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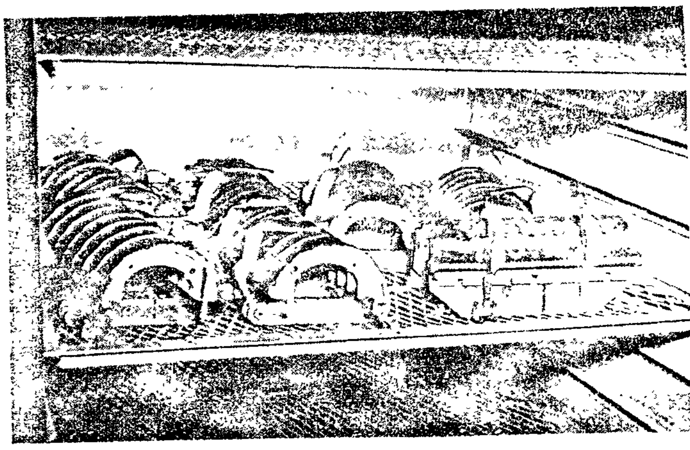
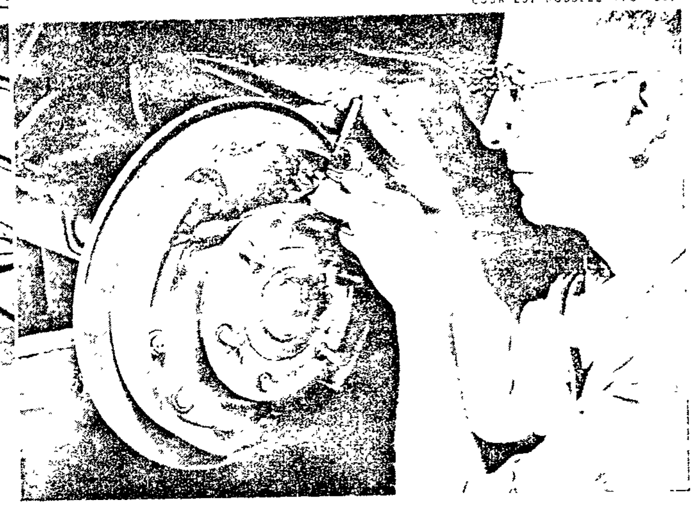


COURTESY SAE JOURNAL

In the Permafuse bonding method, brake lining and impregnated tape are clamped to the shoe and placed in oven



Research on brake lining materials and fastening methods requires extensive testing and checking on wear of lining

COURTESY RUSSELL MFG. CO.

Phenolics in Brake Linings

Resin binders give improved frictional characteristics, longer life, and greater stability under operating conditions; resin adhesives bond linings to shoes, eliminating all rivets

TEN MILLION to twelve million pounds of phenolic resins were used in 1948 in the manufacture of brake linings for automobiles. In addition, the comparatively new development of bonding linings to brake shoes with phenolic adhesives, instead of using rivets, opens up large new resin markets. Of all the brake linings manufactured today, it is estimated that over 90% contain 2 to 25% by weight of phenolic resins.

Binders which are commonly used to give the required frictional characteristics to brake linings were formerly rubber or asphalt. Today, synthetic resin binders, particularly phenolics, give longer life to the linings, improve frictional qualities, and provide better resistance to oil, grease, and water. Besides all this, certain phenolic resins can be used to produce linings that tend to be stable in operation regardless of temperature or humidity. The resins may be used alone or in combination with asphalts, tars, drying oils, sulfonated oils, casein, rubber, and gums.

After years of experience, the automotive manufacturers have settled upon the following 10 essential qualities for the ideal brake lining: 1) proper coefficient of friction, which governs the rate of stopping, 2) resistance to wear, 3) stability of friction, hot and cold, 4) stability of friction, wet and dry, 5) silent action, 6) non-abrasive action, so that metal drums will not become scored, 7) good pedal feel, 8) lack of odor, 9) minimum loss of reserve under usage, and 10) good mechanical strength.

Most engineers are agreed that the first two qualities are paramount. From there on, however, there is little accord on the order of importance. Each year there are differences in automobile brake design which call for differences in brake linings. As a consequence, linings must be tailor-made for specific jobs. One large manufacturer of phenolic resins puts it this way: "By varying the ingredients that go into brake linings, so may the 10 properties be varied. Therein lies the art of making friction materials."

Three types available

Brake linings in use today may be divided into woven, molded fabric, and molded or bonded fiber types. The woven lining consists of an asbestos-cotton-wire fabric, impregnated with a resin or other binder and calendered to size. The ingredients are used in the following range of proportions: asbestos, 41 to 65%; cotton, 7 to 18%; wire, 20 to 34%; and binder, 4 to 16% by weight.

Molded fabric linings

Molded fabric lining consists of a waterproof base on which a friction coating is built up to pre-molded size and is then cured to exact dimensions with heat and pressure.

Asbestos-cotton-wire woven fabric is usually used as the base of molded fabric linings. The fabric is impregnated with the binder as in the case of woven linings, but the binder is used to the extent of only 2 to 5 percent. Some phenolic is used for this type of lining, but drying oils and bituminous materials are still in general use.

Bonded fiber linings

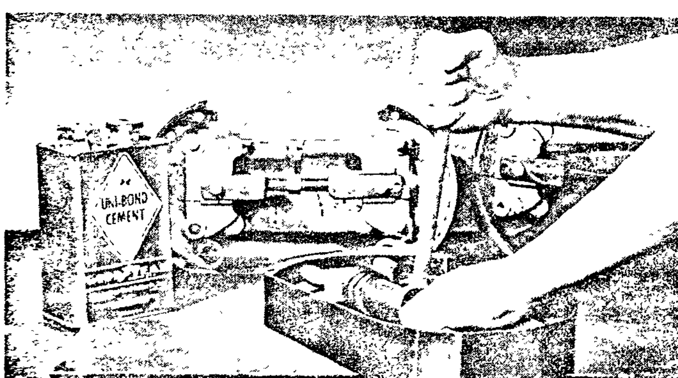
The third type of brake lining, probably the more popular today, is the molded or bonded fiber lining. This type of lining is made from loose fibers which are impregnated with binder materials by either dry mixing and molding or wet mixing and forming with subsequent drying. These molded fiber linings usually contain a higher percentage of resins than do the woven type.

The dry mix method may use powdered phenolics, phenol cresols, phenol cresol modified by linseed oil, phenol cresol modified by linseed oil and chinawood oil, or phenol cresol modified by rubber. The mixed materials are compression molded in one method of manufacture. In another method, a hopper feeds the resin to a pair of rolls that compacts the material into a continuous strip. A wire screen backing may be carried by one of the rolls and incorporated with the friction material. The formed strip is then cured in long lengths or in individual segments.

A typical dry molded brake lining as manufactured by one company is composed of 45 to 65% of asbestos, 12 to 25% of phenolic resin, and the balance of friction modifying agents, such as carbon black, rubber, tars, etc. In molding the mix, a weighed charge is placed in a one-cavity compression mold and subjected to a pressure of 1200 p.s.i. and a temperature of 270 to 300° F. The charge is kept in the mold long enough to flux the resin. While still in soft form, the molded slabs are cooled to stop cure of the resin and to retain the required plasticity. The slabs are then cut to size and ground to the required thickness.

The cut strips are next re-heated for 1 to 5 min. in an oven, formed to the desired radius, and cooled on a water-cooled cylinder. After forming, the linings are cured at a temperature of 325° F. for 1 to 3 hours. The last steps in the process are to drill and countersink the rivet holes, inspect the linings, and brand and test them.

The wet mix process of producing bonded fiber brake lining uses bonding materials similar to those employed in the dry mix process. The linings are subdivided into two types, one in which volatile solvents are used and a stiff, dough-like mass is obtained, and the other in which the mixing is carried out in a wet state and where non-volatile solvents are generally employed. For stiff mixing, a dough mixer is used and the resulting mixture is cured in a mold. For wet mixing, a pulp beater, similar to the

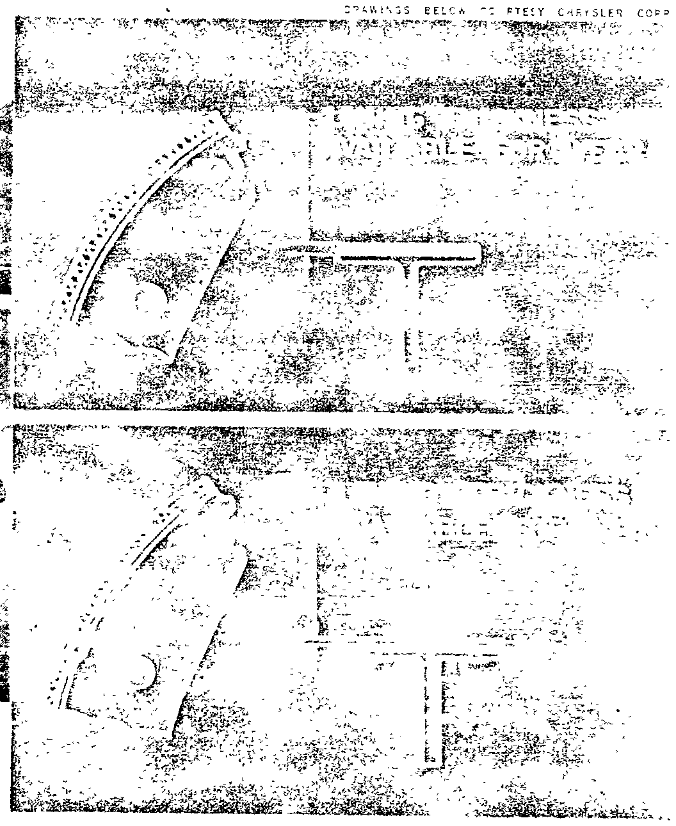


PHOTOS ABOVE COURTESY GOODYEAR TIRE & RUBBER CO., INC.

Flexible steel band applies pressure in Uni-Bond process of bonding linings, which uses a fluid resin. Dealer kit includes bonds, band spreaders, thermometer, and asbestos gloves

Top diagram shows the Cycleweld bonded lining method that provides 1/3 more thickness than riveted lining. Bottom diagram shows limitation imposed when lining is riveted

DRAWINGS BELOW COURTESY CHRYSLER CORP.



kind used in the paper industry, is required, the liquid being filtered or centrifuged to form a thin sheet. This sheet is then dried and laminated to the required thickness.

Bonded vs. riveted linings

During the past 15 years there has been extensive experimental and commercial work done on bonding brake linings to brake shoes. Briefly, the process consists of placing a cement, such as a Buna N synthetic rubber-phenolic resin combination, between the lining and the brake shoe, clamping them together, and subjecting them to heat and pressure.

The advantages claimed for bonded lining over riveted lining include: 1) greater usable lining surface and thickness because of the elimination of rivets, thus resulting in a longer lining life, 2) reduction of drum scoring because there are no rivet holes to collect abrasive material or rivets to cut the drum as the lining wears down, and 3) slightly increased friction surface because rivet holes and chamfers on the ends of the lining are eliminated. In comparisons of bonded and riveted linings, it has been determined that bonded linings may range as high as 600% greater in shear strength than riveted linings.

There are several bonding methods in general use. The Permafuse method[1] makes use of a special Durez phenolic resin as the bonding agent. The bonding material itself, produced by Permafuse Corp., Brooklyn, N. Y., consists of a specially prepared strip of tape impregnated with the phenolic resin. Rolls of tape are available in widths to match standard brake linings. Strips of any desired length can be cut at the time of application. In the bonding procedure, the lining, the Permafuse tape, and the brake shoe are clamped together and heated. The thermosetting resin forms an insoluble and infusible bond between lining and shoe.

A second bonding method, called Cycleweld—a development of Chrysler Corp.—uses an adhesive composed of a phenolic resin-elastomer combination. The lining is painted with the liquid agent, clamped to the shoe, and put in an oven at a temperature of 380° F. for 15 minutes. Such bonded lining is now in use on all Dodge Job-Rated ½ and ¾ ton trucks and is used on the new Chrysler, Dodge, De Soto, and Plymouth passenger cars.

Another method in use is the Uni-Bond process developed by The Goodyear Tire & Rubber Co., Inc., which also uses a fluid resin as the bonding agent. The bonding process is similar to that of the Cycleweld process. Reports indicate that ½ gal. of the cement will bond approximately 600 pieces of passenger car lining. The company also states that Uni-Bond has doubled the life of the lining and has eliminated approximately 90% of drum scoring.

The Uni-Fuse process developed by the Asbestos Mfg. Co., Huntington, Ind., uses an adhesive compound on both surfaces of a tape composed of natural rubber and asbestos. The rubber in the tape is reported to provide a desirable cushion between the lining and the shoe. The bonding procedure is similar to that of the Permafuse process.

Plastilock 601, a brake lining adhesive developed by The B. F. Goodrich Co., has been in use for almost two years. Claims include a shear resistance over twice that of rivets. Another report indicates that 1949 Chevrolet passenger car production has 100% bonded linings.

Still some unconverted

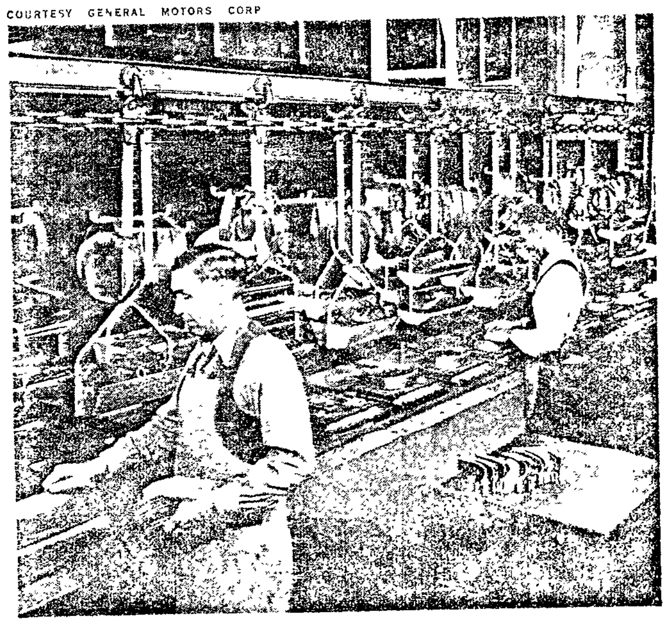
Despite the obvious advantages of bonded linings, there are still some in the automotive industry who are unconverted. One representative of a brake lining manufacturer states that bonding adds to the final cost of installation and that it calls for an investment that has not been proved justified by those who favor bonded linings. He further states that there is no assurance that a resin bond will hold for an indefinite period. This manufacturer remarks that very few, if any, of the lining manufacturers have been willing to assume the responsibility involved in recommending the bonding method. They will furnish the lining ready for bonding, but the responsibility rests with the equipment manufacturer and those who use it.

This, however, is only one opinion. Bonded brake lining, as indicated by its acceptance reported above, appears to be on the verge of widely expanded use. How universal will be the application is still a moot question. Brake lining and brake equipment manufacturers have hastened to develop facilities so that

[1] "Phenolics, Not Rivets, Bond Brake Linings," MODERN PLASTICS 25, 100, (Oct. 1947).

Brake shoes, linings, and bonding agent are placed in a clamping fixture in a Chevrolet sub-assembly line, preparatory to baking process which unites lining and shoe

COURTESY GENERAL MOTORS CORP

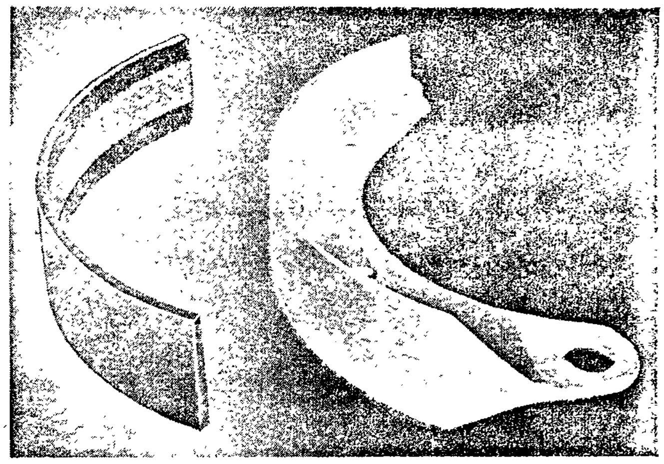


jobbers and dealers will be prepared to cope with maintenance of the bonded type lining. Reports indicate that the future of the bonding process depends largely upon the activities of the automobile manufacturers. The general public as yet knows very little about the difference between bonded and riveted lining. If the auto manufacturers should decide to use bonding on a large scale, and should advertise it widely, there is a definite possibility that most car owners would insist that bonding be used on their re-lining jobs. Of course, whenever such a demand is built up in a given area, it will be economically practical for automotive jobbers and repair shop operators to enter the bonding business.

In 1948 there was a total passenger car production of 3,893,079. Therefore, there were 31,144,632 pieces of brake lining manufactured for immediate installation with approximately another eight million sets (eight pieces of lining to a set) manufactured for replacement. A total of 7,857,378 re-lining jobs were also reported for last year. This represents an increase of 15% over 1947 and means that approximately one out of every five cars on the road had a brake re-lining job during 1948.

The design of today's automobiles has placed appreciably increased heat loads on brake linings. Faster driving speeds, smaller brake drums, and increased shrouding of wheels necessitate linings of greater heat stability and better wear resistance.

The significance of this trend is evidenced in the demand for better heat-resistant phenolic or modified phenolic resins combining good frictional properties. Today, the resin industry is said to be working on new resins that will withstand temperatures between 650 and 800° F. for a greater period of time. Present resins carbonize and disintegrate too rapidly at temperatures above 700° F. If better resins can be developed, brake lining life will be greatly increased, it will be possible to operate automobiles at higher speeds with greater safety, and the cost of brakes per mile of motor car operation will be appreciably lowered.



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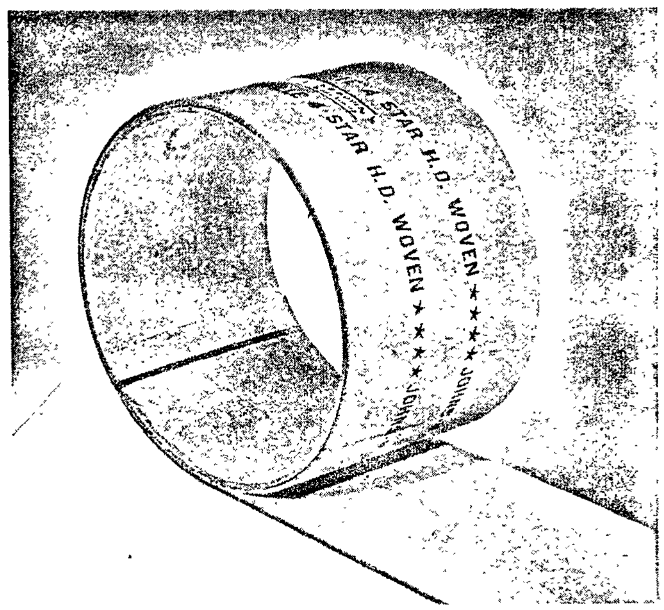
In one type of bonded brake lining the cement is applied in narrow strips at the edges. A cleaned brake shoe is at right



COURTESY JOHNS MANVILLE

Linings of any desired width and length may be cut from heavy duty woven sheet. Woven linings do not fray when cut

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