Planter and Drill Requirements For Soils With Surface Residues

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Summary

Descriptions are given for machines used for planting in conservation tillage conditions and of soil-engaging components for those machines. The functions of available components are discussed relative to soil and crop residue conditions encountered with conservation tillage. A procedure is outlined for identifying components that will work best under anticipated conditions. Planting machine requirements are matched with available commercial machines, or existing machines can be modified by adding the desired components.

Introduction

Planting into soils with surface residues has become the identifying characteristic of conservation tillage systems. The use of conservation tillage has spread from a research curiosity in the 1960s to established practices in the 1980s (Phillips et al., 1980; Triplett and Van Doren, 1977). With the current and proposed national farm programs that provide incentives for adopting conservation tillage, its use in one form or another is expected to rise from 31 percent in 1985 to 42 percent in 1990 (CTIC Annual Report, 1986). To date, farmers with easily managed soils have dominated the adoption of conservation tillage (Cosper, 1983). Other farmers and less adaptable soils must be brought into the program. This broad conversion to conservation tillage requires the identification of appropriate technologies, including the understanding of planter and drill requirements for soils with surface residues.

Developing and selecting planters and drills for conservation tillage has been limited to regional knowledge and technologies. The best machine for a particular planting operation and field condition has previously been determined by trial and error. Knowledge of these results has been passed along by industry, public agencies, media, and research workers as the basis for advising farmers on machine selection. Technology transfer has now started to close the knowledge gaps between regions as evidenced by the formation of the National Conservation Tillage Information Center (CTIC) and increased activities of professional groups, agricultural extension services, the popular press, and other organizations.

Manufacturers have responded to the increasing market for conservation-tillage machinery. In 1986 there were an estimated 44 planters and 121 drills and air seeders available in the USA for conservation planting (No-Till Farmer, 1986a, 1986b). Additionally, many add-on components are available from specialty companies, and total machines can be constructed with components from several sources. Several of the available machine options might be determined to be adequate for a particular need if there were a systematic process for developing a set of requirements for a machine to perform a particular planting operation (Erbach et al., 1983).

Systematic determination of planting machine requirements starts with the evaluation of soil, residue, crop, weather, and management conditions for each individual farming operation. After these examinations, the machinery requirements can be established and matched with available machines and add-on components for the selection or modification of appropriate planters and drills (Figure 1). This comprehensive approach to machine adaptation is addressed in the following sections.

Conditions Critical To Machine Performance

The conditions that are critical to planting machine performance usually involve soil properties related to soil type, soil moisture content, residue properties, and interactions between soil conditions and residue properties. The following is a summary of current knowledge on the effects and interactions of these critical conditions.

There are thousands of soil series classifications, each with its distinct combination of properties, such as friability, plasticity, minimum and maximum bulk density, type of mineralogy, organic matter content, water holding capacity, and structure when wet and dry. These properties and others may affect the performance of planting machines. However, to date, we do not have a systematic approach to estimate a planter performance index based on functional relationships with these detailed soil properties. Therefore, more generalized groupings of soils have been made according to their apparent properties. Machinery performance has often been reported for soils described as being one of 12 categories based on the relative percentages of sand, silt, and clay particles, such as soil being a "loamy sand' (USDA, 1951). An even more general approach has been

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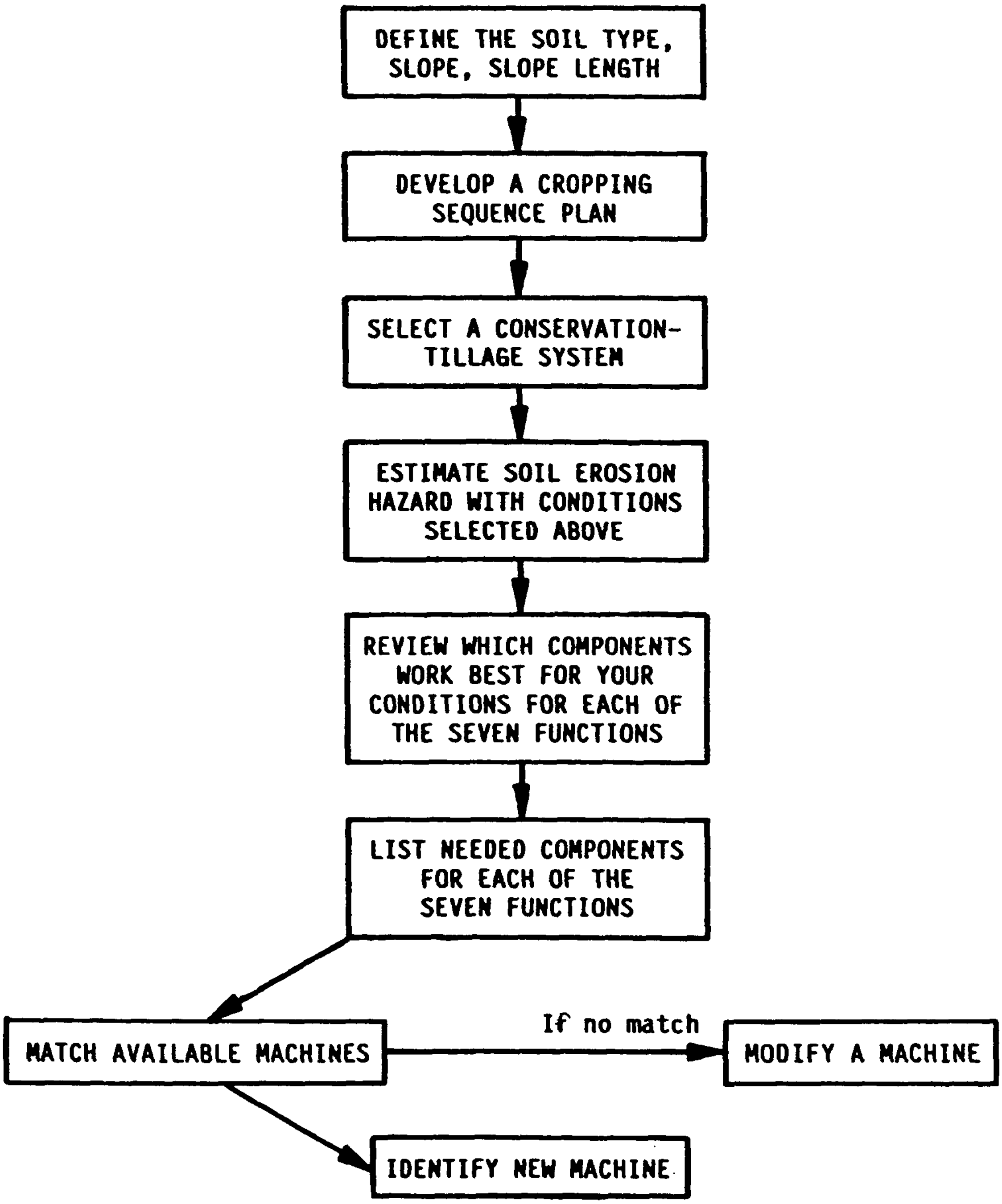


Figure 1. Flow design of procedures to arrive at the selection of an appropriate new or modified machine for conservation planting.

to identify soils as being a) sandy, loamy, or clayey; b) heavy or light; or c) fine or coarse textured.

Based upon accumulated knowledge from empirical observations, descriptions have evolved for planting machine performance interactions with soil properties. Some of these performance conditions are listed below: 1) Heavy, wet, poorly drained soils tend to be adhesive and have seed furrows that are glazed and difficult to close over the seed; 2) Heavy, dry soils tend to be difficult to penetrate with planter openers, produce clods if disturbed by tillage tools, and are difficult for closing seed furrows over the seed; 3) Crusting soils are susceptible to excessive compaction over the seed row, which may reduce plant emergence; 4) Friable, medium-textured, well-drained soils may he planted over wide ranges of moisture content with satisfactory results; 5) Naturally consolidating soils are difficult to penetrate at low moisture contents and are susceptible to excessive compaction by gauge wheels and press wheels when wet; and 6) Soils with consolidated subsoil layers, which must be strip-tilled at planting, can only he planted when topsoil and subsoil properties are amenable to disturbance.

The interaction between planting performance and soil type can he affected by the tillage history, soil structure, organic matter content, and other factors affecting friabilty, adhesiveness, and hardness in the surface 5-cm planting zone. Planting machines must be operable in the worst soil conditions encountered by the individual operator and must be adjustable or adequate for other less severe conditions.

Soil moisture content is an important factor in determining critical planting conditions. For example, the same soil at high moisture content may he easily cut but adhesive, while at low moisture content it is difficult to cut hut non-adhesive. Nichols (1932) showed that uncemented agricultural soils have the common property of rapidly decreasing shear strength and resistance to cutting with increasing moisture content. The effect of moisture content on adhesion is not as consistent as for shear strength, because an increase in organic matter content sharply reduces the adhesion of soil to tillage implements even for clayey soils (Buyanov and Voronyak, 1970). Organic matter is concentrated in the planting zone of established reduced-tillage fields (Doran, 1980). Therefore, soil adhesion may not he a problem with increasing soil moisture content to normal depths of planting and fertilizer banding, or adhesion may become less of a problem as organic matter increases with continued use of reduced tillage. Higher moisture soils are also more susceptible to root zone compaction and to surface crusting (Larson et al., 1980). If the soil moisture content unpredictably varies from dry to wet at planting, then planting machines will be required that will penetrate hard soils and also tolerate soft, adhesive soils without causing root zone or crusting compaction. Such changing soil properties with moisture content require the establishment of the range of soil moistures in which a planting machine must function.

Surface residues affect the critical conditions for planting. Residues are typically comprised of a distribution of stalks or stubble with or without leaves, roots, and chemically killed weeds. These residues can he loose, attached, standing, lying on the surface, or partially buried.

Standing residues are more independent of soil moisture than flattened residues that absorb moisture from the soil. Residue resistance to cutting by planter furrow openers increases with increases in soil moisture (Allen et al., 1984). Therefore, planting performance may be reduced by the presence of damp surface residues that are difficult to cut (Allen, 1986; Choi and Erbach, 1983). To prevent this, residues should be removed or cut from the path of planter furrow openers so that uncut residues do not become entangled on planter components or deposited in the furrows with the seed. Standing residues are largely missed by planter and drill furrow openers, and do not contribute to cutting resistance or soil and residue interaction problems.

The performance of soil-engaging components of planters and drills is directly affected by the interactions between residues and soils. There appears to he an inverse relationship between the soil moisture conditions that allow low-resistance soil cutting and those that enhance residue cutting. For example, soft soil surfaces are easily penetrated hut may not provide enough resistance for residue cutting. Thus residue may be left uncut or pushed (hairpinned) into the soil (Allen et al., 1984). When soils are hard and difficult to penetrate, there are high resistances to cutting forces, and residue cutting is optimal. In soils substantially covered with residues, the planting zone moisture content is often higher than for uncovered soils during planting seasons. Several investigators have found that the retention of surface residues has changed the soil structure by increasing the total percent of non-erodible aggregates and generally increasing both aggregate sizes and void sizes (Hughes and Baker, 1977; Smika, 1979; Hewitt and Dexter, 1980). Because of the changes in organic matter, moisture, and structure, the planting zone soil under established residue retention is of different tilth and will interact differently with planting machines than soils with buried residues.

The field landscape may influence planting machine requirements because of the need to comply with reductions of erosion hazards. The Universal Soil Loss Equation relates field slope and slope length with other factors, as given by,

$$A = RKLSCP, \qquad (1)$$

where A is the annual erosive soil loss, R is the rainfall and runoff factor, K is the soil erodibility factor, L is the slope length factor, S is the slope steepness factor, C is the soil cover and management factor, and P is the support practice factor (Wischmeier and Smith, 1978). Compliance with certain erosion limits may compel farm operators to adopt cropping and residue management practices that require planting through surface residues. Planting machine requirements must reflect crop selection, row spacings, residue amounts, cropping sequence, and chosen tillage system.

Cropping Sequence Plan

Modern farmers must project their plans for current and future operations before they can objectively determine requirements for planting machines. Cropping sequence planning is a very important part of their total plan. Sequence planning affects the interaction of residue with soil conditions on planting machine performance because of the different quantities, types, and conditions of residues, depending upon their place in the cropping sequence. For instance, freshly combined wheat residues are going to have quite different effects on planting machine performance for solid-seeded doublecrop planting immediately following harvest compared with spring row crop planting after nine months of chemical fallow. The row spacings of the stubble residue and the crop being planted, the soil condition, and the residue type and condition are all factors that are determined by the cropping sequence.

Field operation scheduling is also dependent upon the cropping sequence plan. The requirements for planting machine field speed and width depend upon the efficient scheduling of its use.

Selection of A Conservation-Tillage System

Conservation-tillage systems will generally be in one of the five categories listed below. We recognize that each system will have its particular variations, but designating the system to be used is helpful when characterizing the field conditions for operation of planting machines. The five-system categories are:

1. Reduced Tillage : A system in which the primary tillage operation is performed in a manner to reduce or eliminate secondary tillage operations.
2. Stubble-Mulch Tillage : Tillage or preparation of the soil in such a way that plant residues or other mulching materials are left on or near the surface.
3. Ridge Tillage : A system in which crops are planted on top of permanent raised ridges with intervening furrows for drainage and wheel traffic.

Strip Tillage : A system in which only isolated strips of soil are tilled before planting in those strips.

5. No-Tillage : A procedure whereby planting is made directly into an essentially unprepared seedbed.

General Types of Conservation Planting Machines

Conservation planting machines include row planters, disk drills, hoe press drills, powered blade seeders, and air-type sweep, hoe, and double-disk seeders. Many machines have been developed and marketed in specific regions, but most may be described by one of the six general planting machine categories discussed below.

Row Crop Planters

Row crop planters for conservation tillage planting typically employ separate components for soil and residue cutting, depth control, soil opening for seed placement, and seed slot closure. Some also include components for row preparation, and uncovered-seed firming and seed covering. Equipment options for conservation planters include coulter attachments, row preparation devices to permit ridge planting, fertilizer and pesticide placement attachments, and weights or springs to increase downpressure for row units. Frames and hitches can couple two row crop planters for "solid-seeding." Most of these devices permit the planter to function normally when used for conventional planting and thus, increase the range of suitable uses. Major distinctions between row crop planters involve design specifications for strip-tillage, slot-planting, ridge-planting, and flat-planting.

Narrow Row Seeders

The development of narrow row seeders for conservation seeding is much more recent than row crop planters. Some options are air seeders, air drills, disk drills, hoe press drills, and new attachments including coulters, gauge wheels, and fertilizer side banders. Normally, drills do not meter seed as uniformly as planters, especially at low seeding rates. Depth control is less accurate because there is inadequate space for depth control components. Trash clearance may be limiting when seeding into high-residue conditions, but staggering adjacent row units increases trash clearance and flow.

Air Seeders

Air seeders consist of remote central seed hoppers with seed metering and air delivery systems attached to implements such as chisels, field cultivators, or stubble mulch plows. The seed may be released behind chisel points, chisel sweeps, or large 1.5- to 1.8-m wide V-blades. Press wheels are optional but essential in drier climates to ensure seed-soil contact. When releasing seed behind wide V-blades, operators may need to increase seeding rates because of seed scatter. Seed not directly under press wheel tracks may not germinate. Some air seeders are well-adapted for operating through high residues. The relatively large machines have high field capacities and can be easily folded for transport. Air seeders are commonly used for planting small grains but also may be used for soybeans. Variability in depth of seed placement has been a concern because many air seeders lack individual depth control for each row.

Air Drills

Air drills have bulk seed hoppers and integrate seed metering and air delivery systems with hoe or double-disk furrow openers. Individual row unit suspensions and depth-controlling press wheels follow ground contours and give better depth control than air seeders. Air drills can have field capacities and residue clearances similar to air seeders.

Disk Drills

Conservation disk (no-till) drills use single or double disks for furrow openers and press wheels for soil firming. Most manufacturers offer coulters or staggered double-disk openers for cutting soil and residue. Ballast weight may be added to frames or row units. Seed cup block-offs and moveable openers allow row spacing adjustments. Common uses are for seeding small grains, beans, and other solid seeded crops and for interseeding grasses and legumes.

Hoe Press Drills

Hoe-opener press drills are primarily used in drier climates for seeding small grains where the depth to moist soil may be 3 or more inches. The hoe opener can penetrate and place the seed in moist soil, leaving a small furrow without having an excessive amount of soil covering the seed. Much of the drill weight is carried on the rear press wheels to improve soil firming for seed-soil contact. The openers are widely spaced and staggered for residue clearance. Models with coulters mounted in front of the openers have improved residue tolerance, but large amounts (5,000 kg/ha or more of wheat straw) may cause plugging. Stance and moisture content greatly affect the amount of straw that can be tolerated.

Functional Factors To Consider

Equipment Selection

Selecting a brand and the specific components for a conservation planter can be bewildering. Some manufacturers offer a very wide range of options in components. Other manufacturers offer add-on equipment. The dealer may not be prepared to help in selecting the best component option for specific conditions, particularly if the dealer is unfamiliar with new designs and options.

Advice for selecting component options may be available from the manufacturer's representative, other producers, conservationists, extension specialists, or experienced dealers. Field demonstrations of conservation planters and seeders can be very helpful to evaluate components. In the past, considerable trial and error was involved in selecting component options. However, those who do conservation planting and suppliers who work closely with them have valuable experience that should be sought when selecting components.

Component Tracking

On hillsides and curved rows, the seed slot opener may not follow in the coulter slit, or the press wheel may miss the seed slot. This is usually caused by relatively large fore and aft distances between successive seeder components. Strip-tillage and closer-spaced components will help overcome these limitations. Pivots between the coulter, furrow opener, and press wheel will improve tracking on curve rows. Pull-type planters will track better than mounted planters on curved rows, but mounted planters will track better on hillsides.

Residue Accumulation

For conservation tillage, surface residues will cover 30 percent or more of the soil surface at planting time. The residues may be coarse or fine, tall or short, chopped or long, and attached or loose. Planter components should not be expected to operate through large piles of residue deposited by combine harvesters, although the ability to pass through such piles without becoming inoperable is beneficial.

Residues accumulate on planting machines in two ways. Residues hairpin around soil-engaging components, such as chisel shanks, and around supporting struts and frame members. This is usually prevented by effective residue cutting ahead of each component. Residues also catch between adjacent components. This can be reduced by substantially staggering adjacent components, by using smooth-sided wheels, and by eliminating protrusions and bottlenecks between components. Tillage and components of planting machines that detach residues from the roots create problems; attached residues flow between planting machine components much better than loose residues.

Rocks and Other Obstructions

Rocks and other obstructions will require reduced field speeds for safe operation and to minimize machine damage. Obstructions may be more firmly emplaced in non-tilled soils than in soils loosened by primary tillage. Rolling coulters and disk openers will roll over obstructions with momentary loss of depth control. Rigid shank-type openers should be equipped with trips, shear pins, or other protective devices.

Selection of Machine Components

Planting machines can be characterized by their components that actively engage the soil. The components each perform part of the planting process, such as cutting residue, opening a seed furrow, and pressing the seed into contact with the soil. Together the components must be mutually compatible so that the desired total function of the planting machine is achieved.

Considering all of the soil-engaging machine components from the suppliers, there may be as many as 864,000 possible combinations of components that could be selected for a planting machine. Presumably, one or more of these combinations would be the ideal machine for a particular planting condition. Many conservation planting machine components can also be used for conventional tillage, but conservation-tillage machine requirements are not discussed in this paper.

The same soil-engaging components may be available as options on several different kinds of machines, such as on row-planters, drills, and air seeders, and from several different manufacturers. In such cases, machines from several sources may provide comparable performance for the stated condition. In other case, there may be few or none available, and custom modifications will be required to provide a planting machine to meet the specifications. All components selected for a specific machinery requirement must be compatible in function. Machines will not necessarily require all seven component functions listed below for acceptable performance.

Soil and Residue Cutting

Rolling coulters are generally used for cutting soil and residue, although they may be omitted on machines that have an opener, such as a staggered double-disk opener, designed to perform this task and to open the seed slot. A wide range of coulter options is available. Smooth coulters generally cut better and may be sharpened when required. Rippled coulters tend to be self-sharpening and will tolerate some sticky soils. Narrow fluted coulters and bubble coulters accomplish some soil loosening in the immediate row area; however, their usefulness is limited in sticky soil conditions. Wide-fluted coulters accomplish strip tillage in friable soils, but they throw too much soil out of the row at speeds above 6.4 km/hr (4 mph). Additional problems with wide-fluted coulters include the lack of a clean-cut path for the trailing furrow opener and the production, in some soils, of a ragged row of clods that are unacceptable for uniform seed coverage. Coulters cut residue if the soil surface is hard, but they push residue into soft prepared or loosened soil unless they remain sharp. Large diameter coulters cut residues easier but require more downpressure for penetration. Downpressure requirements range from 150 to 400 lbs per unit for penetration in many residue and soil conditions. A powered coulter used on at least one drill may improve residue cutting and residue flow through the machine under conditions where coulter performance is inadequate.

Components for soil and residue cutting (Figure 2) are as follows:

1. Smooth coulter
2. Notched coulter
3. Coulter with depth bands
4. Offset coulter
   a. Bubble coulter
   b. Rippled coulter
   c. Fluted coulter
5. Straw straightener
6. Powered blade or coulter
7. Strip rotary tiller
8. Dual secondary residue disks

Row Preparation

Some machines include a device for preparing the row area. Devices include those used to clear residue for ridge- and strip-till, or to deeply loosen soil ahead of the seeding unit. Row clearing devices remove dry surface soil along with the residues, which brings the planter into contact with the moist underlying soil. Row clearing is not practical on soils that easily form crusts when compacted while moist, and on soils that are unmanageably sticky when moist. Deep loosening is useable only on soils that are friable (non-clod-forming) at planting time. Some row preparation components provide strip tillage behind a soil- and residue-cutting component.

Components for row preparation (Figure 3) are as follows:

1. Sweep row cleaner
2. Two-disk row cleaner
3. Horizontal disk row cleaner
4. Wide-fluted coulter
5. Ripper chisel
6. Subsoil ripper
7. Packer roller
8. Rolling basket
9. Rotary cultivator
10. Spring tines
11. S-tines

Depth Control

Accurate depth control is essential for uniform emergence. Many row crop planters have depth gauge wheels on the sides of each seed slot opener. Front wheels and rear press wheels are used to give a tandem-wheel depth averaging on some planter units. For no-till drills, the rear press wheels are often used to provide depth control because of space limitations; the opener and press wheel are either mounted on a trailing arm arrangement or on parallel linkage as used on row crop planters. For most air seeders, openers are attached semirigidly to the tillage implement frame, in which case depth is controlled by the liftinglgauge wheels. Seeding depth is a function of applied downpressure and soil strength on machines without positive depth controls. Seeding depth with these machines is as variable as the soillresidue conditions.

Components for depth control (Figure 4) are as follows:

1. Rear press wheels
2. Side gauge wheels
3. Skid plate on each opener
4. Front wheels and rear press wheels tandemed
5. Frame liftinglgauge wheels
6. Depth bands
   a. Bands on front leading coulter
   b. Bands on disk opener

Soil Opening for Seed Placement

Many row planters and grain drills use either regular or staggered double-disk openers to open seed furrows. Other opener devices used include runners, stub runners, single disks, and hoes. Additionally, some machines precis ely shape the seed groove by using a V- or U-shaped shoe. Air seeders may place the seed behind and under tillage points or blades. Air drills use any of the means commonly used on row planters or drills.

If not preceded by soil- and residue-cutting components, most openers will either collect surface residues or roll over them, crimping them into the seed furrow. The adhesion of moist soil to opener parts may enhance the accumulation of residues. Disk openers are usually self-cleaning and do not accumulate trash and moist soil. Special rotating scrapers are available for double-disk openers in sticky soil conditions. Rigid runner, hoe, and chisel-boot openers may accumulate trash and wet soil. These should only be used in friable, low-clay content soils.

Narrow furrow openers throw less soil laterally so that more soil is available for seed covering and a deep seed trench is not created. Shallower planting with conservation tillage and slower speeds also help reduce lateral soil removal from the row area.

Components for soil opening for seed placement (Figure 5) are as follows:

1. Double disk with or without shoe
2. Staggered double disk with or without shoe
3. Runner
4. Stub runner
5. Hoe
6. Single disk
7. Coulter
8. Chisel
9. Wide sweep
10. Triple disk
11. Powered blade or coulter

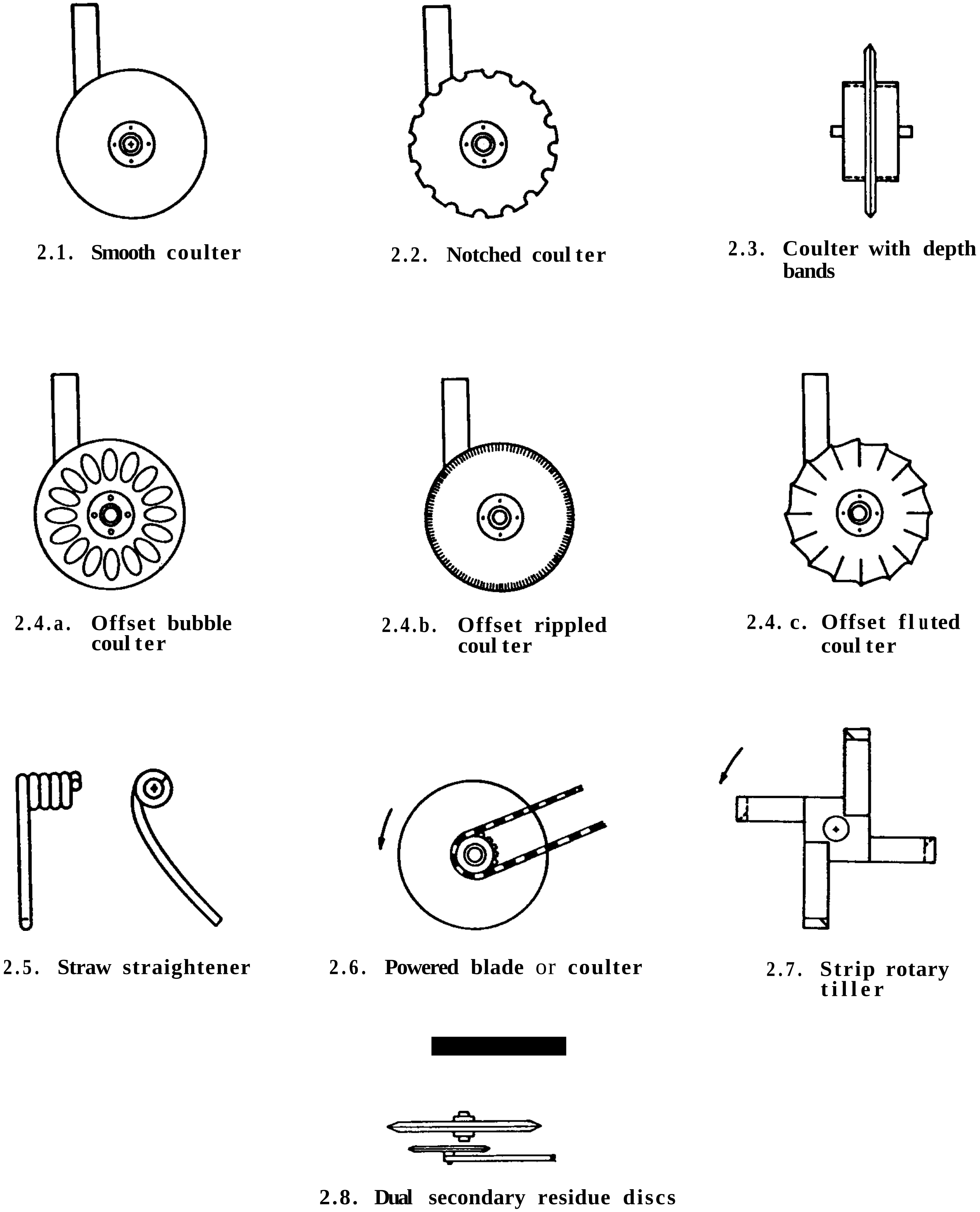
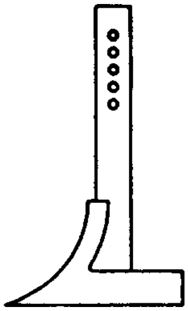
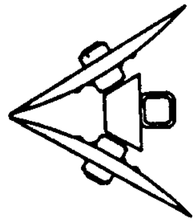


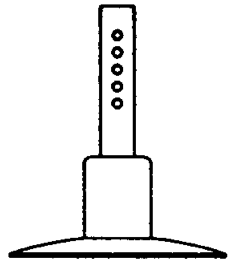
Figure 2. Component options for soil and residue cutting.



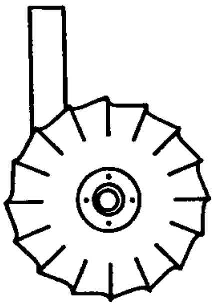
3.1. Sweep row cleaner



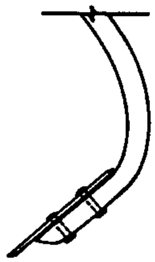
3.2. Two-disc row cleaner



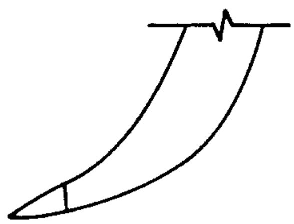
3.3. Horizontal disc row cleaner



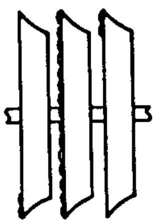
3.4. Wide fluted coulter



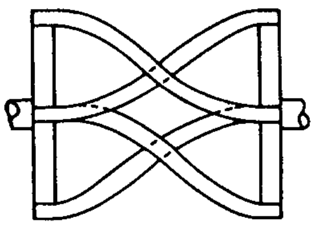
3.5. Ripper chisel



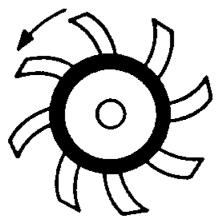
3.6. Subsoil ripper



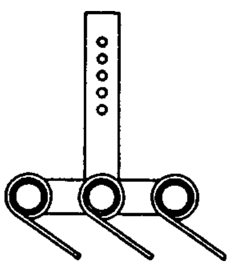
3.7. Packer roller



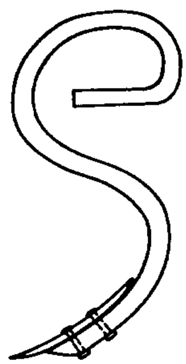
3.8. Rolling basket



3.9. Rotary cultivator

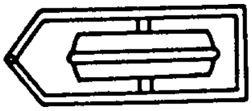


3.10. Spring tines

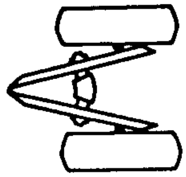


3.11. S-tines

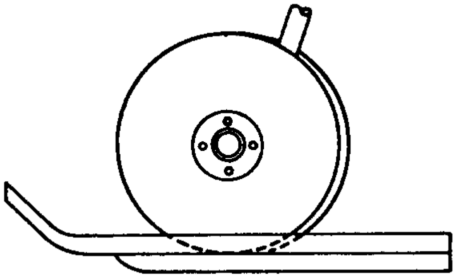
Figure 3. Component options for row penetration.



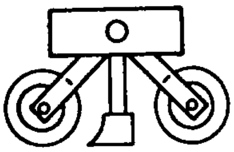
4.1. Rear press wheels



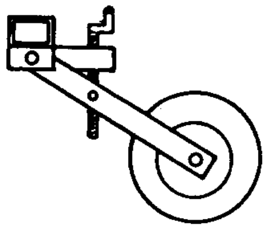
4.2. Side gauge wheels



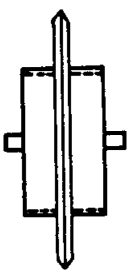
4.3. Skid plate on each opener



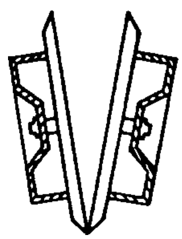
4.4. Front wheels and rear presswheels tandemed



4.5. Frame lifting/gauge wheels

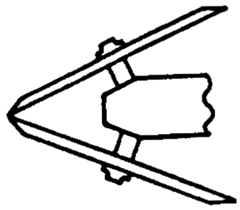


4.6.a. Depth bands on front leading coulter

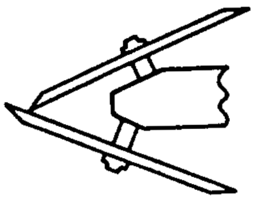


4.6.b. Depth bands on disc opener

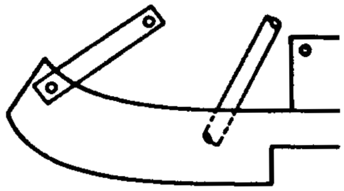
Figure 4. Component options for planting depth control.



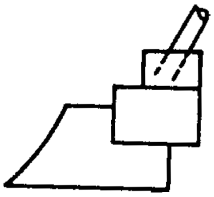
5.1. Double disc



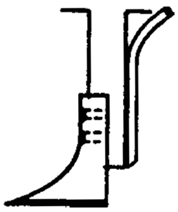
5.2. Staggered double disc



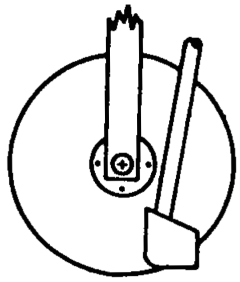
5.3. Runner



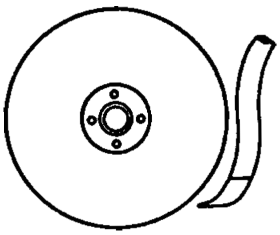
5.4. Stub runner



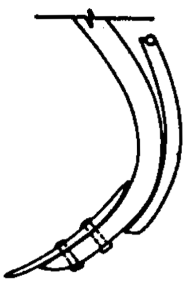
5.5. Hoe



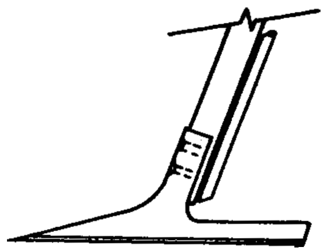
5.6. Single disc



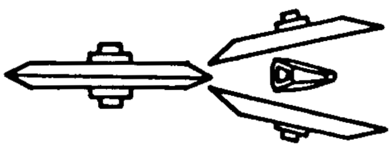
5.7. Coulter



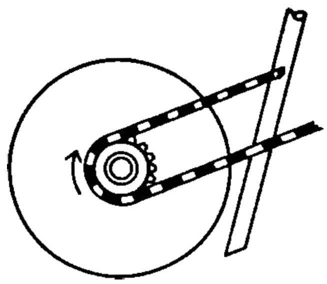
5.8. Chisel



5.9. Wide sweep



5.10. Triple disc



5.11. Powered blade or coulter

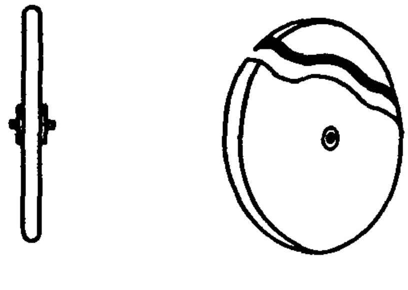
Figure 5. Component options for soil opening for seed placement.

Uncovered-Seed Firming

A seed-firming wheel is sometimes used to press the seed into the bottom of the seed furrow. These devices are semipneumatic rubber wheels ranging from 1X 6 to 1X 10 inches, or solid-plate wheels as narrow as 114 inch. Downpressure, in addition to the weight of the wheel assembly, may be supplied by springs. Uncovered-seed firming wheels improve seed emergence rates under dry soil conditions. They are sometimes used without rear press wheels if followed by seed covering devices. In sticky soil conditions, seed-firming wheels collect soil and can become unuseable because they pick up seed from the furrow.

Components for seed firming (Figure 6) are as follows:

1. Semipneumatic wheel
2. Solid wheel



6.1. Semi-pneumatic wheel **6.2. Solid wheel**

Figure 6. Component options for uncovered-seed firming

Seed Covering

Covering devices must have loose moist soil available to place on top of the seed or must loosen soil and move it over the seed. Moist soil may be available with ridge and strip tillage after row clearing devices have removed dry surface soil. Moist soil is not available with narrow slot-type no-tillage planters and drills that disturb a minimum amount of soil. Residues may accumulate in covering devices. Seed covering components are used when seed slot closure components are either not used or are inadequate to completely cover the seed.

Components for seed covering (Figure 7) are as follows:

1. Single covering disk
2. Double covering disks
3. Paddles
4. Knives
5. Drag chains
   a. Loop
   b. Trailing
6. Spring tines

Seed Slot Closure and Firming

Almost all seeders use press wheels to close and/or compact the seed slot. The exceptions to this are drills that use drag chains and planters that use only seed-firming wheels and covering disks. Press wheels come in a wide variety of sizes, shapes, and configurations. Most have semipneumatic rubber coverings to prevent soil buildup. Some manufacturers offer steel press wheels for dry soil or sod planting. The method of slot closure must be compatible with the amount of soil loosened by preceding components. Dual angled wheels provide positive seed covering as well as soil firming. Some press wheels, such as the single rib and the V press wheels, are used to transmit pressure down to the buried seed to firm it in the soil. Dual ribbed or dual wheels are used on some soils to reduce surface pressure directly over the seed to reduce soil crusting. Press-wheel driven planters must have enough down force on the rear press wheel to both close the seed slot and provide a non-slipping planter drive. Slot closure and firming wheels may be either individually mounted or arranged in gangs. Ganged wheels lack individual flotation over soil surface undulations and may not align with the seed rows.

Components for seed slot closure (Figure 8) are as follows:

1. Wide semipneumatic or steel wheel
2. Single rib wheel
3. Double rib wheel
4. Narrow semipneumatic or steel wheel
   a. V-shaped
   b. Rounded
5. Dual angled semipneumatic or steel wheels
6. Split steel wheels
7. Dual wide flat wheels

Optional Functions

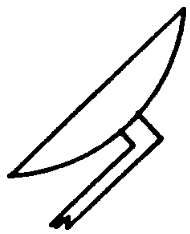
Fertilizer and some chemical incorporation attachments may require additional weight for soil penetration, and, therefore, planting machine frames must be stronger. Such attachments reduce clearance between planting machine components and may reduce machine tolerance to heavy residues. Trailing incorporators, which mix a band of material with the surface soil, may be limited to rolling types to avoid residue raking. Surface residues may reduce the incorporation effectiveness of these devices.

Putting Together The Specifications

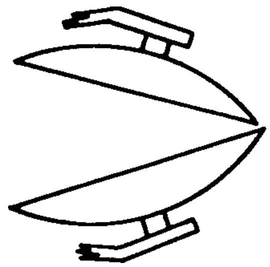
Specifications for selecting conservation planting machines are formed by following three steps: 1) Determine the crop, residue, soil, and management conditions that are going to be used with the machine; 2) Follow the descriptions of each of the seven soil-engaging planting machine functions, and select the potentially useable components for each function; and 3) Delete from further consideration all of the components that are not functionally compatible with other selected components. The result is a set of specifications for a planting machine for the anticipated usage. An example is given in Table 1 for a hypothetical situation.

Choosing From Available Machines

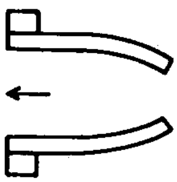
The planting machine specifications from above are matched with available machine components to iden-



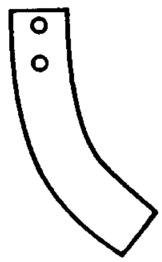
7.1. Single covering disc



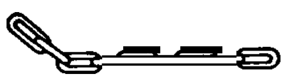
7.2. Double covering discs



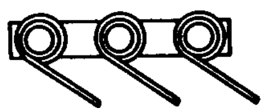
7.3. Paddles



7.4. Knives

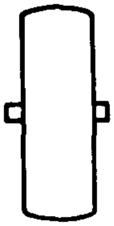


7.5. Drag chains

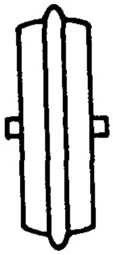


7.6. Spring tines

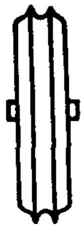
Figure 7. Component options for **seed covering.**



8.1. Wide semi-pneumatic or steel wheel

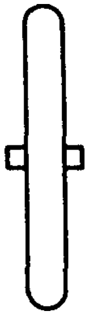


8.2. Single rib wheel

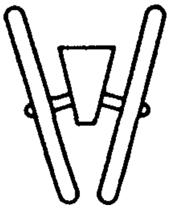


8.3. Double rib wheel

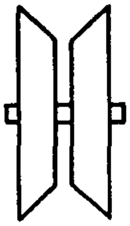
8.4.a. Narrow semi-pneumatic or steel wheel : V-shaped



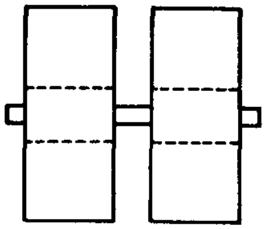
8.4.b. Narrow semi-pneumatic or steel wheel : Rounded



8.5. Dual angled semi-pneumatic or steel wheels



8.6. Split steel wheels



8.7. Dual wide flat wheels

Figure 8. Component options for seed slot closure.

TABLE 1. EXAMPLE OF GENERATION OF PLANTING MACHINE FOR SPECIFIC FARM AND CROPPING CONDITIONS

Conditions:
- Location — Henry County, Illinois
- Soil — Catlin
- Slope — 4.0%
- Slope length — 80 ft.
- Previous crop — wheat
- Previous crop yield — 50 bu/a
- Crop being planted — corn
- Row spacing — 30 in.
- Tillage system — no tillage

Predicted Soil Erosion:
- Annual soil loss — 2.04 T/acre

Soil-Engaging Components Selected:

1. Soil and residue cutting
   - a. bubble coulter
   - b. powered blade or coulter
   - c. smooth coulter
   - d. rippled coulter
   - e. notched coulter
   - f. smooth coulter w/depth bands
   - g. not used
2. Row preparation
   - a. straw straightener
   - b. not used
3. Depth control
   - a. rear press wheels
   - h. side guage wheels
   - c. linked front and rear wheels
   - d. depth rings on leading coulter
   - e. depth bands on opener
4. Soil opening for seed placement
   - a. hoe opener
   - b. double disks
   - c. staggered double disks
   - d. coulter or disk w/seed boot
   - e. chisel opener w/seed boot
   - f. triple disk
   - g. powered blade wheel
   - h. stub runner
5. Seed imbedding
   - a. rubber wheel
   - h. not used
6. Seed covering
   - a. not used
7. Seed slot closure
   - a. dual angled rubber press wheels
   - h. dual angled cast or steel press wheels
   - c. steel press wheel; "V", rounded, or ribbed

New Machines Selected:[1]

Case I-H800	Kinze Double Frame
Deutz-Allis 385	Kinze Rear Fold
Fleischer Buffalo-Slot	New Idea 900/Kinze
John Deere 7000/7100	

[1]Mention of product names does not constitute a recommendation by the authors, USDA-ARS, or the Texas Agricultural Experiment Station over products from other sources.

tify appropriate machines for the anticipated usage. Ideally, matches can be obtained for all seven component functions.

Additional considerations for machine selection include available machine working widths, frame strength, accessories, type and accuracy of seed metering, and parts and service locations.

Modifying Machines

If it is impossible to find a manufactured machine that coincides with the selected specifications, the problem may be resolved by making modifications with components from other manufacturers to complete the machine or to custom-fabricate whole machines. There are more risks involved with machine modifications because the owner cannot take full advantage of the engineering inputs, field trials, and long-term development that is represented by whole-manufactured machines. Some made-to-fit modification kits and assemblies are low-risk possibilities for modification. Generally, machine modification risks include not achieving desired performance, not being cost-effective, and not being adequately reliable.

If an existing conventional seeder is to be converted to a conservation planting machine, then the strength of the frame must be considered. If coulters and additional weight are to be added, then frame and linkages may need reinforcement, and wheels and bearings may need to be upgraded. Caution should be used to avoid using old wide slot furrow openers or press wheels that will not be acceptable for the new conditions. Assembling new combinations of made-to-fit components is the quickest approach to obtain a specialized machine.

Discussion

Components for planters, drills, and air seeders may be selected from lists of available components to form the specifications for a specific conservation tillage planting machine for soils with surface residues. In many cases, several components may be equally effective. In such cases, the specifications will include identified alternatives.

Planting machine selection must be done with consideration of the year-to-year and field-to-field variations in planting conditions. Specific information on planting machine component adjustments are not available, and the operator must take time and gain experience to properly adjust the machine. With careful machine selection and adjustment, satisfactory planting will be accomplished.

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