AGRICULTURAL AVIATION

Farming operations are becoming airborne. Not only have pest control operators taken wing, but fertilizing and seeding operations also are being done with planes for greater speed

Piper PA-18A is the most extensively used agricultural airplane in commercial production. This is the first applicator plane to be built in quantity production with dust and spray dispersal equipment as an integral part of the aircraft. Dust is usually applied from an altitude of 2 to 8 feet, at an airspeed of from 60 to 80 miles per hour. Spray is usually applied from a higher altitude, up to 20 feet

Aircraft Spraying and Dusting

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Crop dusting is no longer a "fly by night" enterprise for daredevils; it has become a highly technical business with technological problems

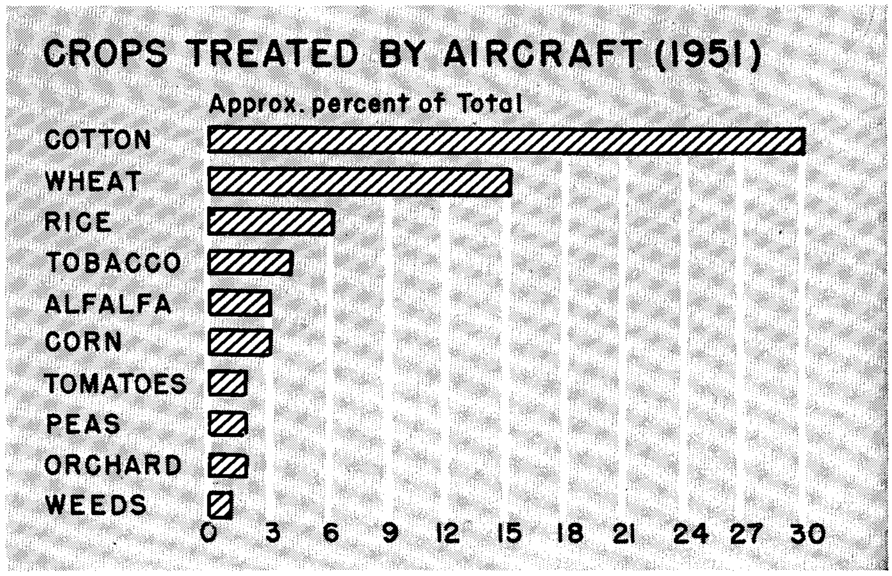
Of the total land area of the United States, about 1 acre in 6 is under cultivation (350 million acres). During the year 1952, approximately 40 million acres are recorded as having been treated from aircraft. Although this amount no doubt includes some acreage that was treated more than once during the year it is nevertheless a substantial figure and is over one ninth of the entire area under cultivation.

Nearly all of the airplane dusting and spraying is done by small companies specializing in this field of activity, rather than by the farmers themselves. There were 1725 aerial applicator firms on record in 1951, and the 1952 total was over 2000. These operating firms average between three and four airplanes each. Only a few firms have over 20 airplanes each, and only one appears to have over 40.

On the map (Figure 1) the location of each of the 1725 applicator firms is represented by a dot. A surprising amount of the country is covered, especially the valleys and plains. The western mountain ranges and the Appalachians in the East stand out as bare areas and even the Ozarks of Missouri and the Bad Lands of South Dakota are noticeable. The wooded area near the eastern half of the Canadian border also has very few aerial applicators. There are concentrations of activity in the Mississippi Valley, the California valleys, and others, but the greatest concentration of all occurs in the Rio Grande Valley at the southern tip of the country, where the dots should overlap and were spread out somewhat so that each one could show.

The airplanes used for dusting and spraying vary from low-powered light planes to four-engine transports, the larger airplanes being used in connection with large-scale forestry or range work. Most of the airplanes are converted trainers of two general types, light high-wing monoplanes carrying maximum chemical loads of from 300 to 600 pounds and somewhat larger biplanes carrying maximum chemical loads of from 600 to 1200 pounds. None of these airplanes was originally designed especially for the purpose of dusting or spraying.

Specially Designed Airplanes



Outstanding crop treated by aerial application is cotton, which uses about 30% of the total. The next in order are wheat, rice, and tobacco. Almost all this spraying and dusting is done by small firms specializing in this field of activity. Larger crop dusting firms migrate with the crops or growing seasons, starting early in the year in Texas. By the end of the year the same firm may be operating in Oregon

In 1949 the National Flying Farmers Association, recognizing the need for improvements in this field, initiated a project for the development of an experimental airplane especially designed for dusting, spraying, seeding, and fertilizing. The airplane was designed and constructed by the Texas A&M Personal Aircraft Research Center with funds and technical aid furnished by the Civil Aeronautics Administration and with counsel from the U. S. Department of Agriculture.

The special features of this experimental agricultural airplane, which was designated the Ag-1, included simplicity of construction, ease of loading, and ease of maintenance. One of the most important problems in maintenance is corrosion, and the corrosion of aircraft structural materials from agricultural chemicals has been rather extensively investigated at our Personal Aircraft Research Center. Only two materials, stainless steel and polyester plastic, were found to withstand all the chemicals tested.

The Ag-1 performance included low speed operation with a special high-lift wing having a powerful full-span flap. Of particular importance in the design, the pilot was given an unusually clear field of view, particularly forward and downward and while in turns close to the ground. In addition a great effort was made to provide protection for the pilot in low speed crashes, which are a hazard both from collisions and from stalls while flying close to objects and making short turns near the ground.

During a CAA demonstration flight before a meeting of the American Cotton Congress, June 26, 1953, the Ag-1 airplane collided with a power line pole and crashed. The airplane was almost totally destroyed except for the cockpit region. The pilot was uninjured even though, as shown by dynamometers installed in the seat-belt connections, he was restrained by one side of the belt by a force of 3000 pounds. The pilot protection features thus appeared justified.

Since the Ag-1 was an individual experimental airplane and had substantially fulfilled its purpose, it is not being rebuilt. There are now, however, a number of airplanes being developed for agricultural use which incorporate the outstanding features of the Ag-1 in varying degree. One of these is a direct modification designated the Ag-2 being developed by the Transland Co. in Los Angeles, Calif. This airplane is expected to be ready for flight tests during the coming summer. It will be fitted with a 450-horsepower engine and is being designed to carry a chemical load of 2000 pounds.

Two other new airplanes which are already flying are the 190-horsepower Snow low-wing monoplane duster built in Texas, and the Air-Tractor, a 450-horsepower biplane, built in the state of Washington. The former incorporates a number of the Ag-1 features and the latter incorporates some of the features of pilot protection.

With these and other developments under way it appears that the dusting and spraying operators should soon have aircraft available that are designed especially for the purpose.

Ag-1 developed by the Personal Aircraft Research Center at Texas A&M, in cooperation with the CAA and other groups. Experimental plane designed to incorporate the characteristics of an efficient duster or sprayer with maximum pilot safety. Purpose was to provide the aircraft industry with basic data for the design of agricultural aircraft

Typical Distribution Pattern Measurements

The results of a typical single swath measurement of an airplane spraying insecticide is shown in Figure 3.

The airplane used for this run was a Boeing Stearman PT-17. It was fitted with a spray rig having 56 nozzles evenly spaced under the lower wing for dispersion of insecticide. The airplane with spray rig was furnished by an old and experienced applicator company and represents good current practice.

A cross wind of 2 miles per hour was moving from right to left and the resulting drift can be seen at the left.

It is apparent that the distribution across the swath is not uniform for it varies from peaks of 15 and 17 pounds per acre to a low spot in the center of less than 6 pounds per acre. This is partly because the airflow around the airplane flows outward below the wing, leaving a thin spray deposit in the center, and partly because the twisting propeller slipstream moves some of the spray from the right side to the left side. A much more uniform distribution should be possible with the proper relocation of the nozzles.

Now by placing these swath patterns at 40-foot intervals and adding up the overlapping portions, we can find the over-all distribution with a 40-foot swath spacing. This distribution is shown in the upper portion of Figure 3. The heavy portions have more than twice as much spray as the lightly covered portions. If the light portions have enough spray to do the job satisfactorily it is obvious that with a perfectly uniform distribution a single airplane load could cover about twice as much acreage.

Optimum Single-Swath Pattern

What then is the most desirable single-swath pattern? If there were no drift and if the airplane could be flown perfectly along predetermined flight paths exactly the right distance apart, a rectangular pattern, assuming it could be obtained, would give perfectly uniform distribution. This is illustrated in the first line of Figure 2. As shown at the right of the first line, however, if one pass (the next to the right) is made a little to

Commercial Agricultural Flying

Activity	*Total (1000 Hr.)*	*% Hr.*	*Total Acres (Millions)*	*Chemicals* Pounds (millions)	*Chemicals* Gallons (millions)
Dusting	279	38	16.8	413.098	
Spraying	219	31	13.1		36.238
Fertilizing	62.9	8.9	2.3	213.6	0.174
Seeding	51	7.2	1.8	92.0	
Defoliation	50	7.1	1.8	15.8	11.2
	707		37.4	736.9	49.3

LOCATIONS OF AERIAL APPLICATOR FIRMS (1951)

EACH DOT REPRESENTS ONE FIRM

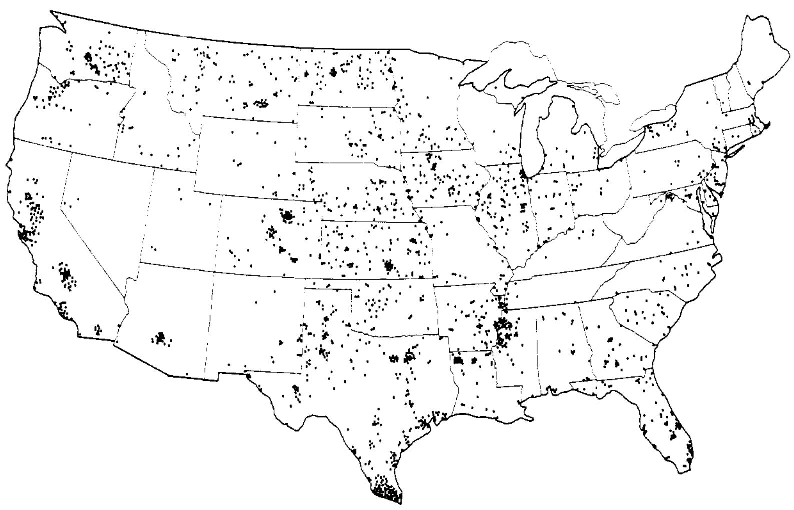
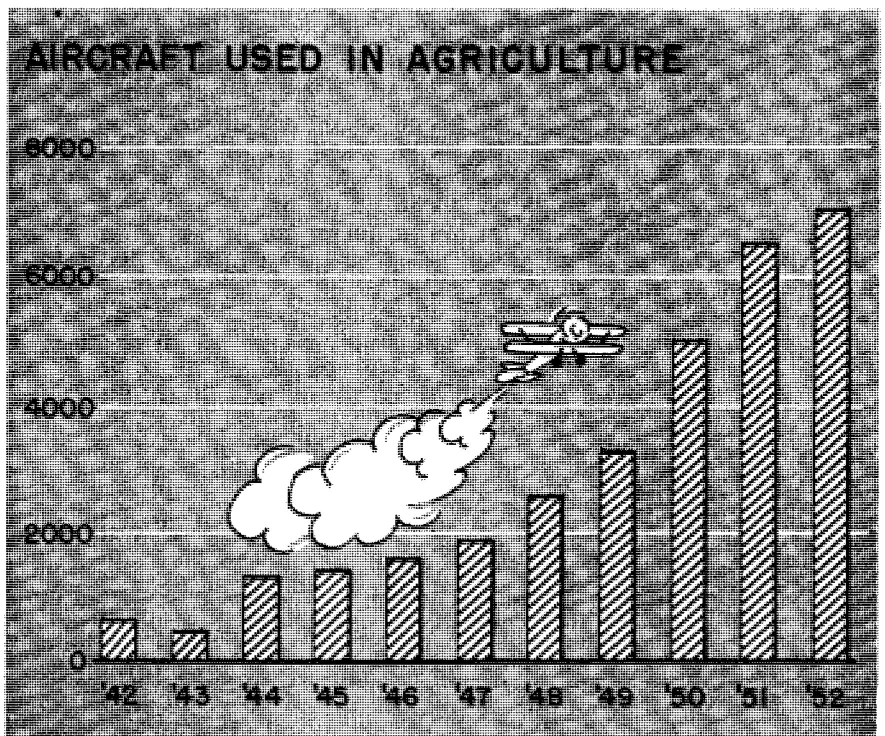
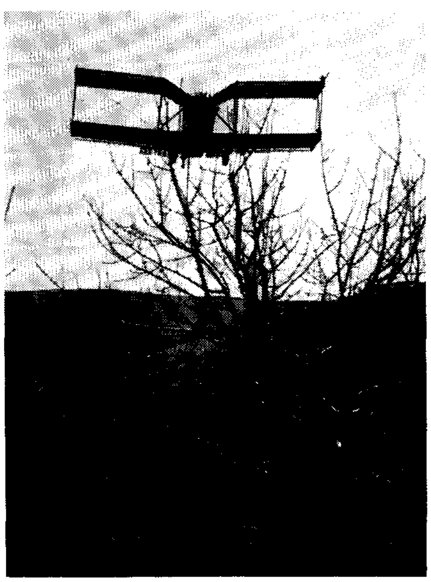


Figure 1



Air Tractor, dust and spray plane, on an operational test run over an orchard at Yakima, Wash.



TYPICAL SPRAY PATTERN FOR A SINGLE SWATH

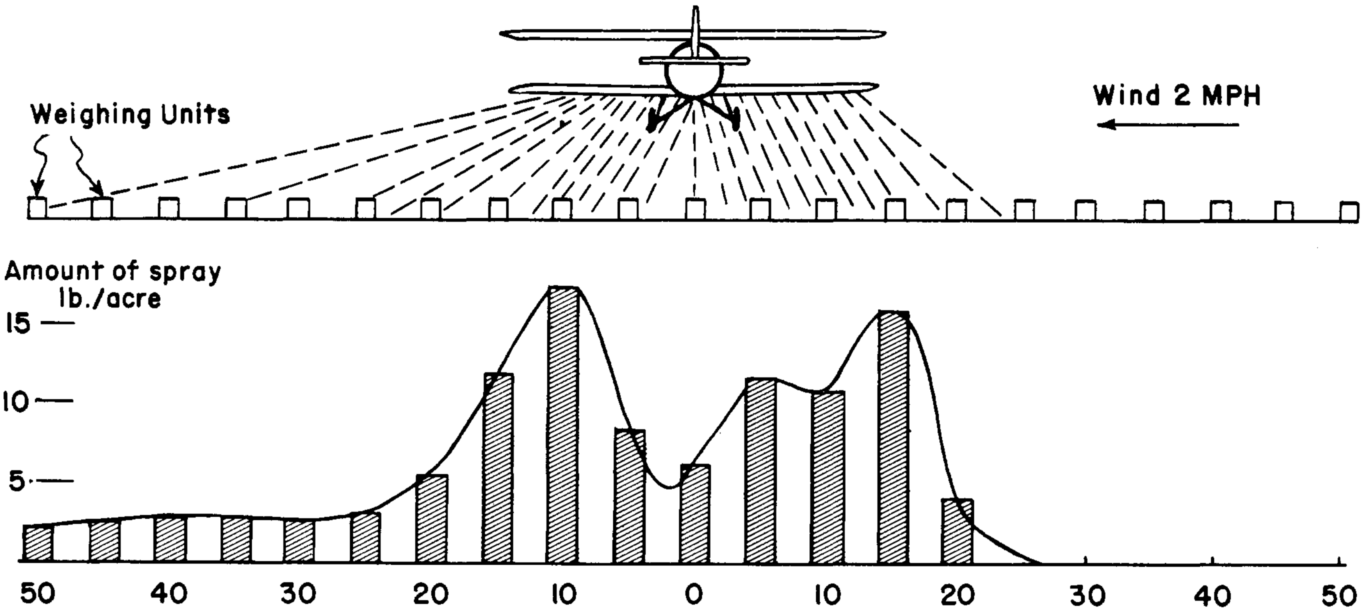


Figure 3

one side, a blank space is left in one place and a space having double the quantity desired is left in another. Thus with only slight imperfection in the flight paths an unacceptable distribution would result.

A sloping sided pattern, as shown in the second line of Figure 2, still gives a perfectly uniform distribution with perfect spacing of the flight paths, and imperfect spacing gives less variation in the distribution than with the rectangular pattern.

The ultimate in this direction is the triangular pattern for the single swath as shown in the third line of Figure 2. This gives the least irregularity in distribution due to imperfect spacing of the flight paths. It may be worth striving for in actual practice. It requires, however, that the single-swath spray pattern be twice as wide as the equivalent rectangular pattern.

The optimum or most desirable pattern is ordinarily the sloping-sided or trapezoidal one shown second from the top in Figure 2. Although the triangular pattern gives the most uniform distribution with imperfect swath spacing, it requires a wider single-swath pattern. Since the over-all width of the single-swath pattern is limited, a larger effective swath width (or larger spacing between swath centers) can be obtained with the trapezoidal pattern. A certain amount of compromise in this direction is probably worthwhile in most cases.

It is important to note that even with an optimum swath-distribution pattern, there is *only one swath spacing* that will produce uniform, over-all distribution. The concentration peaks that occur with narrower spacing and the thinly covered portions that occur with wider spacing are apparent in the right-hand portion of Figure 2.

Nozzle arrangements and distributors producing patterns approximating the optimum trapezoidal form are now starting to get into commercial use. It appears that the improved uniformity of distribution should result not only in improved quality, but also in a substantial reduction in material wasted by overdosing, and a corresponding savings in cost.

(Based on a paper delivered before the Division of Agricultural and Food Chemistry, 126th National Meeting, AMERICAN CHEMICAL SOCIETY, March 26, 1954)

Figure 2

IDEALIZED SPRAY PATTERNS