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THE CHEMICAL COMPOSITIONS OF GERMAN PYROTECHNIC SMOKE SIGNALS

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COMBINED INTELLIGENCE OBJECTIVES SUB-COMMITTEE

LONDON—H.M. STATIONERY OFFICE

THE CHEMICAL COMPOSITIONS OF GERMAN PYROTECHNIC SMOKE SIGNALS

Report by:

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THE CHEMICAL COMPOSITIONS OF
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I. SUMMARY

As a result of the investigation of a number of German pyrotechnic plants, information concerning the chemical compositions of some white, black and colored smoke mixtures has been obtained.

It has been found that the colored smoke compositions were mixtures of organic dyestuffs, potassium chlorate, kieselguhr and lactose, which were granulated by means of water and a water soluble binder. These compositions are given in detail. The chemical formulae of the organic dyestuffs used in these compositions were obtained from the I.G. Farbenindustrie and are given in the appendix of this report.

The white smoke compositions have been found to be either phosphorus phlegmatized with ten percent of paraffin, or mixtures of hexachlorethane with zinc dust.

Two different types of black smoke compositions have been found. The formulae of these compositions are given also.

II. SOURCES OF INFORMATION

A. Interrogation of Dr. Pahlke, formerly of the DEPYFAG (Deutsche Pyrotechnische Fabrik) plant at Malchow near Berlin. Place of interview: Silberhutte/Harz on June 10, 1945.

B. Investigation of the I.G. Farbenindustrie plant at Leverkusen on 13 August 1945. Person interviewed: Dr. Beck.

C. Investigation of the I.G. Farbenindustrie plant at Hochst on 8 October 1945. Person interviewed: Dr. Huss.

D. Investigation of the I.G. Farbenindustrie plant at Ludwigshafen on 5 October 1945. Person interviewed: Dr. Schimmer.

E. Interrogation of Dr. Fischer, formerly Chief of Development Section, Fabrik Deleu, at Schonhagen/Trebbin. Place of interview: Fabrik Moog at Ronsdorf/Wuppertal on 11 August 1945.

F. Investigation of the Duetsche Pyrotechnische Fabrik (J. F. Eisfeld G.m.b.H.) at Silberhutte/Anhalt during the period 7-12 June 1945. Persons interviewed: Director Schneider & Dr. Kirschener, Chemist.

G. Investigation of the Deutsche Pyrotechnische Fabrik at Kunigunde/Goslar on 12 July 1945. Person interviewed: Mr. Jacob Franzen.

H. Investigation of the Ranbskammer Versuchs Platz near Unterluss on 16 July 1945. Person interviewed: Oberst Hirsch

III. COLORED SMOKE COMPOSITIONS

A. General Introduction:

In Germany, development work on the production of colored smokes to be used as signals during daylight began at the time of the first World War. The first efforts were directed toward the use of colored vapors, e.g. violet iodine vapor, purple manganese fluoride vapor, brown nitrogen dioxide vapor, and green nitrsobenzene vapor (Source A). However, favorable results were not obtained and work in this direction was discontinued. A few experiments were also carried out with the idea of scattering colored dust clouds of inorganic or organic dyestuffs by means of small axial charges of explosive inserted in the containers. Negative results were again obtained, since the volume of smoke produced was far too small when compared with the volume of dyestuff necessary (Source A). This was particularly true of small pistol signals, where only a small space for dyestuff was available.

The first serviceable colored smoke compositions were devised by the Americans, at the end of the first World War. They consisted of mixtures of potassium chlorate, lactose and organic dyestuffs. The organic dyestuffs were vaporized by means of the heat evolved from the combustion of potassium chlorate and lactose. The vapors then condensed in the air to form large clouds consisting of finely divided particles of condensed dyestuff. These smoke signals suffered from the disadvantage (Source A) of using dyestuffs which were not particularly suited to the purpose. The dyes employed, e.g., indigo, paranitroaniline red, chrysoidin, etc., produced dull and impure colors. At distances of a few kilometers it was no longer possible to distinguish blue, red, and yellow colored smokes (Source A).

In order to improve the colors produced by smoke mixtures of this type, the DEFYFAG plant at Malchow carried out an extensive series of tests with new dyestuffs. The new dyes were suggested and furnished by the I.G. Farbenindustrie Research Staff at Ludwigshafen.

Only those dyestuffs which possessed relatively low vaporization temperatures and which were able to resist the process of vaporization without chemical change were tested. Promising results were obtained with dyes of the "Sudan" class. By means of a dye of this type, called "Sudanblau G", the first really usable German blue smoke composition was developed. The formula was as follows:

Blue Smoke Composition

Potassium chlorate	25%
Lactose	25%
Sudanblau G	37.5%
Kieselguhr	12.5%

The chemical formula of Sudanblau G, as well as those of the other dyestuffs mentioned in this report, are given in the appendix.

The Kieselguhr was added to the composition both in order to render it lighter and more porous and also in order to economize in the use of dyestuff (Sudanblau cost approximately thirty marks per kilogram and the replacement of 12.5% of it by means of the inexpensive kieselguhr was considered a very considerable economy) (Source A).

The above composition was used in the "Handrauchzeichen" or "Hand Smoke Signal", which consisted of a cylindrical paper case with a single smoke outlet in the base. The composition was simply tamped by hand into the container.

Green and violet colored smokes were also produced at the same time. Since there were no single green or violet dyes available for the purpose, mixtures of dyes were used. The formulae for the smoke compositions were as follows:

Green Smoke Composition

Potassium chlorate	28%
Lactose	25.0%
Auramine	31.7%
Sudanblau G	12.3%
Kieselguhr	3 %

Violet Smoke Composition

Potassium chlorate	25%
Lactose	22%
Rhodamine	44%
Sudanblau G	6%
Kieselguhr	3%

A very large number of tests were made in order to produce red and yellow smoke generators in an analagous manner, using pressed composition and a single smoke outlet in the signal container. Very poor results were obtained. Using yellow and red dyes of the "Sudan" class, in quantities occasionally as high as 60% of the total weight of composition, it was observed that the color of the smoke was red or yellow at the beginning of the evolution; however, after a short time, the color turned white.

By working in conjunction with the staff of I.G. Farben, it was finally found that the cause of the whitening of the smoke was the catalytic decomposition of the dyestuff vapors due to contact with hot carbonaceous residues (slag) formed by the combustion of the initially burned smoke composition (Source A). In the smoke generator which employed pressed composition with only a single smoke outlet, the vaporized dyestuffs always had to pass hot carbonaceous residues before reaching the open air. The yellow and red dyestuffs were not able to resist this treatment and were catalytically converted to colorless compounds.

Therefore, in order to develop satisfactory red and yellow colored smoke generators, a method of leading the smoke out into the open air without contacting the slag had to be developed. Two methods of accomplishing this task were devised: a) the use of loosely filled, granulated smoke composition, and b) the introduction of "sieve tubes" passing through the smoke generator from top to bottom, connected to the smoke outlets in the tops of the generators.

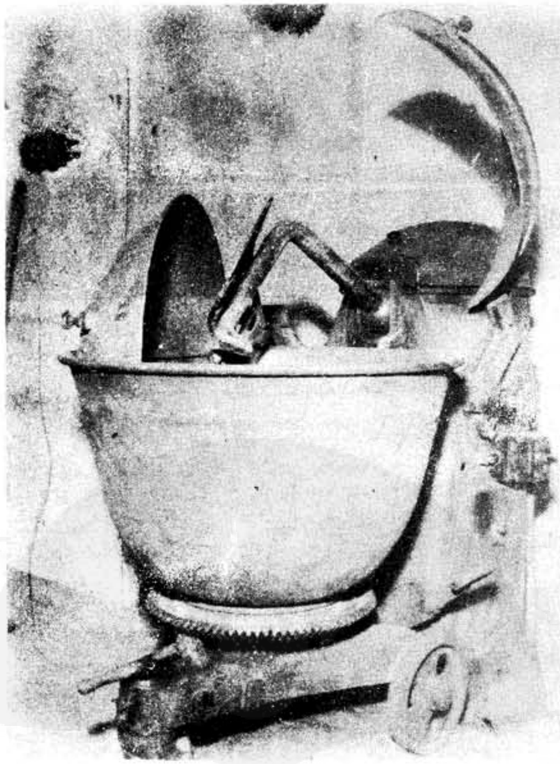
The first of these,ie. the use of granulated composition, proved to be quite valuable. The process of granulating the smoke composition involved mixing the composition in the presence of water with the addition of small amounts of either methyl cellulose or water glue binders. The compositions were mixed in apparatus which was quite similar to that shown below.

After mixing, the composition while still moist, was passed through an ordinary meat grinder equipped with a disc having holes 4 mm in diameter. The long strands of moist smoke composition obtained in this manner were dried at 30°C. As a result of the drying process, the strands disintegrated into small grains about 4mm in diameter and 8 mm in length. The loading of smoke generators with loose, granulated composition provided a larger volume of free space through which the smoke could pass without contacting the usual amount of hot slag.

It was with the aid of granulated smoke composition that the first successful German red smoke generator was produced. The composition was as follows:

<u>Red Smoke Composition</u>

Potassium chlorate	20%
Lactose	20%
Sudanrot G	55%
Kieselguhr	4%
Methyl cellulose	1%



MIXING EQUIPMENT

Several difficulties in the manufacture of generators containing this composition were encountered. The first was the very great effect of moisture upon the burning rate. In order to produce generators with a constant and reproducible burning time, it was found necessary to dry the composition very carefully, first at 30°C, and then in heated rooms, for approximately one week, in order to obtain a constant moisture content.

A second difficulty encountered in the production of all types of smoke generators was the inflammability of the colored smoke when it had reached the open air. In certain cases, merely the insertion of a glowing splint into the colored smoke stream sufficed to ignite the smoke and cause a flame which destroyed the color. According to actual measurements, the temperature of the smoke inside the generators ranged from 450° to 700°C. Therefore efforts were made to cool the smoke to some extent before it reached the open air. This was accomplished by means of the metal sieve tubes which were inserted into the granulated smoke composition. These acted in the same way as the well known miners safety lamp, in conducting heat away from the smoke. These sieve tubes also served to provide paths whereby the smoke could reach the open air without coming in contact with the hot slag in the interior of the generators.

Some experiments had also been carried out with ammonium perchlorate as the oxidant in place of potassium chlorate in order to reduce the tendency toward the production of flame (Source A). It was thought that the nitrogen which would be produced as the result of the combustion would act as an inert gas and prevent inflammation. However, it was reported that large quantities of hydrochloric acid were evolved by the reduction of the ammonium perchlorate. The hydrochloric acid together with the high temperature in the chamber caused the destruction of the color of the dyestuff (Source A) and rendered the use of ammonium perchlorate impracticable.

The use of granulated smoke composition in place of pressed composition was found to be useful for the production of other smoke signals with short burning times and high rates of smoke evolution. The large surface area and large burning surface of the granulated composition caused a very high rate of smoke evolution which could not be produced in any other way. Indeed, efforts to produce fast burning colored smoke compositions by means of increases in the potassium chlorate content had been tried, but were unsuccessful. Whenever the amount of potassium chlorate was increased to more than 35%, the color of the smoke became gray. This was found to be true for all colors (Source A) and was thought to be due to oxidation of the dyestuff by the increased quantities of potassium chlorate. This was further explained by the fact that all colored smoke compositions must contain a rather large excess of dyestuff. For example, red smoke compositions were said to become unusable when the content of dyestuff fell below 45%. Blue compositions were less sensitive, due to the great coloring strength of Sudanblau G; however, if the content of dyestuff fell below 35%, the color was said to become very weak also.

From the above discussion, it is apparent that the use of granulated composition was very important in the production of colored smoke generators, particularly those having a high rate of smoke evolution. A typical example of its usefulness was the development of a smoke generator containing 200 grams of composition in a volume of about 350 cc, having a burning time of from 2-5 seconds. This was said to have been impossible using ordinary pressed composition.

Some disadvantages which resulted from the use of granulated smoke composition were a) the rather long and involved manufacturing procedures and b) the fact that the amount of granulated smoke composition which could be placed in a given volume was not as large as the amount of pressed composition which could be inserted in the same volume.

For some types of smoke signals, the use of tableted, pressed composition was found to be more advantageous. The tablets were pressed in automatic tableting presses, and were formed as large cylinders whose outer diameters were equal to the inner diameters of the signal containers. The tablets usually possessed axial holes through which the sieve tubes of the smoke generators could pass.

The tableted compositions were quite similar to the usual compositions, and differed only in that talcum was used in place of kieselguhr. The talcum facilitated the pressing of the composition in the tableting presses.

In the last year of the war, the lactose necessary for the manufacture of smoke compositions became critical, and was therefore replaced partially by woodmeal. A typical composition employing woodmeal together with talcum is the following:

Tableted Orange Smoke Composition
Used for Rauchsichtzeichen Orange 80

Potassium chlorate	29%
Lactose	13%
Woodmeal	5%
Orange 1584	27%
Talcum	10%
Rauchorange	16%

Most of the violet smoke compositions contained Rhodamine B, which was rather strongly acid, and possessed a pH of approximately 2. Considerable anxiety was expressed concerning the use of this dyestuff in compositions containing potassium chlorate. A large number of tests were therefore carried out with a view toward the development of chlorate-free smoke compositions. At first, efforts were made to replace the potassium chlorate with ammonium perchlorate, then with potassium perchlorate, and finally with nitrates.

No detailed results of the effect of the substitution of ammonium perchlorate are available. However, it was stated (Source A) that the color of the smoke was either gray or white when ammonium perchlorate was employed, and it was supposed that the hydrochloric acid liberated by the ammonium perchlorate caused the decomposition of the dyestuff.

Compositions containing potassium perchlorate in place of potassium chlorate were unsuccessful because of greatly decreased ignitability, and also because there was not a sufficiently large variation in burning rate with changes in the composition (Source A). Compositions containing potassium nitrate exhibited the same faults as those containing potassium perchlorate, but to an even greater extent.

Mixtures of dyestuffs with black powder were also tried. It was thought that the black powder would behave in the same way as mixtures of potassium chlorate and lactose, and merely supply heat for the volatilization of the dye. However, it was found that the colored smokes obtained from mixtures of black powder and dyestuffs were always impure and not uniform in color.

Further efforts to develop chlorate-free smoke compositions were therefore discontinued.

In order to avoid the danger of self ignition of violet colored smoke compositions containing both potassium chlorate and the acidic Rhodamine B, the Rhodamine B was replaced by the weakly alkaline dyestuff, Rhodamine Base B Extra. However, the color of the violet smoke obtained as a result of the substitution was not as good as that produced by the original composition. It was stated (Source A) that tests to find a satisfactory dyestuff or mixture of dyestuffs for a violet smoke composition were still in progress, and had not been completed.

It was also stated (Sourve E) that yellow smoke compositions consisting of potassium chlorate, lactose, and auramine caused a considerable amount of difficulty due to heat evolution and self-ignition in the presence of moisture. The reason for this was not known definitely; but it was thought to be due to an initial reaction between auramine and lactose. It was reported (Source E) that the difficulty was eliminated by mixing the required amounts of lactose and auramine in the absence of potassium chlorate, and then storing this preliminary mixture for a period of approximately one week in order to allow the reaction to complete itself.

Yellow Smoke Puff Composition

This is an interesting example of a fast burning inorganic smoke composition. The composition was as follows:

Cadmium metal	19.3
Cadmium sulfide	20.1%
Zirconium	16.5%
Aluminum	4.0%
Barium nitrate	28.8%
Potassium perchlorate	7.3%
Synthetic resin	4.0%

This composition was loose loaded into the "Rauchballpatrone Gelb" or Yellow Smoke Puff Signal Cartridge. When the cartridge was fired, an inner container holding the smoke composition was expelled, and at the same time, a delay in its base ignited. When the container reached the apex of its trajectory, the smoke composition was ignited by means of an axial inner tube filled with balck powder. The color of the puff was produced by the yellow cadmium sulfide particles. Zirconium was used in order to confer a high degree of ignitability and a very rapid rate of explosion upon the composition.

B. Individual Colored Smoke Compositions

Note: All of the compositions given below have been taken from "Herstellungsberichten", or Reports of Manufacture of the J. F. Eisfeld Co, Source F.

1) Orange Smoke Recognition Signal No. 80 ("Rauchsichtzeichen Orange 80")

Tableted Composition (June 1944)

Smoke Composition:

Potassium chlorate	26%
Lactose	18%
Talcum	10%
Orange 1584	12%
Rauchorange	31%
Rauchgelb	3%

Igniter:

Quickmatch with	
Black powder (meal)	75%
Beechwood charcoal	25%

Tableting Pressure:

25000 kilograms per tablet

Tableted Composition (Nov 1944)

Smoke Composition:

Potassium chlorate	29%
Lactose	18%
Talcum	10%
Orange 1584	27%
Rauchorange	16%

Tableted with a force of 25000 kilograms per tablet.

Granulated Composition (Sept 1944)

Smoke Composition:

Potassium chlorate	20%

Lactose	15%
Woodmeal	5%
Sudanorange [illegible]	35%
Rauchgelb	24%
Methyl cellulose	1%

Mixed and granulated by means of water, and then dried at 35° C.

Tableted Composition (Jan 1945)

<u>Smoke Composition:</u>

Potassium chlorate	29%
Lactose	13%
Woodmeal	5%
Talcum	10%
Orange 1584	27%
Rauchorange	16%

<u>Ignition Composition:</u>

Black Powder	85%
Barium sulfate	15%

<u>Loading Pressure per Tablet:</u>

25000 kilograms

2) Orange Smoke Recognition Signal No. 160 ("Rauchsichtzeichen Orange 160")

Granulated Composition (Feb 1943)

Potassium chlorate	18%
Lactose	22%
Rauchgelb	27%
Orange 1584	32%
Methyl cellulose	1%

The above composition was eixed and granulated with water, and then dried at 35° C. The following ignition system was employed:

Quickmatch with	
Black powder (meal)	75%
Beech charcoal	25%

3) Orange Smoke Recognition Signal No. 350 ("Rauchsichtzeichen Orange 350")

Granulated Composition (Feb 1943)

Potassium chlorate	18%
Lactose	22%
Rauchgelb	24%
Orange 1584	35%
Methyl cellulose	1%

Granulated Composition (Mar 1944)

Potassium chlorate	20%
Lactose	15%
Woodmeal	5%
Sudanorange RLEW	35%
Rauchgelb	24%
Methyl cellulose	1%

The above compositions were mixed and granulated with the aid of water, and dried at 35° C.

Tableted Composition (Oct 1944)

Potassium chlorate	33%
Lactose	18%
Kieselguhr	3%
Orange 1584	12%
Rauchorange	31%
Rauchgelb	3%

Tableting pressure 25,000 kilograms per tablet.

4) Hand Smoke Signal, Green
("Handrauchzeichen grun")

Hand Pressed Composition (1940)

Potassium chlorate	22.66%
Lactose	28.10%
Auramin O	31.04%
Sudanblau	12.30%
Kieselguhr	5.90%

Note: Although the above composition, and also Nos. 5,6,7 and 8 below, are listed without any binders, they were usually granulated with the aid of water and a water soluble glue known as "Glutofix". After granulation they were dried at 35°C, and then pounded by hand into the containers.

5) Hand Smoke Signal, Violet
("Handrauchzeichen Violett")

Hand Pressed Composition (1940)

Potassium chlorate	26%
Lactose	54%
Sudanblau G	7%
Rhodamine Base B Extra	10%
Kieselguhr	3%

6) Hand Smoke Signal, Red
("Handrauchzeichen Rot")

Hand Pressed Composition (1940)

Potassium chlorate	22%
Lactose	18%
Sudanrot G	55%
Kieselguhr	5%

7) Hand Smoke Signal, Blue
("Handrauchzeichen Blau")

Hand Pressed Composition (1939)

Potassium chlorate	25.5%
Lactose	22.1%
Sudanblau	38.7%
Indigo	13.7%

8) Hand Smoke Signal, Yellow
("Handrauchzeichen, Gelb")

Hand Pressed Composition

Potassium chlorate	22%
Lactose	23%
Sudangelb R	50%
Kieselguhr	5%

9) Message Container, Air-Land, with Yellow Smoke Trace
("Meldebuchse Land")

Pressed Composition (Apr 1943)

Potassium chlorate	30.8%
Lactose	24.0%
Auramine O	32.5%
Rhodamine B) 20% dye 80% dextrin	8.7%
Stearic Acid	4.0%

Pressed Composition (Jun 1936)

Potassium chlorate	29.0%
Lactose	18.7%
Sudangelb	13.3%
Auramine	29.7%
Chrysoidine	9.3%

The above compositions were pressed into the containers by means of hydraulic presses, using a force of 25,000 kg.

10) Aircraft Smoke Signal, Red ("Abwurfrauchzeichen Rot")

Two granulated compositions were employed in the filling of this device (1939):

	Composition No. 2	Composition No. 1
Potassium chlorate	18%	24%
Lactose	21%	23%
Sudanrot G	55%	48%
Kieselguhr	5%	4%
Methyl Cellulose	1%	1%

The above compositions were mixed and granulated with the aid of water-alcohol mixture, and then dried at 30°C. The loading of the generator was as follows:

a) Chamber No. 3 (Lower): 155 g of Comp. No. 2
b) Chamber No 2 : 155 g of Comp. No. 2
c) Chamber No. 1 (Upper): 200 g of Comp. No. 2
d) " 60 g of Comp. No. 1
e) " 10 g of Comp. No. 1

The compositions employed in steps a, b,c, and d were pressed with a force of 1000 kilograms.

11) Aircraft Smoke Signal Violet ("Abwurfrauchzeichen, Violett")

Two granulated compositions were employed in the same manner as has been described for the "Hand Smoke Generator Red", except that 90 g of Comp. No. 2 and 100 g of Comp. No. 1 were used in the upper chamber.

Smoke Compositions

	Composition No. 2	Composition No. 1
Potassium chlorate	19	30
Lactose	54	49
Rhodamine Base	12%	10%
Sudanblau G	9	7%
Kieselguhr	5%	3%
Methyl cellulose	1%	1%

12) Aircraft Smoke Signal, Blue
("Abwurfrauchzeichen Blau")

In the manufacture of this device in 1941, four separate chambers were loaded in each signal. The lower three chambers were filled with Composition No. 1. The upper chamber was filled with two layers: a layer of 150 grams of Comp. No. 1, and a top layer of 100 grams of Comp. No. 2. A loading force of 2.5 tons was used. The compositions were as follows:

Composition No. 2

Potassium chlorate	26%
Lactose	25%
Sudanblau G	43%
Kieselguhr	5%
Methyl cellulose	1%

This composition was mixed and granulated with the aid of water. The particles were formed by passage through a meat grinder having holes 5 mm in diameter.

Composition No. 1

This was a mixture of two separate compositions:

<u>Part A</u>:

Comp. No. 2 (described above, but reduced in particle size by passage through a sieve having 9 mesh per sq. cm) 77.5%

<u>Part B</u>:

Sudanblau G 80%)
Methyl cellulose 20%) 22.5%

Part B of Composition No. 1 was mixed and granulated with the aid of water and passed through a sieve having 9 mesh per sq. cm.

13) Aircraft Landing Smoke Signal ("Landungsrauchzeichen")

Igniter:

Barium nitrate	67.5%
Sulphur	9.5%
Black powder (meal)	15.0%
Charcoal	5.0%
Methyl Cellulose	3.0%

Smoke Composition:

Rhodamine B 80% dextrin) 20% dye)	9.1%
Auramine O	34.3%
Lactose	24.2%
Potassium chlorate	32.4%

This composition was pressed using a force of 25,000 kilograms for each container.

14) Violet Smoke Parachute Signal Cartridge ("Fallschirmranchpatrone Violett")

Igniter:

Black powder (meal)	65.0%
Potassium nitrate	11.0%
Barium nitrate	17.3%
Sulphur	5.9%
Glutofix (Water Soluble Glue)	0.8%

Smoke Composition:

Potassium chlorate	26%
Lactose	40%
Kieselguhr or talcum	10%
Sudanblau G	9%
Rhodamine Base B Extra	15%

The above composition was pressed into the smoke container using a force of 5000 kilograms.

15) Smoke Trace Signal Cartridge, Red ("Rauchspurpatrone rot")

Smoke Composition:

Sudanrot	32.5%

Paratoner B	29.1%
Lactose	13.8%
Potassium chlorate	24.6%

The above composition was mixed and granulated with the aid of a fluid binder known as "Zapponbindemittel". The nature of this substance is not known.

The granulated composition was loose loaded into the signal container.

16) Smoke Trace Signal Cartridge, Blue ("Rauchspurpatrone, Blau")

Smoke Composition:

Sudanblau G	35-40%
Indigo	12-14%
Lactose	14-18%
Potassium chlorate	32-35%
Glutofix (Water Soluble Binder)	0.5-1%

17) Smoke Trace Signal Cartridge, Yellow ("Rauchspurpatrone" Gelb)

Smoke Composition:

Chrysoidine
Auramine
Sudangelb
Potassium Chlorate
Lactose

This composition was granulated by means of water and the addition of 1% of a water soluble binder, or by means of "Zapponbindemittel".

18) Blue Smoke Indicating Trace Signal Cartridge for Rifled Flare Pistol ("Leutpatrone Z mit blauem Rauch")

Smoke Composition:

Potassium chlorate	30%
Lactose	20%
Sudanblau G	50%

This composition was pressed into the signal case with a loading pressure of 500 kg/sq cm.

19) Yellow Smoke Trace Indicating Signal Cartridge for Rifled Flare Pistol
("Deutpatrone Z mit gelbern Rauch")

Smoke Composition:

Potassium chlorate	25.5%
Lactose	21.5%
Sudanorange R	36.0%
Auramine II	17.0%

A loading pressure of 500 kg/sq cm was employed to load the composition.

20) Smoke Cluster Signal Cartridge, Red
("Rauchbundelpatrone, Rot")

Smoke Composition:

Potassium chlorate	17%
Lactose	10%
Nitrocellulose (12% N)	12%
Kieselguhr	15%
Sudanrot	34%
Rhodamine	12%

21) Smoke Cluster Signal Cartridge, Blue
("Rauchbundelpatrone, Blau")

Smoke Composition:

Potassium chlorate	22%
Lactose	12%
Nitrocellulose (12% N)	6%
Kieselguhr	15%
Sudanblau	33%
Indigo	12%

This composition was mixed dry by hand, and was then moistened with a two percent glue solution (200 cc per kilogram). The composition was then pressed into ring pellets, with a loading force of 1000 kilograms, while still moist. The pellets were dried at 30 to 50°C for two to four days. Moist igniter composition was then applied on both sides of the pellet, which was again dried.

IV. PYROTECHNIC WHITE SMOKE COMPOSITIONS

According to Source F, it had been found that the smoke produced by burning phosphorous possessed the greatest density, and hiding power of any white smoke composition evolved by a pyrotechnic reaction.

phosphorous smokes were said to be followed in efficiency by the smokes produced by the so called "Berger Mixtures", which consisted of zinc dust with chlorinated hydrocarbons.

Phosphorous was rather widely used for the production of white smoke puffs in artillery shell. For this purpose red phosphorous, phlegmatized with about ten percent of paraffin, was loaded into cylindrical tubes which were then placed in the shell with the H.E. charge. When the shell exploded, a white puff of smoke, due to phosphorous pentoxide, was formed.

One of the more important white smoke signal devices, employing a Berger Mixture was the "Nebelkerzen 39B", or "Smoke Candle 39B". This was not a candle, but consisted of a cylindrical metal container holding a single large cylindrical block of smoke compositions. This device has been described in F.A. Technical Report. The following composition was employed when the device was first manufactured (Source G).

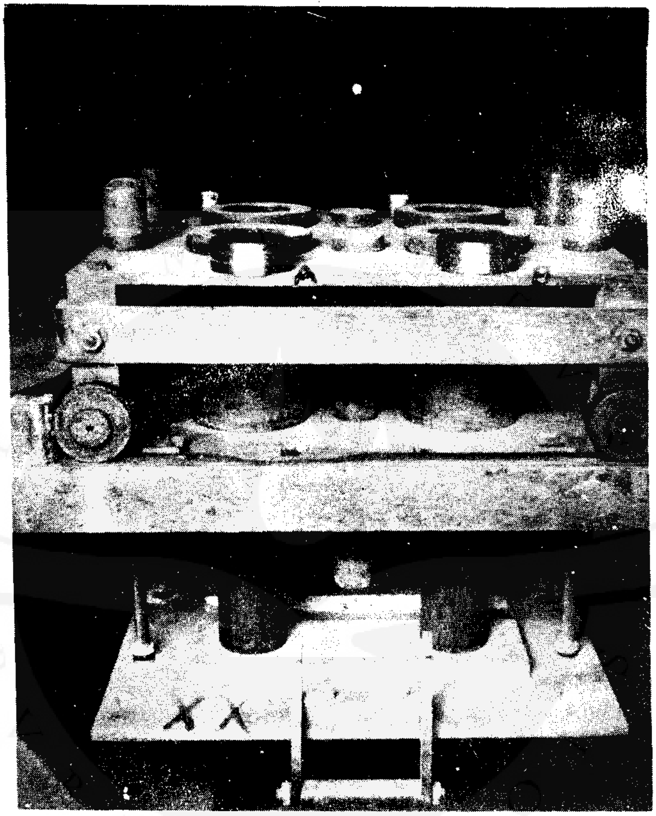
Hexachlorethane	57%
Zinc dust	42%
Magnesium powder	1%

The magnesium powder was added in order to increase the ignitability of the composition. However, due to a subsequent shortage of magnesium, efforts were made to conserve as much as possible, and barium nitrate was then employed in place of it. The following composition was the one which was being employed at the time of the cessation of hostilities:

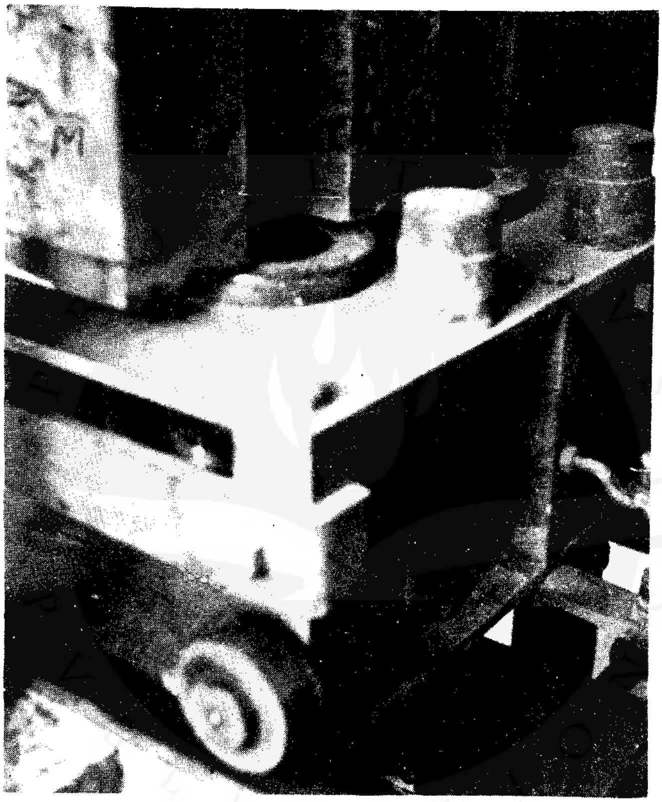
Zinc dust	44%
Hexachlorethane	55%
Barium nitrate	1%

It was recognized that this composition was quite unstable and possessed a tendency toward self-ignition in the presence of moisture (Source G). On several occasions, when loose composition was allowed to stand in very humid atmospheres, the composition became very hot (Source G). An entire storage magazine containing thousands of these generators was completely burned because rain fell upon a few generators and penetrated to the composition. After this occurence, very great care was taken in order to protect the composition from moisture. The generators were therefore always packed and shipped in carefully sealed boxes which were equipped with rubber gaskets.

The method used to press the cylindrical block of composition for this generator is quite interesting. The composition was pressed directly in a steel mold without any paper liner. Photographs of the mold and press which were used at the DEPYFAG plant at Kunigunde, (Source G), are shown below.



MOLD USED TO PRESS CYLINDRICAL BLOCKS
OF SMOKE COMPOSITION FOR NEBELKERZEN 39B



MOLD INSIDE PRESS SHOWING LATERALLY
SLIDING BLOCKS (M, N, O) WHICH MAY BE
SLID INTO POSITION OVER OPENINGS IN MOLD

The mold consists of a steel frame which rides on rollers leading directly into the press. There are four cylindrical cavities for the smoke composition. In the base of each of the four cavities there is fitted a steel ram (see attached photograph). The four rams are all attached to the same base plate XX. These rams rise into the cavities when the base plate is pushed upward. The actual pressing operation involved placing the loose composition into the cavities, placing the steel discs A, B, C and D on top of the loose composition, rolling the mold into the press, laterally sliding the steel blocks into position so that they covered the filled cavities, and then allowing the main ram of the press to rise and press against the base plate XX. In order to remove the pressed blocks of smoke composition from the mold, all that was necessary was to move the steel blocks laterally a few inches to the position shown in the photograph, and then allow the main press ram to rise and press against the base plate XX. The frame of the mold was held in position, and the blocks of smoke composition were forced upward and outward by the rising rams and base plate.

The white smoke composition used in the "Rauchballpatrone Weiss" or "White Smoke Puff Signal Cartridge" was as follows (Source F):

Black powder (meal)	60%
Zinc dust	40%

This composition was loose loaded into an inner metal container which was placed inside the outer case of the signal cartridge. When the cartridge was fired, the inner container was expelled, and a delay in its base ignited. When the delay burned through, the flame was communicated to a strand of quickmatch which passed axially through the loose smoke composition. The loose composition then exploded, producing a puff of white smoke.

V. BLACK SMOKE COMPOSITIONS

Only two examples of the use of black smoke compositions have been found. The first involved the use of large numbers of pellets which were placed in the 15 cm RSSG Anti-Pathfinder Rocket, see CIOS Report "German Pyrotechnic Anti-Pathfinder Devices". The pellets which were employed possessed the following compositions:

Igniter:

Black powder

Intermediate:

Potassium nitrate	24.0%
Hexachlorethane	24.6%

Tetranitrocarbazol	18.0%
Anthracene	5.6%
Naphthalene	2.4%
Aluminum powder	18.0%
Magnesium powder	7.4%

Black Smoke Composition

Hexachlorethane	61.5%
Magnesium	18.5%
Anthracene	8.0%
Naphthalene	12.0%

The pellets employing the above compositions were pressed directly in steel molds without any paper liners.

The second example of the use of a black smoke composition was in a generator employing the following composition (Source A):

Anthracene	60%
Potassium chlorate	38%
Kieselguhr	2%

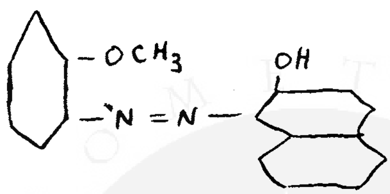
Information concerning the manner in which this composition was loaded into the generator was not available. However, it was stated (Source H) that samples of the generators had been removed by the British C.D.E.S. at Porton.

APPENDIX "A"

THE CHEMICAL CONSTITUTIONS OF THE DYESTUFFS EMPLOYED IN COLORED SMOKE COMPOSITIONS

A) <u>Sudanrot G</u>

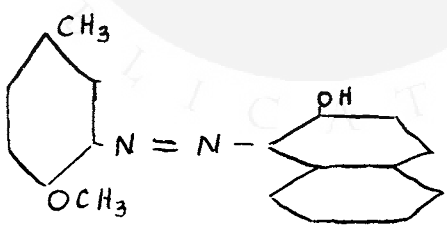
This was an azo dye, manufactured by coupling o-anisidine with beta naphthol, (Source B). The formula is as follows:



SUDANROT "G"

B) <u>Sudanrot R</u>

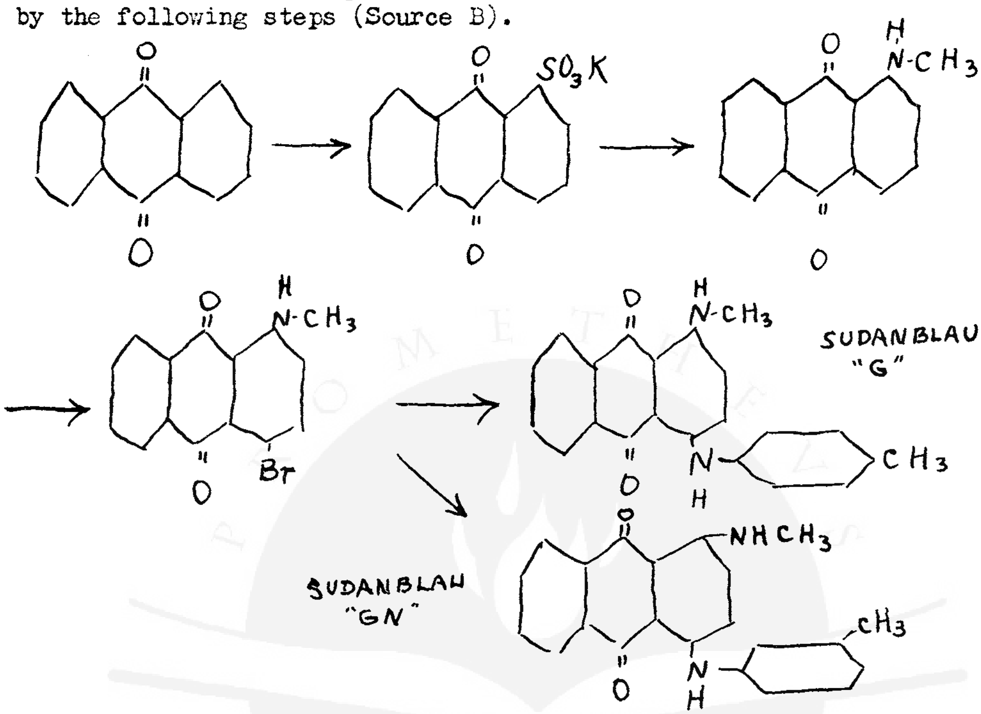
This was also an azo dye manufactured by coupling 3 amino, 4 methoxy toluene with beta naphthol. Its formula is as follows; (Source D):



SUDANROT "R"

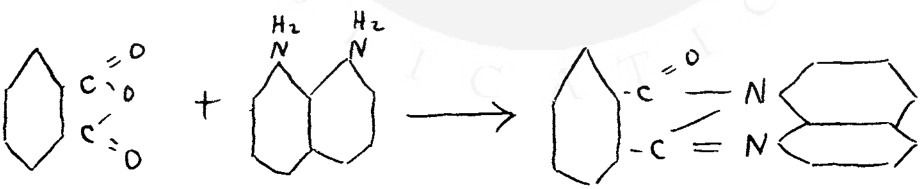
C) <u>Sudanblau G, Sudanblau GN</u>

These were anthraquinone derivatives, which were synthesized by the following steps (Source B).



<u>Orange 1584</u>

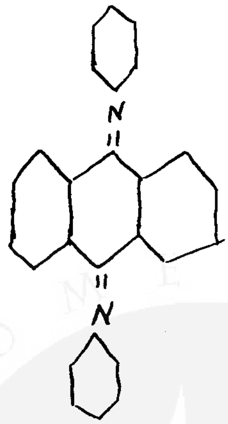
This dyestuff (phthaloperinone) was the result of condensing 52 parts of phthalic anhydride with 57 parts of 1,8 naphthylene diamine (Source D):



ORANGE 1584

Rauchgelb

This dyestuff (9,10 dianilido anthracene) was prepared by heating aniline and anthraquinone. It possessed the following formula (Source D):

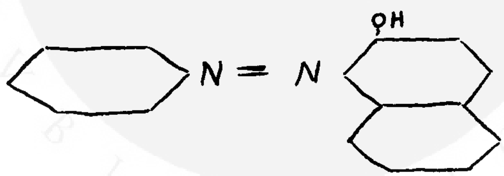


RAUCHGELB

Sudan Orange RLEW

Sudan Orange R

These were exactly the same substance, namely, an azo dye prepared by coupling aniline with beta naphthol (Source C):

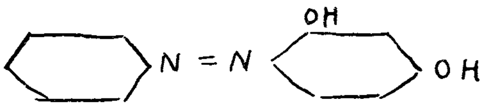


SUDAN ORANGE R

SUDAN ORANGE RLEW

Sudangelb GG

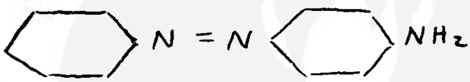
This was an azo dye with a structure similar to sudan orange. However, resorcinol was employed in place of beta naphthol (Source D):



SUDANGELB "GG"

Rauchgelb R:

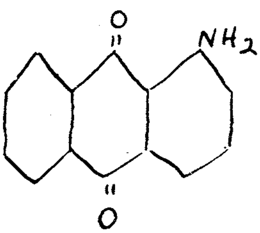
This was simply aminoazobenzene, (Sources C and D):



RAUCHGELB "R"

Rauchorange G:

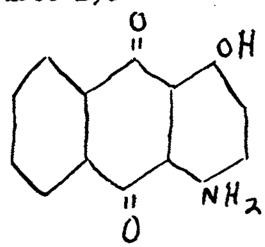
This substance was manufactured in large quantities as an intermediate in the manufacture of other dyestuffs (Sources B and C). However, it is not known whether "Rauchorange" was the same substance as "Rauchorange G". The formula for "Rauchorange" is therefore not known with certainty: that of "Rauchorange G" is as follows:



RAUCHORANGE "G"

Rauchbordeau BN

This dyestuff was an anthraquinone derivative having the following formula (Source B):



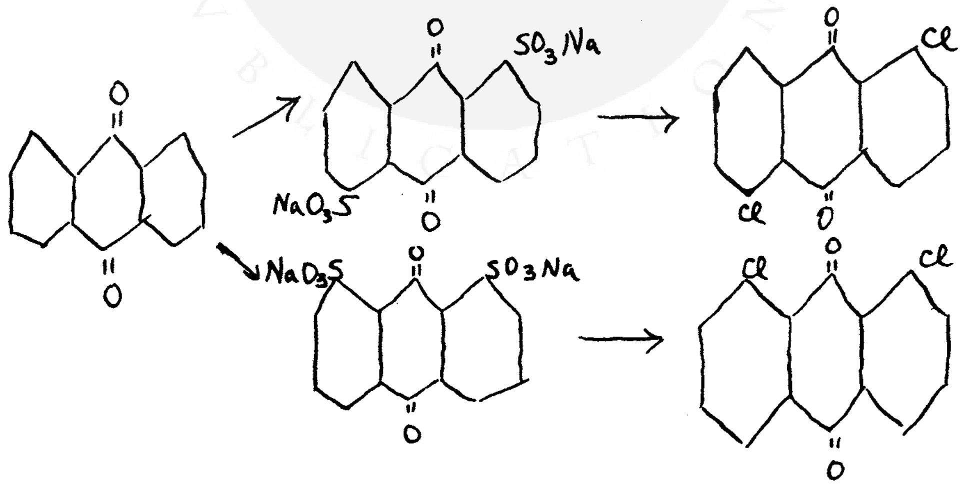
RAUCHBORDEAU "BN"

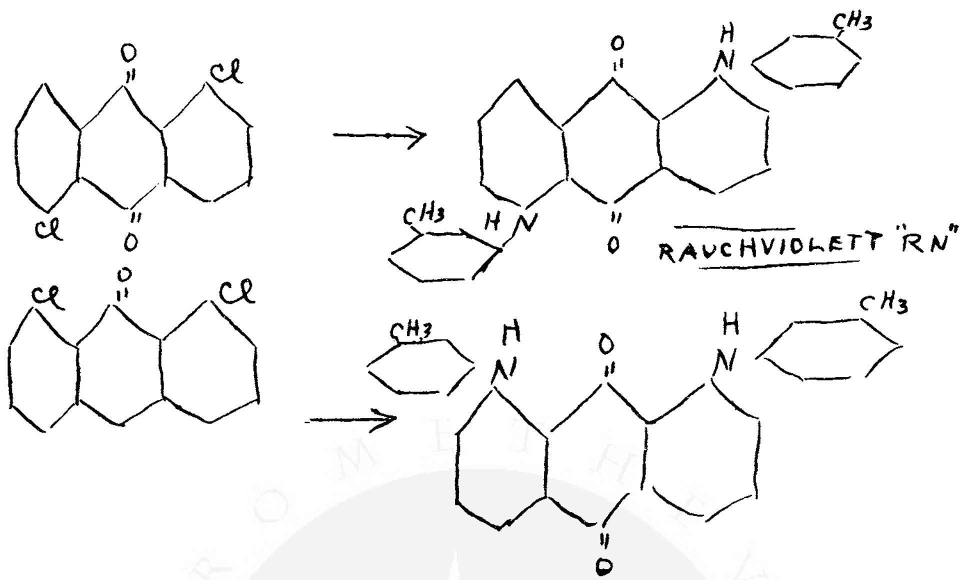
RHODAMINE B
AURAMINE
RHODAMINE BASE B EXTRA
LITHOL ECHT GELB
PARATONER B

These are all well known dyes whose structures are to be found in the standard treatises dealing with dyestuffs.

Rauchviolett RN

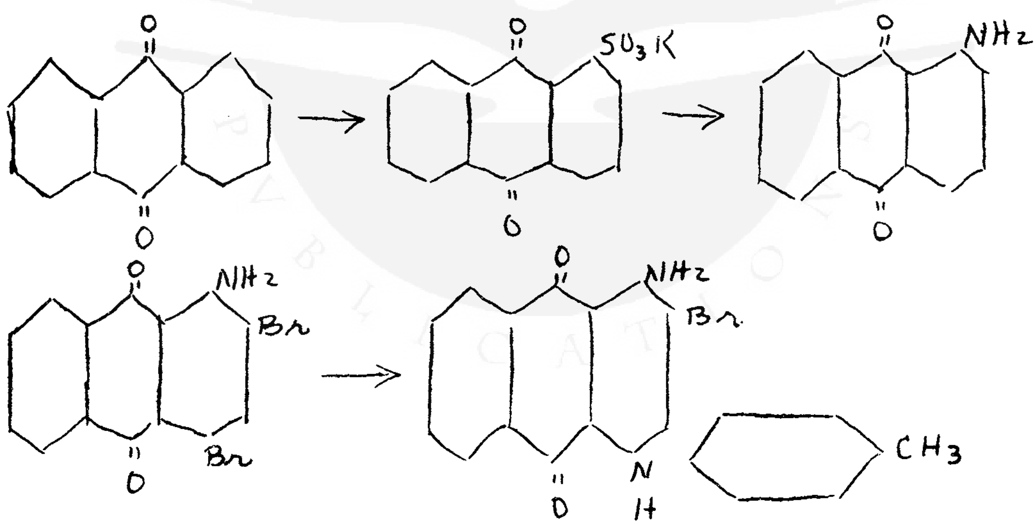
This dyestuff was a mixture of two substances which were prepared from anthraquinone by the following reactions (Source B):





Rauchblau R

This substance was produced only experimentally. The total quantity which was manufactured was only one hundred kilograms. The synthesis of the dye from anthraquinone was as follows. (Source B):



RAUCHBLAU "R"