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Letter
Circular

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CARBON PAPER AND TYPEWRITER RIBBONS

This letter circular has been written to give some general information on the manufacture of carbon paper and typewriter ribbons, and to describe the methods of testing in greater detail than is possible in an ordinary letter. By following the instructions, any careful person can make comparative tests of samples of different brands, and will then be able to form his own opinion as to their relative merits.

The National Bureau of Standards often receives letters that ask for information about carbon paper and typewriter ribbons. Some of the writers want to be told what brands are the best to buy. The Bureau can not possibly keep fully informed about the relative merits of all the brands of carbon paper and ribbons that are on the market. To say that any given brand of either material is the best might be untrue, because the statement would be based upon incomplete information. Correspondents who ask to be told what to buy are advised to do their own testing and to decide for themselves.

General

Very little published information on the manufacture of carbon and typewriter ribbons can be found. This is especially true of formulas for the ink used on the ribbons, and for the coating (also called "ink" by the manufacturer) on the paper. The books of formulas that are in every public library tell how to make these materials. The reader is told to mix the ingredients, though mixing alone will not make a satisfactory product. It is essential to grind the materials together in a suitable mill. The reason for thorough grinding is to disperse the particles of pigment, or solid coloring matter, throughout the vehicle, or more or less liquid part, of the ink. Fine-grained as it looks, carbon black is made up of clumps of much finer particles clinging together. This formation of clumps of particles is familiarly called "snowballing". Grinding the ink mixture separates the particles from one another, and coats them with the vehicle, so that new clumps will not be formed. Mixing by stirring will not break up the clumps, nor is this easy to accomplish by hand-grinding with a mortar and pestle. A single trial will be convincing. If the mixture is rather fluid, the motion of the pestle will do little more than make the ink swirl around in the mortar, and many of the clumps escape being broken up. If the mixture is somewhat stiff in consistency, it tends to become spread all over the interior of the mortar and on the stem of the pestle, and again many of the clumps remain intact. If by dint of persistent grinding, some patient person overcomes these difficulties and succeeds in making a proper ink or coating, he is then confronted with the problem of spreading it by hand, uniformly and in the right quantity, upon the fabric or the paper tissue. It is safe to say that the finished product, whether a ribbon or a sheet of carbon paper, will not be equal in quality to the cheapest kind that can be bought. Some things can be done better by machine than by hand.

Manufacture and Properties of Carbon Paper

The directions for making carbon paper, given in the books of formulas that have been referred to, are evidently for pencil carbon coating, and not for the relatively hard coating generally used for typewriting. Instead of any of these formulas, one found in a German chemical journal will be copied. (See B. Walther, Chemiker-Zeitung <u>45</u>, 287-288 (1921)). It is given partly for the reason that it is the only one which calls for grinding, instead of simply mixing, and partly because it is typical of the published formulas. All parts are by weight.

> Grind 10 parts of carbon black with 40 parts of paraffin oil or other mineral oil. Add 1 2/3 parts of nigrosine base dissolved in 3 1/3 parts of oleic acid; and finally add 40 parts of paraffin or ceresin dissolved in 30 parts of oil at 40° to 50°C (104° to 122°F). Grind again and spread at 40° to 50°C.

The large proportion of oil and the absence of carnauba wax and other waxes that are harder than ceresin show that this formula will make a relatively soft coating, and not the usual hard coating that is customary for typewriting. The degree of hardness of a coating made according to this formula will depend upon the softness (as measured by its melting point) of the paraffin, or whether paraffin or ceresin is used. The viscosity of the oil will also have some effect upon the hardness.

Each manufacturer makes paper with hard, medium, and soft coatings, and with different surface finishes, as glossy and mat or dull. There are no generally recognized standards for the degrees of hardness, but each manufacturer has his own. Some manufacturers by changing the formula step by step produce a greater number of grades than are generally recognized by the trade.

The hardness and surface finish of the carbon paper to a great extent determine its suitability for a given class of work, though there are several other factors that affect the results.

Among these are the thickness and stiffness of the first and copy sheets, the thickness of the carbon paper, the number of manifold copies to be made, the size of the type, the characteristics of the typewriting machine, and the touch of the operator. If only one to three manifold carbon copies are to be made at one time, a hard finish is best, because it gives sharper copies, wears off more slowly, and has less of a tendency to smudge than the softer finishes. On the other hand, if a large number of copies must be made at one time, and the blow of the type will have to be transmitted through many layers of paper, carbon paper with a soft coating is needed. Because there is no convenient, accurate method for measuring the hardness of the coating on carbon paper, the best way to ascertain its suitability for a particular class of work is to make the writing tests described further on.

In the preceding paragraph it was said that one of the factors that have an effect upon the copying qualities is the thickness of the carbon paper. In practice the thickness is stated in terms of the weight of the uncoated paper tissue. This is expressed as the weight of 500 sheets, 20 by 30 inches. For instance, if a box of carbon paper is marked "4-lb" it means that the uncoated paper is supposed to weigh 4 pounds per 500 sheets of the size 20 by 30 inches. Actually the paper is rarely so light in weight as this, but is more apt to weigh from 4.3 to 4.8 pounds, or even a little more. Seldom indeed is the weight below 4 pounds, though the Bureau has a record of 3.6 pounds for one sample. The tissue of the numerous grades of carbon paper intended for different uses ranges in weight from these so-called "4-lb" papers up to about 18 pounds, which is the weight of pencil carbon.

The 4-pound and other light papers are generally made of linen or other similar fibers in order to secure the desired high quality of coating and the necessary compactness and strength. The heavier papers are composed wholly or in part of wood fibers. For this reason, and because they are easier to make, the relatively heavy tissues are cheaper than the lighter ones.

The machine for coating the paper has a series of rolls that pick up a supply of the melted mixture from a reservoir, distribute it uniformly, and apply it to the paper. Some of the rolls must be hot, but the others can be heated or cooled as desired. The machine is capable of close adjustment to control the amount of coating, and to apply it uniformly across the width of the long roll of paper, and from one end to the other. The production of well-coated carbon paper requires more than the mere possession of a good working formula. Skill and experience on the part of the operator are equally necessary.

The finished carbon paper is cut to the desired sizes and packed.

Manufacture of Typewriter Ribbons

Walther, whose formula for carbon paper has already been given, discusses typewriter ribbon inks on pages 169 to 171 of the same volume of the chemical journal referred to. His formula for black ink is, in parts by weight:

> Grind together 10 parts of carbon black and 40 parts of petrolatum. Add 1 2/3 parts of nigrosine base dissolved in 3 1/3 parts of oleic acid, and again grind.

For colored ribbons, various dye lakes and other pigments are used instead of carbon black. Of course the nigrosine dye is omitted, but sometimes other oil-soluble dyes are used in its place. Copying ribbons contain water-soluble dyes which, in spite of the oil vehicle, dissolve sufficiently to make copies in a letter-press. Although they have bright colors when dissolved in water, many dyes are dark brown powders which can be mixed readily with carbon black and other dark pigments.

The fabric of which ribbons are made is almost always cotton, though a few silk ribbons are made. It is woven in lengths of several hundred yards, and is about 42 inches wide. Before being inked it is put through a finishing process, and is then cut into strips of the width required for the ribbons. The edges are gummed to prevent fraying. Some special ribbons are woven to the required width, so their edges are not gummed.

The thickness of the fabric is in the neighborhood of 0.005 inch. It is rarely below this value, and 0.0055 inch is perhaps a fair average. In selling ribbons the thickness is not made much of, but the thread count is stressed. This is the number of threads per inch. Sometimes the numbers of warp and filling threads are given separately, for instance: warp, 152, filling, 150. Perhaps because it makes the fabric seem more finely woven, many prefer to add the two figures and to say that the thread count is 302. On the latter basis, possibly the highest count ever found by this Bureau was 321, there having been 165 warp and 156 filling threads to the inch. This is in marked contrast with a count of 231, or 116 and 115, respectively, which represents almost the other extreme for a ribbon with cut and gummed edges. Ribbons with selvages commonly have a filling count as low as 110.

In theory, if not in practice, it is best for the two counts to be nearly alike. The argument is that when the ink is exhausted to such an extent that the impressions made on paper are not continuous lines but series of dots, the writing will look less spotty if the counts are nearly equal, than if they differ by 20 or 30 threads to the inch.

The inking machine has a series of rolls, adjusted to apply uniformly the right quantity of ink. Aside from the manufacturer's ideas, whether a ribbon has light, medium, or heavy inking depends upon the amount of ink applied to the fabric, the fluidity of the ink, and the characteristics of the fabric. After the inking operation, the long strip of fabric is measured and cut into lengths by machine. The metal parts are attached to the ends of the ribbon, and it is then wound upon a spool, wrapped and boxed.

Brief accounts of the manufacture of carbon paper and ribbons are given by C. A. Mitchell and T. C. Ainsworth in their book, Inks, Their Composition and Manufacture (Chas. Griffin & Co., Ltd., London). Those who read German and can get hold of the book will find something about typewriter ribbons under the heading "Schreibmaschinenfarben" in the article "Tinte", in F. Ullmann's Enzyklopaedie der technischen Chemie, 2nd ed., 10, 9-11 (Urban & Schwarzenberg, Berlin and Vienna, 1932). In Chemical Abstracts there are a few scattered references to patents or published articles. See also C. J. West, Bibliography of Paper Making (Lockwood Trade Journal Co., Inc., New York), for references on carbon paper.

Testing Carbon Paper

The ordinary user makes only one, or maybe two or three, carbon copies of what he writes. If he wishes to get as much use as possible from each sheet of his carbon paper, he can make serviceability or wear-down tests of a number of brands, and decide for himself which is the best to buy. For those who make six, eight, or more carbon copies at a time, the manifolding test will show which of a number of carbon papers should give the best results. Because the sharpness and legibility of the carbon copies are affected by the thickness and stiffness of the first and copy sheets, as well as by the other factors mentioned on pages 2 and 3, all tests should be made as nearly as possible under the conditions of actual service.

Serviceability Test.- The serviceability, or wear-down, test is made as follows: From a new sheet of carbon paper cut a piece about 1 by 2 inches and, by means of a strip of gummed paper across each end, fasten it with the coated side out to a sheet of the letter paper with which it is to be used. Place this, together with a sheet of the usual copy paper, in the typewriter. Then by means of paper clips, pins, or in some other way, fasten the first sheet to the back of the carriage, so that the first sheet carrying the sample will not move when the platen, or roller, is turned to shift the copy sheet from one line to the next. Before starting to write, give the platen a slight turn so as to pull the first sheet taut.

Now write the letter g, or any other letter with small loops, 10 or 12 times. Use the same light, uniform touch for this and all the lines that follow. Shift the copy sheet a line by turning the platen, and write the same number of g's over the same place as before. Repeat this until 15 or 20 lines have been written, and then examine the copy sheet. The lines should gradually grow paler, from one line to the next. The more lines of reasonably good intensity of color, the better the serviceability of the sample. Sometimes the first sheet carrying the carbon paper moves a very little during the test, or the machine may be worn, so that the type-bar has a little play and the type does not always hit in exactly the same place. If, for instance, the carbon paper shifts a little to the right, each g will have its lines blacker at the left. If the type hits to the right, the black edges will be at the right. In either case the reason is that a narrow band of the carbon coating that has not been hit by the type now contributes to the blackness of the letter. It is not easy to fasten the first sheet so securely that there will be absolutely no shifting. The presence of black edges to the g's should not mislead the person who is making the test.

If a sample of carbon paper makes, say, 15 good copies in the wear-down test, it should be possible to use a sheet of it more than that number of times in actual service. When the sheet is put in the machine the second and succeeding times, it is always in a slightly different position with respect to the type. Also, each time the sheet is used the words are different. As a result, when a sheet of carbon paper is finally worn out, comparatively little of its surface has escaped doing its share of the work. It is then very different in appearance from the exhausted test piece, which shows the g's as transparencies.

Manifolding Test.- Sometimes it is necessary to make 6, 8 or even as many as 12 or 15 carbon copies at one time. This can be done with a good grade of very thin carbon paper, together with thin first and copy sheets, and preferably pica type, instead of the smaller elite. To find out which of a number of samples of carbon paper will give the best copies, a manifolding test is made as follows: Assemble in the usual way an ordinary first sheet and 5 copy sheets, each with a sheet of the carbon paper, and insert in the typewriter. Then write, in unrelated order and twice over, all the capitals, small letters and numerals. The stroke should be rather heavy, but as uniform as possible. The fifth copy sheet is then examined. Obviously if the numerals are not all readable, the copy is not satisfactory. On the other hand, a tolerance of 5 illegible letters among the total of 104 is reasonable. The reason is that words and sentences can be read even when a considerable number of the letters are so badly blurred that they can not be recognized. This is shown by the sentence below, in which a hyphen takes the place of every sixth letter (17 in 104), and which would be still easier to read if there were blurred letters, some low and others tall, to give the readers clues. For instance the shape of the blur would show whether -een is <u>b</u>een or <u>s</u>een.

> Manuf-cture-s of ca-bon pa-er, who-e opin-on has -een as-ed, agr-e that -he leg-bilit- test h-re des-ribed -s more -evere -han a t-st in w-ich mo-e copi-s are m-de, but -n whic- words -r a sho-t sent-nce is -ritte-.

<u>Pencil carbon</u>.- Pencil carbon paper is tested very simply. A piece of it is laid, coated side down, near the top of a sheet of white paper, and a short word is written on it with a well-sharpened hard pencil. The carbon paper is shifted half an inch, and the word is again written, making the pencil follow exactly the strokes of the first writing. This is done until the word has been written 20 times. If the writer does not bear too heavily upon the pencil, good carbon paper will make 20 legible copies.

<u>Fiber Composition and Weight</u>.- The determination of the fiber composition and weight of the paper tissue can not be made without laboratory facilities, but fortunately they do not have such a direct bearing upon the writing qualities of the paper as the tests that have been described. The coating must first be removed with benzene (benzol) or other suitable solvent, aided by gentle scrubbing. An apparatus for removing the coating was devised by the Bureau. (See Paper Trade J. <u>80</u>, 53 (Mar. 19, 1925); <u>95</u>, 34 (Oct. 20, 1932)). The cleaned paper is dried to remove the solvent, "conditioned" in a room that is kept at a definite atmospheric temperature and humidity, and finally weighed and measured. From the weight and size of the few sheets used for making the test, the weight of 500 sheets, 20 by 30 inches, is calculated. The fiber composition of the paper is ascertained by suitable microscopical methods which need not be described here.

Testing Typewriter Ribbons

The writing qualities of a typewriter ribbon are determined by serviceability or wear-down, recovery, and type-filling tests. It is customary also to get the thread count, or number of warp and filling threads per inch, and to measure the thickness. These last may be of importance in a specification, but the writing tests give practical information about the ink as well as the fabric.

<u>Serviceability and Recovery Tests</u>.- The serviceability test can not be made in the same way as the corresponding test of carbon paper because, when writing, the piece of ribbon would be inclosed between two pieces of paper. To test a ribbon, first wind a yard or two of the ribbon upon an empty spool, so as to get to a part of it

that has not been handled. Lay the spools one at each side of the typewriter, with the ribbon close to the platen. With paper clips or other means fasten the ribbon to each end of the carriage, with the part in between under just enough tension to keep it straight. It must be in such a position that the type will strike it as far from the edge as when writing normally. Insert in the machine a long piece of paper, for instance two letter sheets pasted together end to end. Then with a light, uniform touch, write a line of about 30 E's or R's. Shift the paper a single-spaced line, push the carriage back to the starting point, and again write the letters, over the same part of the ribbon. Proceeding in this way, and without delaying, write 100 lines in all. Leave the ribbon undisturbed for 20 minutes, and again write a line of the letters.

The line last written shows the amount of "recovery", or flow of ink in the fabric. This flow starts as soon as ink is removed from any part of the ribbon when typing, so the wear-down test will not give strictly comparable results with two or more ribbons unless it is carried to completion for each, without delays. To avoid the necessity of stopping to count, each line that is an odd multiple of 5 can be marked by typing one or two extra letters at the right, and the lines that are multiples of 10 can be marked with three or four extra letters. Anybody can tell without stopping when 5 lines have been written, and it takes but a fraction of a second to type the extra letters.

It frequently happens that the first line of the test is too black, and possibly somewhat blurred, but this should not be true of the lines that follow, unless the ribbon is heavily inked. Although there are no established standards for the degrees of inking, anybody who tests many ribbons soon comes to recognize heavy, medium and light inking. Ribbons with medium inking are used in greater numbers than the others. Some of them will write as many as 100 lines in the test. The last 10 lines or so are pale, to be sure, but they would be accepted in an emergency. Other ribbons, also medium-inked as shown by the first few lines, will write barely 50 acceptable lines. In general, single-color ribbons give better results in the wear-down test than two-color ribbons, because the ink in the latter must be less fluid, so that the colors will not mingle in the fabric. When comparing two or more ribbons, all should be of the same degree of inking, and not light, medium and heavily inked.

<u>Permanence</u>.- The ink in black ribbons consists of carbon black mixed with oily materials in which a black dye is dissolved. The permanence of the writing depends upon the carbon, because it never fades, though dyes eventually disappear. There seems to be a growing tendency to lessen the amount of carbon and to increase the proportion of dissolved dye. This makes the ink flow more freely and improves the recovery, because dissolved dye can move through

the fine interstices in the fabric more easily than particles of carbon can, especially if the grinding was not continued long enough when the ink was made. This tendency to increase the amount of dye at the expense of carbon is said to be the cause of a fault that has been noticed in recent testing. A short time after writing, a faint yellow or brownish zone is noticed around each letter, and sometimes on the opposite side of the paper. This is caused by the spreading of the excess oil in all directions from the ink marks. The dye does not spread, but is held by the paper. In time the oil stain disappears, but while it lasts the writing is unsightly.

The presence of too much dye in proportion to the carbon is sometimes suggested by the faint purplish or bluish gray of the last 30 or 40 lines in the wear-down test. The dye in the ink looks black when in a thick layer, but when spread out very thinly on paper it is purplish or bluish. If part of the test sheet, with lines 75 to 80, is cut out and exposed to direct sunlight for a few days, the writing will fade out more or less completely. If lines 5 to 10 are similarly exposed, the writing should change only by becoming brownish. The reason is that the natural color of the carbon in a thin layer is brownish black, and this appears when the dye in the ink fades in the light. In the laboratory, a special carbon arc lamp is used because it is more constant in intensity and more dependable than sunlight.

If the writing of lines 5 to 10 should fade badly in the test, it is advisable not to use the ribbon for records that are to be kept for a great many years. Red, blue and other colors than black may last several decades if kept in the dark most of the time, but carbon should last as long as the paper endures.

<u>Type-Filling</u>.- Some ribbons have a tendency to clog or fill the type. To test for this fault, the ribbon is placed in the usual way, and the letter e is written 800 times. All of the impressions should be clear, with no evidence of filling the type.

<u>Non-uniform Inking</u>.- Complaint is sometimes made that ribbons are unevenly inked. The complaint may even be backed up by the display of writing in which pale letters are scattered here and there among much blacker letters, though it is evident from the appearance of the latter that the ribbon is becoming exhausted. In the laboratory the only way this condition could be discovered would be to write over the full length of the ribbon a great many times. This does not seem worth while, for it may be doubted whether the unevenness actually exists. The fabric is inked, several hundred yards at a time, by running it through a carefully adjusted inking machine. It is not likely that the amount of ink in adjacent parts of the ribbon could vary as much as the exhibits seem to show,

especially when the recovery due to the movement of the ink in the fabric is taken into account. It seems more probable that the operator's uneven touch is the cause of the trouble. Slight variations in touch are more apparent when the supply of ink in the ribbon is running low.

It is believed that any careful person can make the tests described in this letter, and that the results will make it possible to select from a number of samples those that will give the best service.