined by electric and magnetic properties of shield material, structure, its geometrical sizes and radiation frequency. Efficient EMR shields based on synthesized water-containing composite material have low weight and flexibility and electromagnetic characteristics of the structure depend on the properties of dispersed filler. It is necessary to create brand new universal composite coatings for EMR shield structures, which will attenuate electromagnetic radiation of microwave range, are eco-compatible with human body, cost less and have smaller weight and size characteristics, to suppress electromagnetic channels of information leakage, protect residential, industrial and meeting rooms from electromagnetic pollution, what was the purpose of the conducted research.

Such peculiarities of wave distribution as absorption of electromagnetic wave in material and reflection of electromagnetic wave from the interface of two media are used when shielding EMR. EMR absorption is determined by interaction of electromagnetic field with material substance. When EMR is distributed at the interface of two media characterized by different properties (e.g. different characteristic impedance of metal and air), electromagnetic energy partially penetrates through them continuing distributing in a new medium and is partially reflected from the interface of two media and reflection coefficient depends on the ratio of impedance characteristics of adjacent media. Different ways of shielding based on materials, devices and constructive methods reducing electromagnetic radiation are applied to suppress electromagnetic channels of information leakage.

1. MODERN METHODS AND MEANS OF ELECTROMAGNETIC RADIATION SHIELDING WITH CARBON-CONTAINING MATERIALS FOR TECHNICAL TOOLS OF information PROTECTION

1.1. Methods of armed and special machinery detection

1.1.1. Radiolocating

Radiolocating (from radio and locatio (lat.) — placement, disposition) – field of science and technology, subject of which is observation of different objects (targets) using radio-technical methods (radar observation) – their detection, identification, measuring of coordinates (position) and derived coordinates, identification of other characteristics. Radiolocating also means the process of objects observation (location) itself. When several objects are present, detection should provide their required resolution (separate observation). Tasks on detection and identification are solved by means of *Radio Detection and Ranging (radar)* and sophisticated radar systems, as is characteristics measurement. Radiolocating is closely related to radionavigation, very often their methods and equipment have almost no differences [i].

The following is used to observe the objects: echo signals created as a result of radio-waves reflection from the object irradiated by the radar (radiolocating with probing radiation); radar signals reradiated by retransmitting device placed in the object, location of which is detected (radiolocating with secondary radar); own radio-wave radiation of the object – radiation of radio devices placed in the object or thermal radiation of the object itself determined by its temperature (passive radar).

The measured characteristics of the object are distance to it (ranging or distance measuring), the direction of signal arrival (radial and angled velocity of movement, etc. Observation of the objects using radar allows defining of many of their characteristics, e.g. determining the parameters of ice sheet of water surface, atmosphere moisture content, object sizes and configuration, etc. Measurement data can be discrete (produced in certain time intervals) or continuous. The observed objects can be single or multiple or be presented by a solid structures. Complex (combined) observation is possible, e.g. radar scanning of the space in one sector that allows searching and detecting new objects in this sector and continuously receiving current coordinates of the detected objects at the same time.

Radar objects are divided according to the type of reflection or radiation, first of all, into concentrated (which are single objects with the sizes smaller compared to the sizes volume allowed by radar) and distributed.

Distributed objects in their turn can be surface (earth surface with ploughland, shrubbery, snow, etc., sea and moon surface, etc.) and dimensional (all the possible heterogeneities in the atmosphere – clouds, rain, snow, artificial radar chaff, etc.). Smooth surfaces where unevenness sizes make an insignificant part of irradiating wave length (still water surface, concrete canvas, etc.) reflect specularly, i.e. certain phase relations between irradiating and reflected waves are observed.

If the unevennesses are commensurable with the length of irradiating wave or exceed it, diffuse reflection of the waves reflected from different elements of the surface, i.e. summation of the waves with random phases, takes place. In general physical surfaces create reflected waves containing both specular and diffuse component. Comparing the sizes of a single object not just with the volume allowed by radar but also with the length of the wave it radiates, 3 cases are distinguished:

1. Object sizes are much bigger than wave length (optical scattering – surface and boundary);
2. Object sizes and wave length are similar (resonant scattering);
3. Wave length significantly exceeds object sizes (Rayleigh scattering).

These cases differ not only by reflection intensity but also by the nature of reflected signal dependence on wave length and polarization of sounding signal. The case of large value of the relation of the object to wave length is of special practical interest while waves of centimeter range, in which surface and boundary sizes of most objects exceed wave length in many times, are the most used. Independence of radar cross-section (RCS) from polarization of sounding signal and possibility of dividing a large object into separate almost independent parts are typical for such (optical) scattering.

1.1.2. Radar reconnaissance means

1.1.2.1 Integrated radar system (IRS) of firing equipment site reconnaissance and fire monitoring "Zoopark-1"

It is intended for reconnaissance of firing position of mortars, artillery by round (fire), for identification of tactical launching positions of the enemy and providing fire activity of friendly firing equipment (Figure 1.1) [ii].

Figure 1.1. Outward appearance of IRS "Zoopark-1"

It performs electronic scanning in the sector of 60 degrees in any direction, simultaneous detection of up to 70 positions in a minute and simultaneous tracking of up to 12 targets, display of firing positions coordinates until shell fall, automated information exchange with control post. It is resistant to the influence of electromagnetic radiation and radio-electronic countermeasures. The system includes:

- Monopulse three-dimensional radar with phased array antenna (PAA) on tracked chassis;
- Maintenance vehicle with towed stand-by plant ЭД30-Т230;
- Autonomous means of navigation and survey control.

Technical characteristics:

Operating range	G-H
Maximum reconnaissance range with the probability of 0,8 by the first round (fire) of, km:	
mortars	13-17
field artillery	10-12
multiple launch rocket system	15-22

tactical ballistic missiles	40-45
Maximum range of fire control with the probability of 0,8 by the first round (fire) of, km:	
mortars	18-22
field artillery	15-20
multiple launch rocket system	25-35
tactical ballistic missiles	40-45
Number of simultaneously tracked targets	12
Set-up time, min	5
Crew, ppl.	3

Additional means: Maintenance vehicle; mobile stand-by electric power supply plant; data transmitting equipment; navigation and survey control equipment; communication equipment.

1.1.2.2 Artillery integrated radar system of reconnaissance and service of fire activity of field artillery АРК-1М "Rys"

It is intended for reconnaissance of firing position of mortars, artillery, multiple launch rocket system as well as tactical launching positions of the enemy by round (fire) and for providing fire activity of similar domestic means [iii]. Parabolic reflector antenna is used in the radar (Figure 1.2).

Figure. 1.2. Outward appearance of АРК-1 "Rys"

Composition: three-dimensional monopulse radar of 5-cantimeter range with automated coordinates survey, base chassis МТ-ЛБу, power-supply set.

Technical characteristics:

Radar range, km during reconnaissance:	
mortars	16-17
howitzers	13-15
MRLS	20-30
TM	
During fire activity service:	
mortars	12-13
howitzers	7-9
MRLS	20-30
TM	30
Mean errors of rectangular coordinates setting during fire reconnaissance (control), m	30-90
engagement rate, targets/min	2-3
Reconnaissance sector, degrees	30
Set-up (tear-down) time, min.	5
Crew, ppl.	4

1.1.2.3 Radar of mean detection range "Credo-1E"

It is intended for reconnaissance of ground and surface moving targets, artillery spotting. "Credo-1E" (Figure 1.3) is Doppler pulse coherent radar with solid-state multiliteral master oscillator with a klystron and slotted waveguide antenna [iii]. It can be applied independently, with reconnaissance vehicles, can be placed on different base chassis and helicopters ("Credo-C", CHAP-10).

Figure 1.3. Outward appearance of "Credo-1E"

It provides automatic detection and tracking, identification of target type, all-round view, sector observation, automatic frequency agility, display of target environment against ground map, color target coding, moving target track shaping, working with digital ground map, automatic track-while-scan, memorization and documentation of radar data, information exchange by standard interface.

Technical characteristics:

Operational range	Ku
Range of detection, km:	
person	15
machinery	up to 40
helicopter	35
155-mm shell	15
Detection accuracy	
in distance, m	10
in azimuth, degrees	0,12
Resolution capability:	
in distance, m	60
in azimuth, degrees	1,6
Display type	color, LCD
Weight, kg	10,5

The radar is placed on tripod, crawler bases, mast-hoisting gear, helicopters, unmanned aerial vehicles.

1.1.2.4 "Monitor-M" radar

"Monitor-M" (modernization of production radar ПСНР-5) – portable all-weather surveillance radar for automatic location detection and identification of moving people, machinery, low-altitude helicopters with ground and water surfaces in the background (Figure 1.4) [iii].

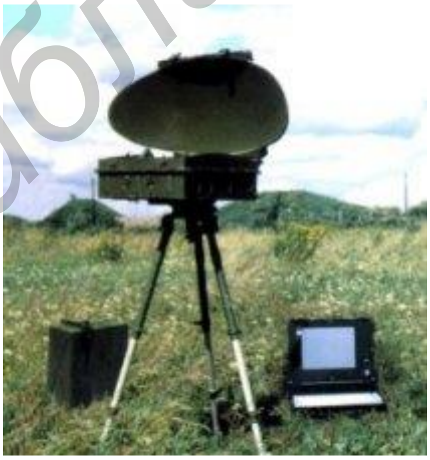

Figure 1.4. Outward appearance of “Monitor-M” radar

Main characteristics:

coherent Doppler pulse radar;

automatic detection and localization of moving objects;

coverage range up to 20 km;

simultaneous tracking up to 10 targets;

identification of target type by the nature of audio signal;

display of target environment against ground map, moving target track shaping;

color target coding;

overhang of control unit up to 100 m;

information exchange by standard interface.

1.1.2.5 Mobile ground artillery reconnaissance station CHAP-10M

Modernized item with extended coverage range for reconnaissance of moving columns of machinery, tanks, APC, automobiles, groups of people, soldiers and for own artillery spotting (Figure. 1.5) [iii, iv].

Main characteristics:

maximum acquisition range up to 40 km;

Doppler pulse radar with true coherence working in Ku range;

automatic detection and multichannel target tracking;

all-round view, sector observation;

signal digital processing;

digital ground map;

information exchange by standard interface;

visual control by means of optics.

Figure 1.5. Outward appearance of CHAP-10M

1.1.2.6 Shorter range radar "Fara-1"

Portable radar for detection and tracking of moving people, machinery against ground and water surface and for guiding heavy automatic small arms in conditions of no optical visibility. Coverage range up to 5 kilometers [iii].

Main characteristics:

Doppler radar working in J range;

solid-state receiver/transmitter;

sector observation;

automatic detection of moving targets;

identification of target type by the nature of audio signal;

remote control unit;

information output by standard interface is provided upon the customer's request;

installation on automobile armored vehicles.

Radar is carried and operated by one person. Associated with optics, machine-gun, grenade launcher (Figure 1.6).

Technical characteristics:

Operational range	J
Range of detection, km:	
person	2,5
machinery	5
Location accuracy:	
in distance, m	20
in azimuth, degrees	0,9
Weight, kg	16


Figure 1.6. Outward appearance of “Fara-1” radar

1.1.3. Combined means of reconnaissance

1.1.3.1 Mobile reconnaissance unit ПРП-4М “Deiteriy”

It is intended for artillery reconnaissance of mobile and immobile targets day and night in any weather conditions [iii].

Composition: thermal-imaging reconnaissance device, active-pulse night vision device, ground reconnaissance radar, laser range finder, means of survey, communication, life support.

It is placed on powered crawler floating chassis, on the basis of components and assemblies of IFV-1 (Figure 1.7).


Figure 1.7. Outward appearance of ПРП-4М “Deiteriy”

Technical characteristics:

Range of tank reconnaissance (detection) by optical and optoelectronic devices, m:	
At day time	10000
At night	3000
Range of moving tank reconnaissance with radar, m	8000-10000
Mean error of target location, m:	
OES	25
radar	50

1.1.4. Mobile integrated radar system of ground targets reconnaissance «Credo-1C»

Reconnaissance system with mast-hoisting gear on armored personnel carrier БТР-80 for work on heavily rugged and forested terrain, detection and visual observation of moving ground, air and surface targets and for artillery spotting (Figure 1.8). It consists of radar equipment, television equipment with laser rangefinder, thermal- imaging equipment, mast-hoisting gear, automated commander’s and operator’s stations, autonomous survey control system, self-contained power supply, data transmitting equipment and means of communication [iii].

Main characteristics:

Maximum detection range up to 40 km;

Automatic target detection and tracking;

visual observation and identification of target type;

all-round view, sector observation;

display of target environment against ground map;

color target coding, moving target track shaping;
hoist height of mast-hoisting gear - 4, 8, 12 m;
information exchange by standard interface.

Figure 1.8. Outward appearance of “Credo-1C” radar

1.1.5. Radar and visual observation system "Strazh-CT"

System of radar and visual aid for day-and-night al-weather detection, identification and documentation of location of moving surface and ground objects in guarded water zones, territories and areas of smuggled goods and units transportation (Figure 1.9) [iii].

Figure 1.9. Outward appearance of radar and visual observation system "Strazh-CT"

Main characteristics:

Automatic detection and surveillance of moving objects;

Measuring of coordinates and parameters of detected objects movement;

Producing data in distance and bearing for interceptors;

Range of radar detection up to 20 km, visual identification – up to 10 km;

Generation of radar image of the water zone observed, territory against stylized map with code designations of radars and television cameras location;

Creation of milestones (closed areas) of any random configuration;

Automatic alarm initiation when detecting a violator;

Violation documentation;

Information exchange with other interacting means of physical protection by standard interface.

1.2. Masking from radar reconnaissance

Masking from radar reconnaissance means of an enemy is provided by:

application of special masks and nets reducing reflectivity if masked objects;

mask structures made of radio-waves reflectors which create interferences for radar observational means.

Special devices and materials, functional principle of which is based on reflection and absorption of radio-waves, are applied to create radar masks. Different types of reflectors, the most widely used of which are metal corner (folding) reflectors MCR, are applied during generation of interferences for radars.

Local materials applied for masking of armament, machinery and constructions from optical means of reconnaissance possess the properties of radio-wave absorption and provide some reduction in range of detection of hidden objects by radar reconnaissance aids. Therewith, radio-wave absorption depends on density and thickness of the materials as well as on their moisture content.

1.2.1. Artificial masks

Masks are special engineering structures or local features intended for concealment of armament, machinery and constructions from reconnaissance means of the enemy.

The distinguished masks are natural (forest, topographic inequalities, constructions, etc.) and artificial (engineering masking structures).

According to application in frequency ranges, artificial masks are divided into optical, radar, combined and special.

Troops get artificial masks in the form of basic camouflage nets and screens, which are produced on site by troop forces from local and consumable materials.

МКТ-4Л is applied for masking of military equipment and army objects against summer vegetative background from optical and radar reconnaissance means (Figure 1.10).

Figure 1.10. Camouflage net МКТ-4Л

Camouflage net МКТ-4П is applied for masking of military equipment and army objects against desert-steppe vegetative background from optical and radar reconnaissance means (Figure 1.11).

Figure 1.11. Camouflage net МКТ-4П

Garnished nets МКТ-4Л and МКТ-4П represent net base with interlaced in it garlands made of perforated and stranded color strips of three-layer conductor material. Garnished nets consist of 3 and 6 standard elements 3x6 m each, which are bound together with seaming cords. Total area of garnished net is 216 m^2.

Complex (optical and radar) camouflage load with three-dimensional structure МКТ-5Л is applied vegetative background.

Camouflage net МКТ-5Л is applied for masking of military equipment and army objects against summer vegetative background from optical and radar reconnaissance means (Figure 1.12).

Figure 1.12. Camouflage net МКТ-5Л

Garnished net represents net base with interlaced in it garlands made of perforated and stranded color strips of three-layer conductor material. Garnished net consists of 3 and 6 standard elements 3x6 m each, which are bound together with fast unsewed seams with seaming cords. Total area of garnished net is 216 m^2.

When concealing armament and machinery from the system of reconnaissance technical means, basic camouflage nets and screens are applied in conjunction with thermal and radar shields made of local materials.

Electromagnetic wave scattering coating made of synthetic materials together with heat-reflective coating made of metallized film (fabric) is applied for machinery and armament masking from the enemy's integrated reconnaissance [v].

Heat-reflective coating is fixed under scattering coating and placed above radiating surfaces of masked machinery (Figure 1.13). At the same time, metallized surface of heat-reflective coating should be facing masked object [vi].

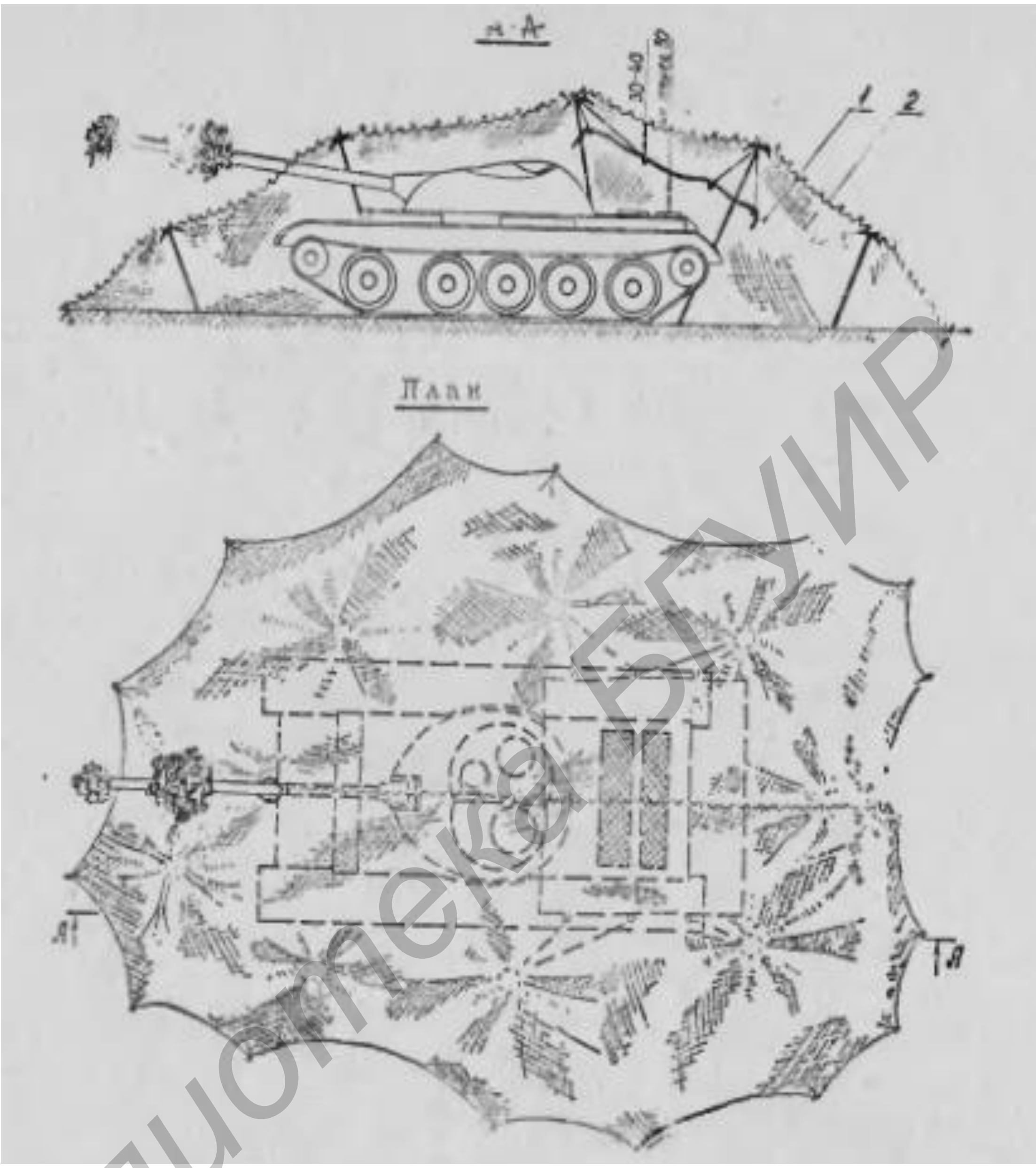

Figure 1.13. Screen masking of the tank from optical, radar and heat reconnaissance: 1 – heat-reflective coating; 2 – electromagnetic wave scattering coating

According to intended purpose, structure and appearance, artificial masks are divided into drape net, flattop and vertical.

During development and creation of camouflage nets and coating, it is possible to use the following radar absorbent materials as samples for reduction of signatures of armament and machinery in radar frequency band of wave lengths:

Broadband garnished net representing two fastened along the perimeter modules 1, containing supporting material 2, made of dielectric threads, and interlaced filling material 3, which is made of filament yarn of different resistance consisting of glass filament 5 enlaced with iron-base with addition of cobalt microwire 6 with the diameter of 3 micrometers for one module and 5 micrometers for another, and the structure obtained is fixed by high-density enlacing with glass filament 7 (Figures 1.14–1.16).

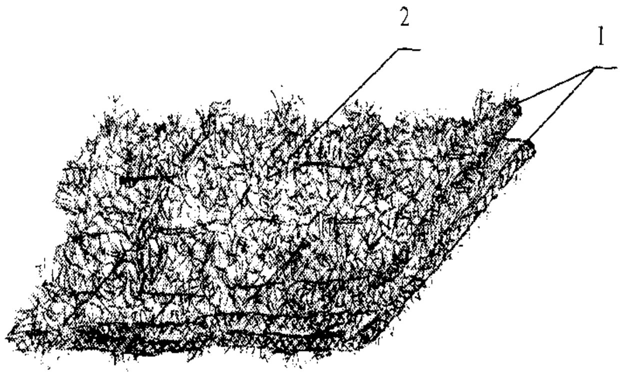

Figure 1.14. Broadband garnished radar-absorbent net

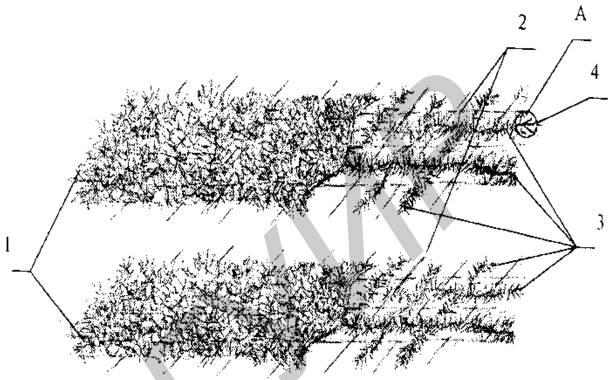

Figure 1.15. Coating modules

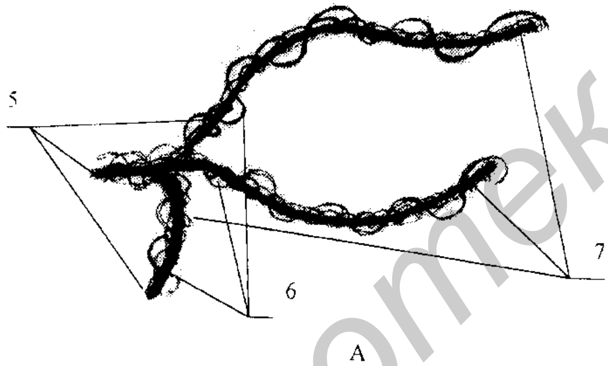

Figure 1.16. Cutaway A in coating module

There are known garnished nets, which are used in concealing ground objects from optical and radar reconnaissance means. In such nets, the elements, which have inner conductive layer in the form of metal, carbon fillers and other, are fixed to supporting material.

There is known garnished net, the base of which is a net made of dielectric threads with enlaced separate elements of conducting material of olive drab color.

The means of object protection from radar detection containing flexible netted base 1, on separate sections of which the bands 2 are fixed, which are made of conducting material and intended for creation of areas 3 with different reflection coefficient (Figure 1.17). Reflection coefficient value of each area 3 is within the limits of value change of reflection from underlying surface coefficient.

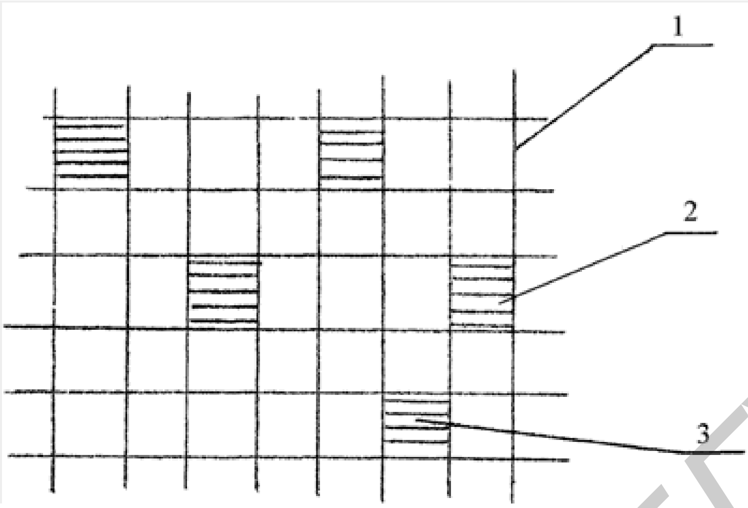

Figure 1.17. Protective means structure

Such protective coating belongs to the means of objects masking and can be used as garnished net concealing the object placed under it from surveillance systems of radar detection.

There was a protective means developed, which represents a netted base 1, in each mesh of which there is a hanging loop created by the band 2 made of film with surface impedance layer, for objects protection from radar detection [vii] (Figure 1.18). There are at least two intercrossing through cuts made in the center of every hanging loop on the band.

3. The size of cuts 3 makes 0,1-0,8 of band width and its hanging loop height. Hanging loops fixed on netted base make three-dimensional radar-absorbent structure with outer relief surface directed to falling wave.

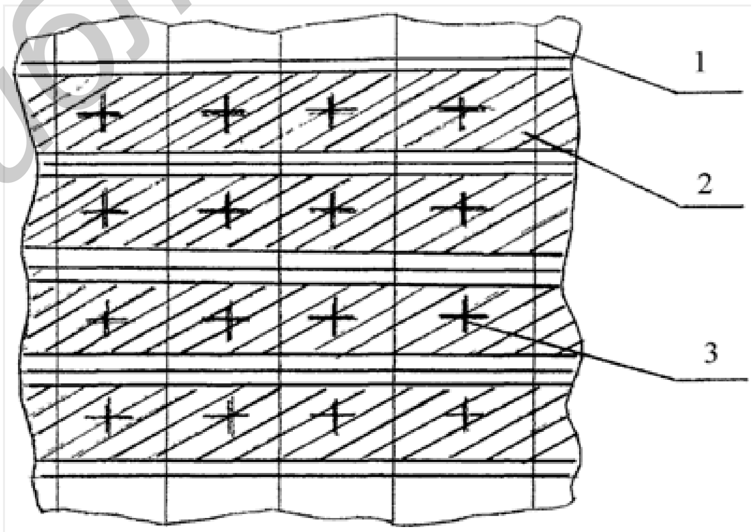

Figure 1.18. Means of protection from electromagnetic radiation.

There was a structure of absorbent material suggested [viii], which can be used as garnished net concealing placed under it object from surveillance systems of radar detection. The device contains netted base 1, into the meshes of which one or more radar-absorbent fragments 2 are enlaced (Figure 1.19). The fragments 2 represent flexible cylindrical elements with electrically-conductive, radiating from them micro-dipoles made of a workpiece 3 spirally twisted along the axis (Figure 1.20). Sideview of lateral faces of the workpiece 3 has a form of alternate ledges and concaves. Sideviews of lateral faces of workpieces 3 of radar-absorbent fragments 2 enlaced into the respective mesh differ from each other. Interlacement of radar-absorbent elements in the shape of brushes forms a stable three-dimensional structure.

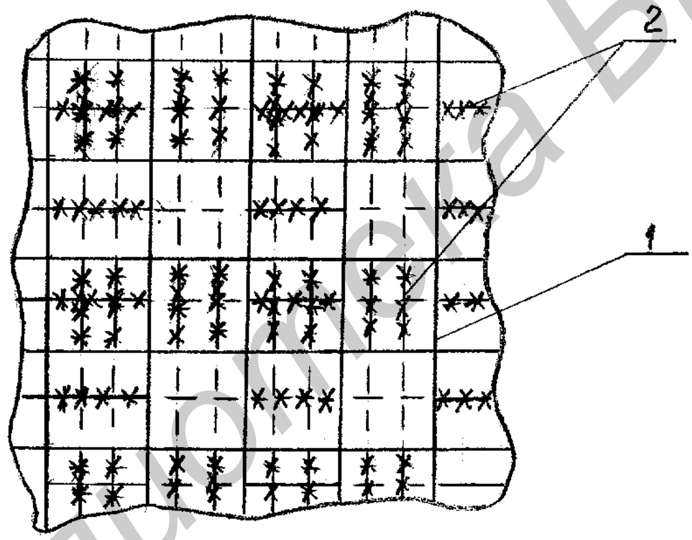

Figure 1.19. Device structure

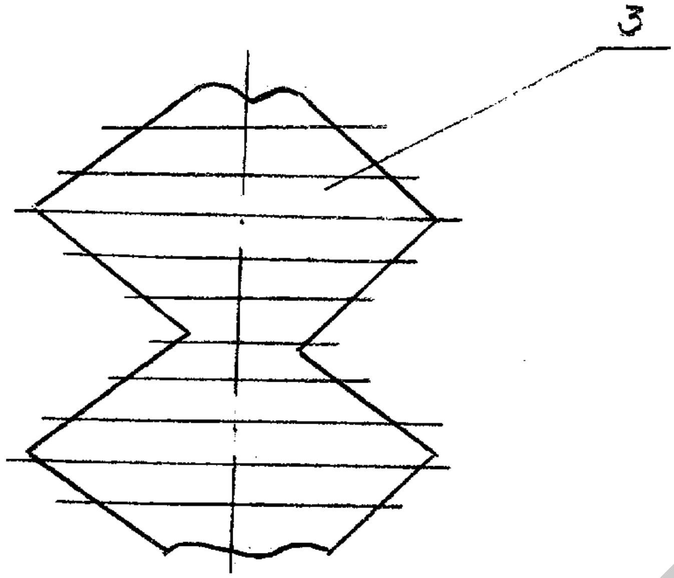

Figure 1.20. Workpiece for cylindrical elements production

There is a protective device known [ix] made in the form of incasing shielding canvas made of highly-conductive perforated film (Figure 1.21–1.22).

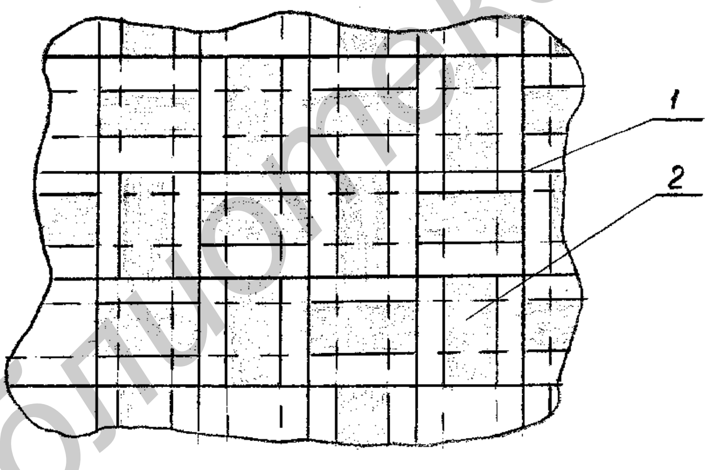

Figure 1.21. Masking device

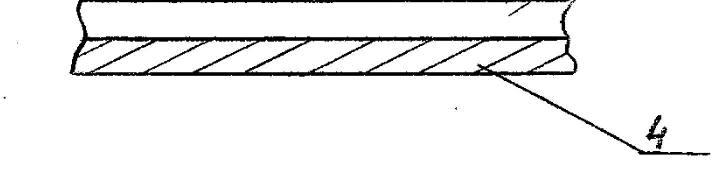

Figure 1.22. Double-layer band structure

Radar-absorbent structure consisting of the elements 1, which absorb electromagnetic waves and are fixed against each other with self-fusing foam 2, was suggested in [x] (Figure 1.23). The elements 1 are made of thin-layer resistive material absorbing electromagnetic waves. Foam with absorbing elements 1 placed in it makes a stable in shape layer, the density of which increases over its thickness in the direction of one of the outer surfaces. The outer surface of the layer corresponding to a minimum density is directed to falling wave. Adjustment to a different frequency range of electromagnetic radiation is possible by choosing shape and size of absorbing elements 1 as well as by means of density change law in regard to foam filling them.

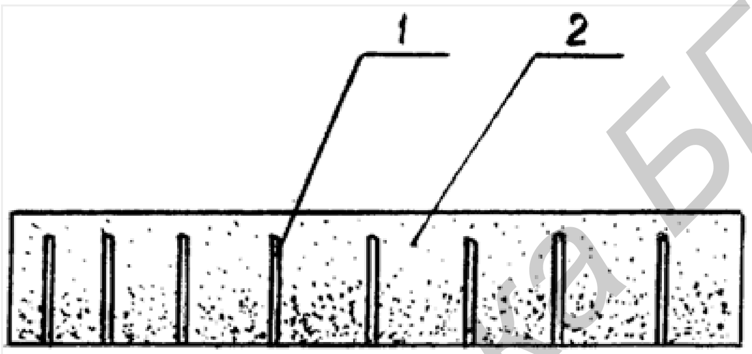

Figure 1.23. Cross-section of radar-absorbent structure

The following models are similar to radar-absorbent structure in engineering solution:

- three-dimensional radar-absorbent structure [xi] containing tubular elements made of thin-layer resistive material, front parts of which are directed to falling wave and have a slant of profiled shape. The known device has a good connection with free space and low reflection coefficient but its range of efficient operation is not wide enough. Moreover, tubular elements have low mechanical resistance;

- three-dimensional radar-absorbent structure [xii] consisting of the elements bound together and possessing a quality of electromagnetic waves absorption (matching of free-space and material impendences). The disadvantages of the engineering solution are low mechanical resistance and high fire hazard. High flammability and low mechanical resistance of the material, which the elements absorbing electromagnetic waves are made of, cause these disadvantages.

CONCLUSION

The influence composition of composite coating based on powder charcoal with different binding components has on the characteristics of electromagnetic radiation shielding in the frequency range of 0.3…17 GHz has been studied. As a result of the conducted studies, the possibility of application of the developed composite coating on the surface of the structure with pyramidal inhomogeneities, what leads to the increase of efficiency of electromagnetic radiation (EMR) shielding on the average by 10…12 dB in the whole studied frequency range, was shown.

The obtained results allow recommending the developed methods of models creation for formation of finishing panels for electromagnetic shielding of microwave sources and for provision of service personnel and PC users as well as users of medical and industrial equipment with environmental security. Besides high absorbing properties of solution and powder fillers in microwave range, decrease of reflection coefficient can also be reached by means of formation of geometrically inhomogeneous shield surface, what leads to the occurrence of multiple re-reflections within the shield and to EMR energy attenuation.

Formation of pyramidal shield structures from the developed moisture-containing materials provides EMR attenuation about 2.0…9.0 dB in frequency range of 0.7…3.0 GHz and 6.0…17.0 dB in frequency range of 2.0…17.0 GHz when reflection coefficient is -4.0…-22.0 dB in the whole studied frequency range. Thus, pyramidal structure of moisture-containing shields with the developed combined coatings based on charcoal allows increasing efficiency of EMR shielding in frequency range of 2.0…8.0 GHz on the average by 10.0 dB compared to the shield with plane structure, what can be taken into account during creation of highly efficient shields and absorbents of EMR of microwave range.

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