in that way improving coverage and at the same time cutting the stalks into short lengths that are not easily dragged out by the cultivator. On the other hand, if the ground is damp and heavy enough to pack, the disking may leave it more difficult to pulverize and thus hinder coverage. Rolling or dragging the stalks to lean them in the direction of plow travel is a benefit provided the stalks are not broken loose and the ground is not injured by packing. Extension rims on the land wheel of the tractor are sometimes of benefit, since they roll down the stalks and reduce soil packing. Where husking lands conform to plow lands the stalks are easier to turn under than where they are bent opposite to the direction in which the plow travels.

It is difficult to have headlands and backfurrows clean under any condition, as the ground is almost always packed on the headlands and it is impossible to place the stalks at the proper depth on the backfurrows. Disking or harrowing will bring them to the surface even if they appear nicely covered when plowing is finished. Therefore, the best way is to rake and burn these strips before plowing. If a 25-foot border around the entire field is treated in this way, it will dispose of most of the borers that might crawl out of the plowed land into fence rows or other fields to find new shelter for completing their life cycle.

WALLACE ASHBY,
Associate Agricultural Engineer, Bureau of Public Roads.

COTTON Breeding To-day Works with Main Types Known in Remote Past

There are two principal types of cultivated cottons — Asiatic and American. The American cottons may be classified roughly in two groups, the Mexican-Central American and the South American. Upland cotton (fig. 34) belongs to the first group, which is characterized in the main by whitish flowers without spots on the petals, large, smooth, rounded 4-lock or 5-lock bolls, relatively short, white lint, and very fuzzy seeds. The South American group, of which outstanding examples are the Sea Island, Egyptian, and Rough Peruvian cottons (fig. 35), is characterized in the main by yellow flowers with a dark red spot on each petal, rough, pointed, mostly 3-lock bolls, relatively long, cream or buff-colored lint, and smooth or only partly fuzzy seeds. The lengths of lint of these types are shown in Figure 36, and seeds are shown in Figure 37. Bolls characteristic of the two American groups are shown in Figure 38.

The Asiatic and the American cottons are so different that it is very difficult to make them cross or hybridize. On the other hand, it is easy to make crosses between any of the cultivated American cottons. This fact indicates that there is a closer relationship among the American species than between the American cottons in general and the Asiatic cottons.

When cotton plants first attracted the attention of civilized peoples, representatives of all the main groups were already in cultivation and probably had reached very nearly their present stage of development. Modern effort in the improvement of cotton, as of many other crop plants, has been largely a reworking of the materials bequeathed to us by the unknown plant breeders of the remote past.

Sea Island Cotton

Sea Island cotton seems to have been the first subject of intelligent breeding in modern times. It is supposed to have originated in South America and to have reached this country, by way of the West Indies, about 1786. It owes its name to the fact that it was grown in greatest perfection on the islands off the coast of South Carolina. Persistent selection by individual planters led to the production of lint measuring 2 inches or even longer, the longest and finest cotton ever grown anywhere. Only 1,000 to 2,000 bales of these choice strains, the so-called crop lots, were produced annually. European lace makers and manufacturers of fine sewing thread absorbed the product. The spread of the boll weevil to the Atlantic coast in 1916 and 1917 and economic disturbances after the World War put an end to the cultivation of this late-maturing cotton in our territory. It is now grown almost exclusively in some of the West Indian islands.

FIGURE 34.—A plant of the Acala variety of upland cotton, representing the Mexican-Central American group. (Photograph by H. F. Loomis)

FIGURE 35.—A plant of the Pima variety of Egyptian cotton, representing the South American group. (Photograph by H. F. Loomis)

The Sea Island planters gave extraordinary care to the growing, picking, and ginning of their fine cotton. They were probably the pioneers in practicing annual selection of a superior individual plant and increase of its seed to provide for the planting of future crops. To avoid seed mixture, a small hand gin was used on each plantation in ginning the selected seed. Individual planters were extremely jealous of their choice seed stocks, and the product of certain plantations sustained its high reputation year after year and was in continuous demand by particular European manufacturers.

Egyptian Cotton

Next to Sea Island cotton in length of lint, and hence in market

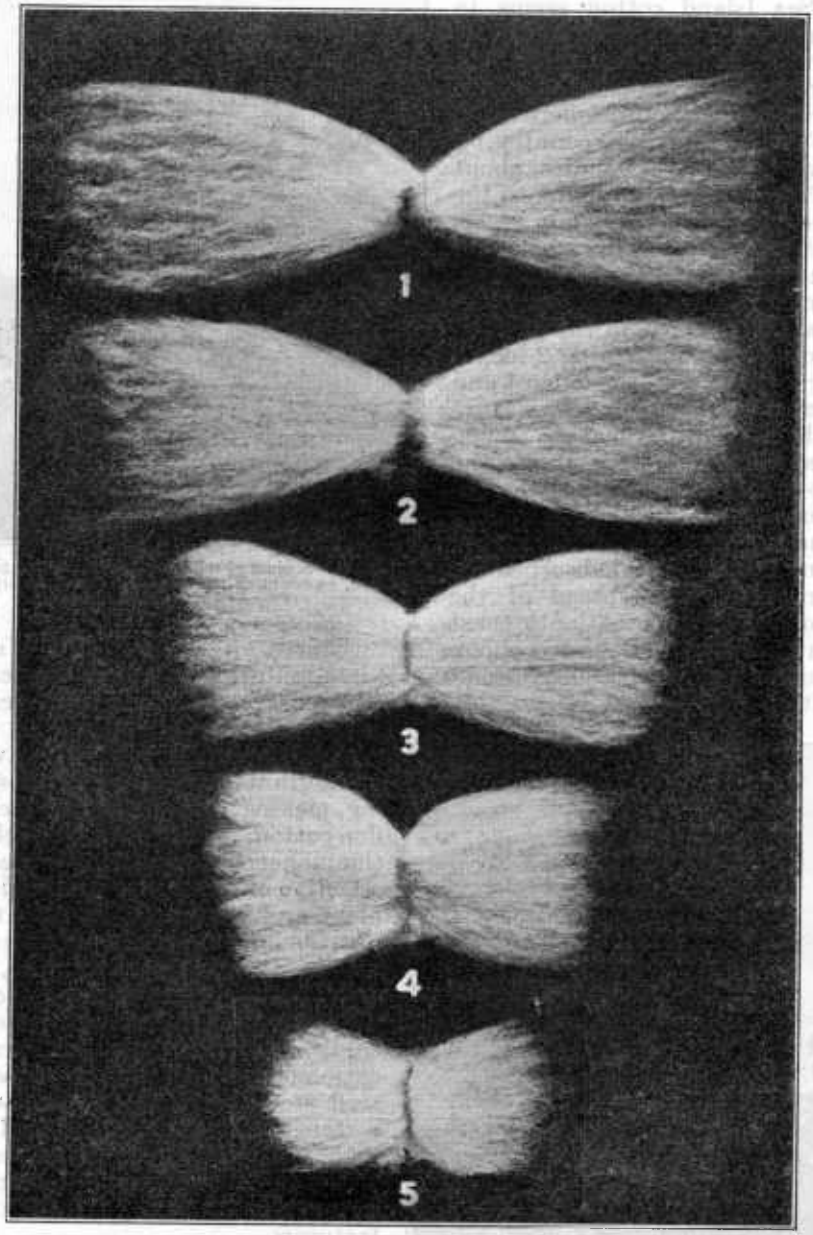

FIGURE 36.—Lint combed out on the seeds to show the range of length in commercial cottons. They are: 1. Sea Island. 2. Egyptian (Pima variety). 3. Long-staple upland. 4. Short-staple upland. 5. Asiatic. (Photograph by R. L. Taylor)

value of the product, are the Egyptian cottons. This type was developed in Egypt during the period 1820 to 1850. Like Sea Island, it clearly belongs to the South American group, but its parentage can only be guessed at. The first well-marked variety, Ashmuni, which is still grown in upper Egypt, had lint of a brownish color and about $1\frac{3}{16}$ inches long. Numerous other varieties have since arisen. The most valuable of these, Sakellaridis or Sakel, has lint about $1\frac{1}{2}$ inches long and much lighter in color than that of Ashmuni. Egyptian cottons, which constitute about 6 per cent of the world's crop, are greatly in demand among manufacturers of fine cottons. They are used largely for fancy dress goods, sewing thread, and fabrics for automobile tires and airplane wings.

Each of the varieties developed successively in Egypt appears to have originated with the selection by some cotton grower of a superior individual plant, the seed of which was increased and finally planted on a field scale. Formerly, few precautions were taken to keep the different varieties apart, and their uniformity was soon lost as a result of cross-pollination in the field and mixing of seeds at the gins. The work of selection and seed increase has been taken over recently by Government experts, and large supplies of relatively pure seed are now available for planting.

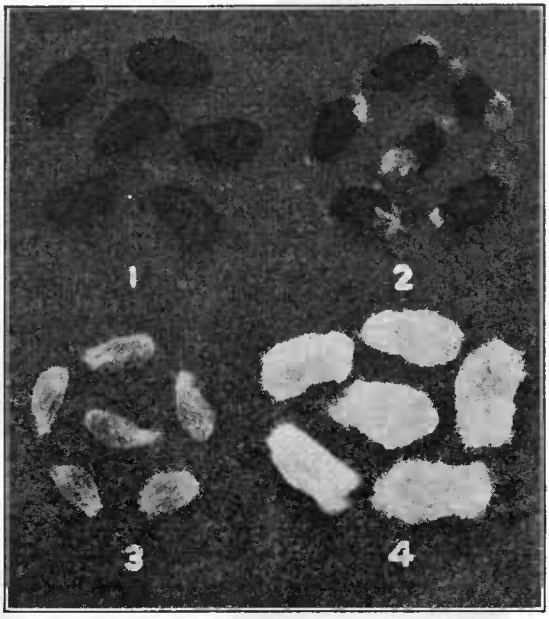

FIGURE 37.—Seeds of various commercial cottons, with lint removed, showing differences in fuzziness. They are: (1) Rough Peruvian with seeds practically naked; (2) Sea Island with fuzz confined to the ends of the seed; (3) Asiatic, seeds covered with short greenish fuzz; and (4) American upland, seeds covered with long white fuzz. (Photograph by R. L. Taylor)

Seed of one of the Egyptian varieties was introduced into the United States by the Department of Agriculture some 30 years ago, and experimental plantings were made in various localities. The results showed that this kind of cotton grows best in the hotter parts of Arizona and California, where the climate is most similar to that of Egypt, and where, as in that country, the crop is grown under irrigation. A superior plant of distinctive type, selected in 1907 from the imported stock in Arizona, was the starting point of a new variety, called Yuma. In 1910 a single plant found growing in a field of Yuma cotton was selected because of its fruitfulness and the excellence of its lint, and from it was developed Pima, the only variety of the Egyptian type now grown commercially in the United States. (Figs. 35 and 38.) The lint of this variety averages about $1\frac{5}{8}$ inches long. (Fig. 36.) The successive stages in the development of Pima cotton from its Egyptian ancestor are shown in Figure 39.

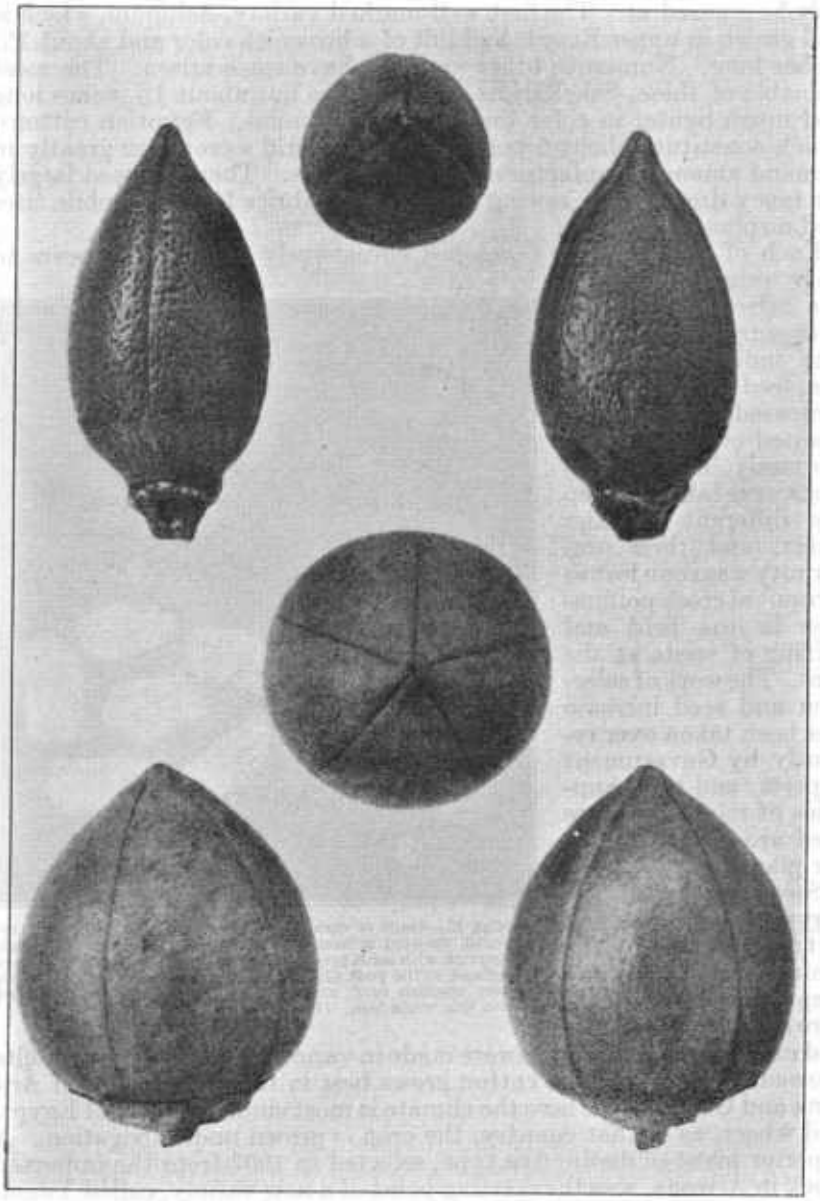

FIGURE 38.—Full-grown but unopen bolls of Acala upland cotton, representative of the Mexican-Central American group (lower), and of Pima Egyptian cotton, representative of the South American group (upper). The bolls of the first group usually have four or five locks or cells and are larger, much less pointed, and smoother than the bolls of the second group, which are prevailingly 3-celled. (Natural size.) (Photograph by H. F. Loomis)

Upland Cotton

Although less spectacular than the long-linted Sea Island and Egyptian cottons, upland cottons far outrank all other types in general utility. They constitute almost the entire crop of the United States and at least 60 per cent of the world supply. The original home of upland cotton probably was in Mexico or Central America, since forms similar in character to the cultivated upland varieties are found in that region growing wild or in a state of semidomestication by primitive tribes. History gives no clear indication of when and how these cottons first reached the territory that is now the United States. There is little doubt, however, that at the beginning of the nineteenth century most of the American crop was of the upland type.

Selection by farmers of individual plants which caught their fancy soon gave rise to an enormous number of so-called varieties, many of which differed in little but name. In recent years the agricultural experiment stations of the Southern States and the United States Department of Agriculture, as well as private breeders, have been active in producing new varieties of upland cotton. A list compiled by the Department of Agriculture includes about 1,200 names of varieties, of which some 400 have been added during the last 10 years. The lint of

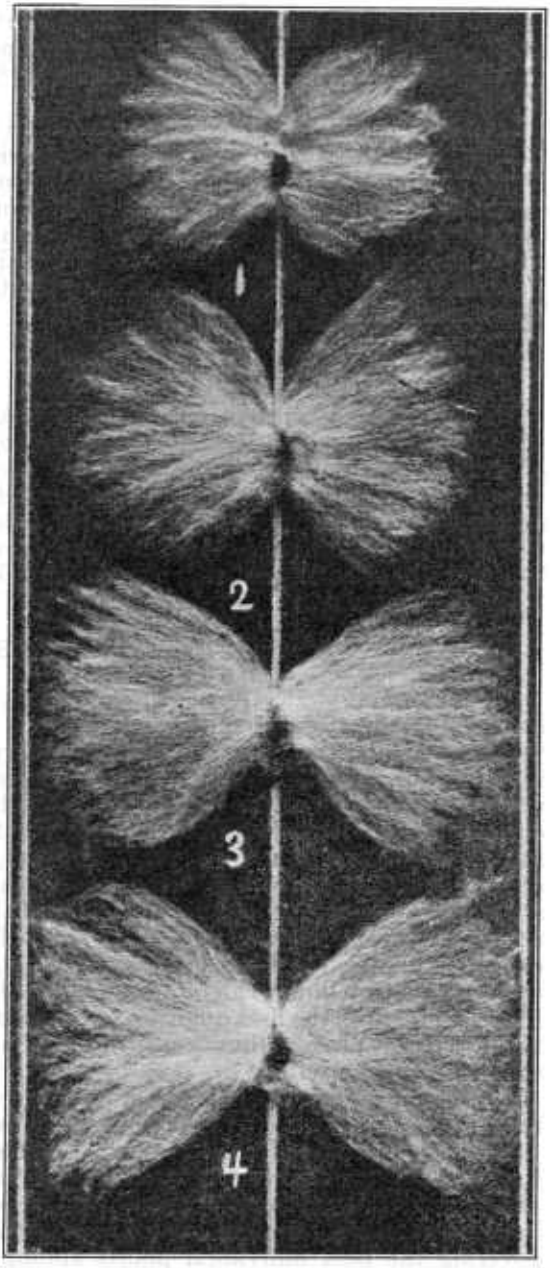

FIGURE 39.—Lint combed out on seeds to show progressive improvement in the staple of Egyptian cotton after introduction into Arizona. (1) Mit Afifi as first introduced from Egypt; (2) the same after several years selection of the longest-linted individuals; (3) Yuma; (4) Pima

upland cottons ranges from about three-fourths inch to 1 5/16 inches in length, with a few "long-staple" varieties producing still longer lint. In one of these, Meade, the length averages 1⅝ inches and even reaches 1⅞ inches in special selections.

Several kinds of "big boll" upland cotton have been introduced in late years from Mexico and Central America by the United States Department of Agriculture. When first grown in this country these stocks showed much diversity, but selection of the best individual plants has led to the development of uniform varieties. One of these, Acala, is now the leading upland variety in the irrigated sections from western Texas to California and is grown without irrigation in central Texas and Oklahoma. (Figs. 34 and 38.)

Asiatic Cotton

The great bulk of the cotton produced in Asia is of the Asiatic type, which constitutes about 28 per cent of the total world crop. The lint of most Asiatic cottons is comparatively short and coarse, the staple usually not exceeding three-fourths of an inch. (Fig. 36.) There are numerous varieties, especially in India, where plant breeders in the Government service are engaged in the improvement of the local forms. The work of selection is being carried on also in China, Japan, and Russian Turkestan.

Methods Used by Cotton Breeders

The large and showy flower of the cotton plant is well adapted to both self-fertilization and cross-fertilization. Cotton is self-fertile and will "set" bolls even when the flower buds are inclosed so as to exclude insects, thus permitting pollen to be deposited only by automatic discharge at the base of the stigmas. To the breeder this is a desirable condition, since it enables him to develop uniform varieties by inbreeding. Fertilization is more nearly complete, however, and the yield of seed and lint is greater, when additional pollen is carried to the stigmas by bees and other insects. Most of the pollen deposited by insects comes from the same flower, but some of it is brought from flowers on other plants, resulting in cross-fertilization. The readiness with which the cotton flower can be cross-fertilized makes it possible to combine, by crossing, the best qualities of different forms, but, on the other hand, natural cross-pollination by insects is a constant threat to the uniformity of varieties.

In the improvement of cotton, as of other crop plants, there are two main lines of attack, (1) selection accompanied by inbreeding, and (2) cross-breeding or hybridization. Until lately, simple selection has been the only method used consciously in improving the cotton plant, although doubtless in many cases the plants selected have been natural hybrids. Cotton breeders have directed their efforts mainly to discovering the best individual plants among the mixed stocks which have come down from primitive times and to increasing the seed from such plants in order to establish more uniform varieties.

The method of selection differs only in minor details from that used by breeders of other crop plants. Starting, let us say, with a rather mixed population, such as is found in most fields, the breeder first picks out the individual plants that seem most typical, are most productive, and have the largest bolls and the most desirable habit of growth.

When the bolls open the plants are compared as to abundance of lint and its length, strength, and general quality. The choice thus is narrowed to such of the individuals selected on the basis of plant type as prove also to have superior lint. Seed from each of these individuals is saved and planted separately the year following.

When the progenies of the selected plants are examined the next summer, some of them are likely to show diversity in type of plant. These will be rejected without further consideration because of lack of uniformity. Others, although uniform, will be lacking in fertility or show an undesirable habit of growth. These also will be discarded promptly. In the fall the remaining progenies are compared as to character of lint, and only those that appear satisfactory as a whole are finally retained. The most desirable individuals in these progenies are selected, and their seed is saved for planting the second generation progenies. The process of selecting the best progeny, and the best individual plant in that progeny, is continued year after year until it becomes evident that no further progress is being made; in other words, that uniformity has been attained. Thereafter the problem is one of increasing the seed for planting on a field scale.

Where it is merely a question of improving an existing variety, more rapid progress usually can be made by selecting plants in the most uniform progenies, even though occasional individuals in less uniform progenies have superior lint. This is not to deny that an outstanding individual plant of conspicuous merit, wherever it occurs, should be considered as the possible source of a new and better variety.

Breeder Should Avoid Accidental Crossing

The cotton breeder must use the utmost vigilance to protect his selected stocks from becoming contaminated by accidental crossing with other kinds of cotton. In the breeding nursery the exclusion of pollen-carrying insects is effected by inclosing the flower buds in bags or wiring them before they open and by saving for planting only the seed produced by these strictly self-fertilized flowers. In fields grown for increase of seed, however, the labor and cost of thus treating a sufficient number of flowers would be prohibitive, and the only solution of the problem is to have the field located at a safe distance from any other kind of cotton. As an additional precaution, seed-increase fields should be inspected early in the season, in order to determine whether any contamination has resulted from accidental crossing the year before. If such proves to be the case, the field should be "rogued," which means that all plants appearing to be different from the selected type should be pulled up. "Off-type" plants, usually of a degenerate character, appear occasionally in inbred families, even when every conceivable precaution has been taken to protect them against accidental cross-pollination. Since the occurrence of such "rogues" can not be guarded against, it is obvious that even the most carefully isolated strain of cotton should be kept under close observation and rogued whenever necessary.

Heretofore, the deliberate creation of new types of cotton has scarcely been attempted, but interest is awakening in the possibilities of guarded cross-pollination as a means of getting new combinations of desirable characters. There is good reason to expect that this method will prove fruitful, especially when the forms to be crossed are not too distantly related. The cotton flower, because of its large size and the

accessibility of its reproductive parts, is easy to cross-pollinate. This is done by opening the bud and removing the stamens the evening before the flower is due to open naturally, thus preventing self-fertilization. The emasculated bud is then bagged to keep out insects, and the following morning its stigmas are dusted with pollen from the plant selected as the other parent of the cross.

Experience has shown that when crosses are made between two varieties of the same type, Egyptian, for example, it is possible to obtain a blend of the best qualities of both parents. The resulting new variety can be rendered "fixed" and uniform by selection in a few generations. But when very distinct types of cotton, such as upland and Egyptian, are crossed, an entirely different condition is encountered. After the first generation the hybrid plants show immense diversity in all their characters and the great majority are unproductive or otherwise undesirable.

Reorganization of Cotton Production

The ancient Greek fable of the man who was condemned eternally to trundle a stone uphill only to see it come rolling down again aptly characterizes the work of the cotton breeder. Numberless excellent varieties have been originated in the breeding nursery, but, when placed in the hands of farmers, they have soon deteriorated and have had to be replaced by new ones. It came to be believed that some unknown law of nature determined the length of life of a variety of cotton and that it was bound to "run out," automatically, within a few years. There is, however, no real evidence that a variety can not be maintained indefinitely if the planting seed is kept pure.

Recently a beginning has been made in reorganizing cotton production on the basis of one-variety communities. This system was proposed by O. F. Cook as a means of avoiding the loss of uniformity due to cross-pollination in the field and mixing of seed at public gins, which occurs wherever two or more varieties are grown in the same neighborhood. If the system were generally adopted, the breeder of cotton would be inspired to redouble his efforts, since he might hope to see his creations perpetuated until replaced by something better, instead of disappearing a very few years after they begin to be grown agriculturally.

T. H. Kearney,
Principal Physiologist, Bureau of Plant Industry.

Cotton Fabrics are the Most Suitable for Children's Wear

There are no fabrics so suitable for children's wear as cotton. Variety of weave, texture, weight, and color makes it possible to use cotton for practically all garments from underwear to out-of-door play suits.

A happy child is one who is allowed to have free and unrestricted play. Silks, velvets, and fancy woolens are not intended for little folks who make mud pies and climb fences that have stray nails. They are made for the grown-ups. Children must have fabrics that are durable, comfortable, not easily wrinkled, resistant to dust, easily laundered, and never so expensive that an accidental tear becomes a crime. One can afford several outfits when cottons are chosen, and it is possible to have the frequent changes needed for comfort, cleanli-