



(12) **United States Plant Patent**
Felker et al.

(10) **Patent No.:** **US PP21,760 P2**
(45) **Date of Patent:** **Mar. 8, 2011**

(54) **CACTUS PEAR VARIETY NAMED ‘DAR 1-12-19 RED’**

(50) Latin Name: *Opuntia ficus-indica*
Varietal Denomination: **DAR 1-12-19 Red**

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(*) Notice: Subject to any disclaimer, the term of this
patent is extended or adjusted under 35
U.S.C. 154(b) by 0 days.

(21) Appl. No.: **12/584,815**

(22) Filed: **Sep. 14, 2009**

(51) **Int. Cl.**
A01H 5/00 (2006.01)

(52) **U.S. Cl.** **Plt./156**

(58) **Field of Classification Search** **Plt./372,**
Plt./156

See application file for complete search history.

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(57) **ABSTRACT**

A new and distinct variety of cactus pear having the following
unique combination of desirable features:

1. A fruit with a red colored edible interior portion.
2. An average Brix of 14.8%
3. An average firmness of the pulp of 3.4 lb
4. An average pulp percentage of 59%.
5. A fruit weight ranging from 125 to 180 g.

5 Drawing Sheets

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Latin name of the genus and species of the plant claimed:
Opuntia ficus-indica L. Miller.

Variety denomination: ‘DAR 1-12-19 Red’.

No federal or state sponsored research funding was used in
the development of these materials.

BACKGROUND OF THE INVENTION

Fruits of spiny and spineless *Opuntia ficus indica* are about
110-180 grams, range from 12 to 15% total soluble solids
(Brix), have a variety of fruit colors, i.e. green, orange, red
and purple, and have been grown in many arid regions of the
world such as Mexico, Brazil, Chile, Argentina, Spain, Italy,
Israel, South Africa for commercial fruit production (Parish
and Felker, 1997). The market use of the fruit is to be con-
sumed fresh after the peel is removed. Mexico is the world
center of production with great variation in spines, fruit col-
ors, dates of maturity and Brix (Mondragon and Gonzalez,
1996). While the lime green variety Reyna is the leading
cactus pear variety in Mexico (Mondragon and Gonzalez,
1994), this variety has long spines that prevent its cultivation
in the USA due to objections from harvesting crews. Mon-
dragon and Gonzalez, (1996) have reported fruits of many

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colors, but they have not provided experimental details on
field design, laboratory methods or coefficients of variation
for these properties and they do not provide data on firmness
of the edible inner portion which Felker et al., (2005) have
suggested needs to be greater than 2.2 lb for a good quality
fruit. Moreover D’Arrigo Bros data on fruit Brix, firmness,
weight, peel thickness, percentage of edible portion on more
than 30,000 fruit of existing varieties and progeny of new
crosses is not in agreement with Brix values of 15-16 for red
or purple colored fruits reported by Mondragon and Gonza-
lez, (1996). *Opuntia* fruit data from refereed journal articles
in which field and laboratory experimental details with esti-
mates of the variation, have been provided by Barbera et al.,
(1992), Nerd et al., (1991) and Felker et al., (2005).

In 1998, D’Arrigo Bros obtained copies of the more than
100 *Opuntia* clones from Texas A&M University Kingsville
(that were later deposited in the USDA *Opuntia* germplasm
collection in Parlier, Calif.) that represented all of the major
types present in Mexico, South Africa, Argentina and Chile.
As described below, none of the existing cultivars met
D’Arrigo Bros objectives of high pulp firmness (>2.8 lb),
high Brix, (>14), thornlessness and red color in the same plant
and therefore hybridizations were conducted to obtain the

desired variety. This collection included the Texas A&M University Kingsville accession 1281, that was collected at the Universidad Autonoma de Chapingo where its common name was rojo vigor, and that is similar to the Rojo Pelon described by Mondragon and Gonzalez (1996).

There are extensive plantations of cactus pear for fruit in the Mediterranean, principally Sicily but also Spain and Israel. *Opuntia ficus indica* was brought to Spain on one of the first voyages of Christopher Columbus from where it spread to the rest of the Mediterranean region. In the largest commercial production area of the Mediterranean in Sicily, there are 3 varieties, 'Rossa' (with red fruit), 'Gialla' (with yellow fruit) and 'Bianca' (with almost colorless fruit) (Barbera et al., 1992). These three varieties were essentially the same with regard to fruit quality with a maximum Brix of about 13% (Barbera et al., 1992). Nerd et al., (1991) in Israel, found the Brix of the summer Ofer variety (which is yellow and similar to the 'Gialla' from Sicily) to be 11.8% in the winter and 12.8% in the summer. In Argentinean field trials Texas A&M Kingsville (TAMUK) accession 1281 (which is very similar to the Italian 'Rossa') and TAMUK 1277 and 1320 (which are similar to Italian 'Gialla') had Brix values of about 12.6, 12.7 and 13.0 respectively (Felker et al., 2005).

In spite of acceptable fruit sugar concentrations of about 13% in high yielding varieties, such as Italian 'Rossa' and 'Gialla' types (including 1281, 1277, 1320), these varieties have very low pulp firmness of about 2 lb (versus 4 lb for spiny orange 1287 and green fruited Argentine and Chilean varieties) which lead to poor consumer acceptance in Argentina (Felker et al., 2005). While firmness is the parameter measured, the objectionable quality is that pulps with low firmness values lack structural integrity and may break apart when the peel is separated from the pulp. A pulp firmness of about 2.2 lb has been suggested as the minimum acceptable for cactus fruit (Felker et al., 2005).

In the USA, the only commercial variety, the Andyboy red, is similar to the Italian 'Rossa'. The Andyboy red has a Brix of about 13.5 in the summer crop, but maybe as low as 10.5 in the mid winter crop. Perhaps due to the cooler weather of the growing region in the USA, the red fruits do not break apart when peeled, but they are not as firm and juicy as other types. The Andyboy red is also in the low range of pulp firmness of about 2 lb. In the USA, the major demand from consumers is for the red colored fruit, which also has higher antioxidant values than the yellow or green fruits, but is less than the purple ones (Stintzing et al., 2005).

In addition to the published work on the lack of firmness and Brix in red colored fruits, one of us (PF) has visited cactus plantations in South Africa, Italy, Mexico, Chile and Argentina and has not found firm, high Brix red fruits in any existing germplasm collection.

Therefore using the basic crossing technique of Wang et al., (1996), hybrids were made between high firmness, high Brix fruits of other varieties and commercial high producing, low Brix, low firmness red fruited varieties to develop a high Brix, high firmness red fruit with a good commercial yield. Progeny of various crosses were planted near Chualar, Calif. and evaluated for Brix and firmness using previously described techniques (Felker et al., 2005). About one dozen clones of each color class (green, orange, red and purple) from more than 3000 progeny of various crosses were selected and planted in a randomized complete block trial with four replicates (with one plant per replicate) to directly compare fruit characters for these advanced selections. For two years, several fruits were taken from each of the four

replicates, once a month from about September till May. The best red fruited variety of this randomized complete block trial, originally from Block 1, row 12 plant 19 of this trial was found to have the best overall combination of characters and is the subject of this patent. The parents of this plant were a spineless red fruited commercial and a spiny green fruited plant denoted BR-59 from our germplasm collection. None of the parents have been patented or have patent pending.

Asexual propagation

All cactus pear varieties are asexually propagated by cutting an approximate one year old cladode from the mother plant, allowing the cut scar to heal over for approximately 2 weeks and then planting this unrooted cladode (botanically a portion of a dicot stem) about $\frac{1}{3}$ of its height into dry soil. If the cladode does not rot, 100% of them will root in less than a month without any hormone treatments.

Apomixis, that is the asexual reproductive process that occurs in the ovule of flowering plants, frequently occurs in *Opuntia ficus indica* (Mondragon-Jacobo, 2001). While the ratio of apomictic seedlings to seedlings resulting from fertilization varies greatly among female parents, we have found that apomixis occurs in this new variety. Thus this variety could be propagated asexually from apomictic seedlings. It is envisioned that this variety could be genetically engineered to include other traits.

This variety is asexually propagated by planting unrooted cladodes. The claimed plant retains its distinctive characteristics and reproduces true to type in successive generations.

BRIEF SUMMARY OF THE INVENTION

This invention relates to overcoming soft, low Brix characteristics in red fruited cactus pears by controlled hybridization to produce cactus pears with significantly greater fruit firmness and total soluble solids (Brix).

BRIEF DESCRIPTION OF THE DRAWINGS

In FIG. 1 can be seen the exterior and interior portions of mature fruits of 'DAR 1-12-19 Red' at optimal harvest conditions after the spines and glochids removed. The interior of the fruit, after the peel has been removed, is the edible portion.

In FIG. 2 can be seen immature fruits of 'DAR 1-12-19 Red' showing the glochids.

FIG. 3 illustrates a one year old cladode of 'DAR 1-12-19 Red' showing spines on the flat surface and margins of a cladode.

FIG. 4 shows a mature upright, four year old plant of 'DAR 1-12-19 Red' that was thinned to increase fruit size.

FIG. 5 shows open flowers of 'DAR 1-12-19 Red' illustrating the variation in petal colors from morning to afternoon, the stigma and dehiscing anthers.

DETAILED BOTANICAL DESCRIPTION

The color chart used in this specification follows The Royal Horticultural Society Color Chart year 1996. The fruits have a narrow elliptic shape. At optimal harvest conditions, the external peel color ranges in color from a pinkish/red 53C, 53B, 54A to an orange/red 171B while the interior edible portion of the fruit ranges from 47B that is the pinkish matrix to 50C that is the whitish interior. Other red varieties are too soft if harvested when 100% of the fruit surface has the red/pink color and must be harvested when 50-60% of the fruit is covered with the pinkish/reddish color. In contrast, due

to the high firmness, this variety can be harvested when the external peel color is 100% red. There are about 57 areoles per fruit in which the number of glochids per areola greater than 2 mm in length is about 6. Due to the cool weather in the area where these fruits are grown, there are considerable glochids, especially on immature fruit as can be seen in FIG. 2. The maximum glochid length is about 11 mm. There are less than about 100 glochids per areole. There is no pubescence. According to the UPOV classification, the stalk length is medium and the classification of the floral scar depression is 2. The peel thickness is about 5 mm.

While this variety does not have multiple, long (3-5 cm) spines coming out from each areole of the cladodes as do *Opuntias* from the wild, as can be seen in FIG. 3, it does have single small semi erect spines of color 155D about 7 mm in length coming out of some of the areoles. These spines occur most frequently on the margins of the cladode but can also be seen on the flat side of the cladodes. There are about 37 areoles per cladode with a color of 166A. There are no glochids on one year old mature pads. The cladodes, which have a color of 137C, have a smooth surface that is not waxy or pubescent. The sizes of the cladodes are greatly influenced by the climate and growing conditions. Nevertheless, near Gonzalez, Calif. where these plants are grown, a typical mature pad would have a narrow obovate shape and be about 55 cm long, 20 cm wide and 1.9 cm thick. Many of the cladodes have a concave aspect, either along the main length axis of the cladodes or along the width axis of the cladodes. A mature 4 year old plant is about 4 meters wide and 2.5 meter tall.

The flower diameter is about 5 cm and the length of the flower only (not including the immature supporting bud) is about 3 cm long. The length of supporting immature bud, when the flower is open, varies from about 2 cm to 6 cm depending on season of the year and moisture/fertility conditions. The flowers lack fragrance. The color of the broad elliptic shaped petals ranges during the day from about a 23A yellow-orange group when recently opened, to about an orange—red group 30A at the end of the day. This range of colors is illustrated in FIG. 5 with two flowers of different ages on the same cladode. Only one stigma, with a height of about 5 mm, occurs with a light green color (144B). The style has a color of 69D. There are about 500 stamens per flower that are about 14 mm long and that have color 2D on the top portion and 62D on the bottom portion. Anthesis, in the location where the plants are grown, peaks in May and June depending on the weather but some anthesis occurs as late as November. The flowers are not pollinated by honey bees but rather by a specialized cactus bee that makes its nest in holes in the ground.

In Table 1 can be found a comparison of the means and 95% confidence intervals for 93 analyses of Texas A&M 1281 which is a red fruited variety, that is very similar to the commercial ‘Rossa’ from Italy, and our new variety ‘DAR 1-12-19 Red’. It is to be noted that the Brix of 12.7, fruit size of 145 grams and 55% pulp percentage are similar to published values for the Rossa variety described above. In contrast the average of 187 analyses for ‘DAR 1-12-19 Red’ shows a 2% increase in Brix (from 12.7 to 14.8), a 78% increase in firmness (from 1.9 to 3.4) and a slight increase in pulp percentage (from 55 to 59). The average fruit weight of ‘DAR 1-12-19 Red’ is smaller than 1281, but we believe the much greater eating quality will make up for this difference. The fruit size of ‘DAR 1-12-19 Red’ is very susceptible to cultural management and we have been able to increase this size with cultural practices.

TABLE 1

A comparison of new ‘DAR 1-12-19 Red’ <i>Opuntia ficus indica</i> with red fruit to a standard commercial red type fruit TX 1281.					
Variety	Number of analyses	Average of Brix (%)	95% CI of Brix	Average of firmness (lb)	95% CI of firmness
1-12-19	187	14.8	0.19	3.4	0.09
TX1281	93	12.7	0.20	1.9	0.07

Variety	Average of Fruit weight (g)	95% CI of fruit weight	Average of pulp percent (%)	95% CI of pulp percent
1-12-19	125.4	5.0	59	1.0
TX1281	145.5	4.9	55	1.2

With regard to seed content, the TX 1281 had 4.59 grams of seeds per 100 gram of edible pulp (with a 95% confidence interval of 0.56) while the ‘DAR 1-12-19 Red’ had 3.28 grams of seeds per 100 grams of pulp (with a 95% confidence interval of 0.56)

In the area where these cacti are grown commercially in Gonzalez, Calif., approximately 40 km from the Pacific Ocean, the maximum daily temperatures during the growing season rarely exceed temperatures of 30C for more than a few hours. However occasionally in the fall of the year, the orchards experience daily maximum temperatures of 35 C for several days. In some varieties, particularly green varieties without any betaxanthin or betacyanin pigments, this abrupt change in temperature results in serious damage to fruit quality. In this case, the edible portion of the fruits changes from an opaque solid appearance to a water soaked, translucent appearance and the flavor is no longer acceptable. This phenomenon has been denoted “clearing” by growers. In contrast to the green fruited varieties, this reddish/pink ‘DAR 1-12-19 Red’ does not experience “clearing”.

In the location where the varieties are grown in the cool coastal region of central California, normally the date of first picking is the first of September and the date of last picking is May 15. Under optimal storage conditions of refrigeration and humidity control, this non climacteric fruit has a shelf life of about 3 weeks. The plant can withstand a few hours of 20 F with the only damage being to flowers and immature cladodes. Temperatures in the Salinas Valley where the plants are grown never exceed 98 F and the plants suffer no damage from these temperatures. The plant is has good vigor in producing new cladodes from March/April until late November.

The major disease is known as engrosamiento de cladodios (pad swelling) in Mexico that causes stunting of fruits and pads. Our recent research indicates this is caused by an Umbravirus that is transmitted by cowpea aphids. To date all commercial fruit type varieties are susceptible to this virus. The plant is also susceptible to damage from wild cochineal (*Dactylopius* spp) insects.

The invention claimed is:

1. A new and distinct red fruited *Opuntia ficus indica* plant named ‘DAR 1-12-19 Red’, substantially as illustrated and described, characterized by an increased pulp percentage and substantially increased Brix and firmness over any red fruited cactus pear variety.

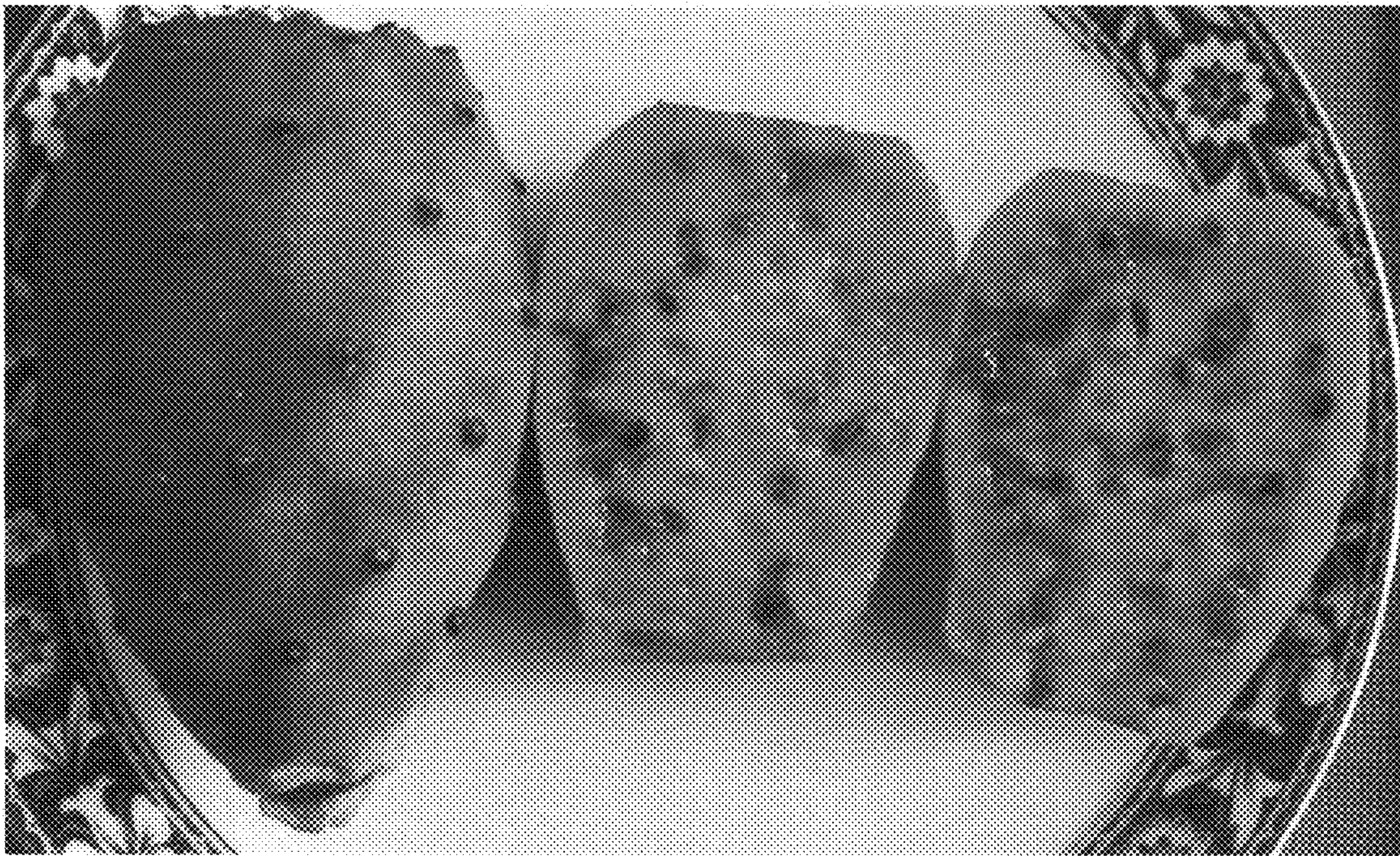


FIG.1

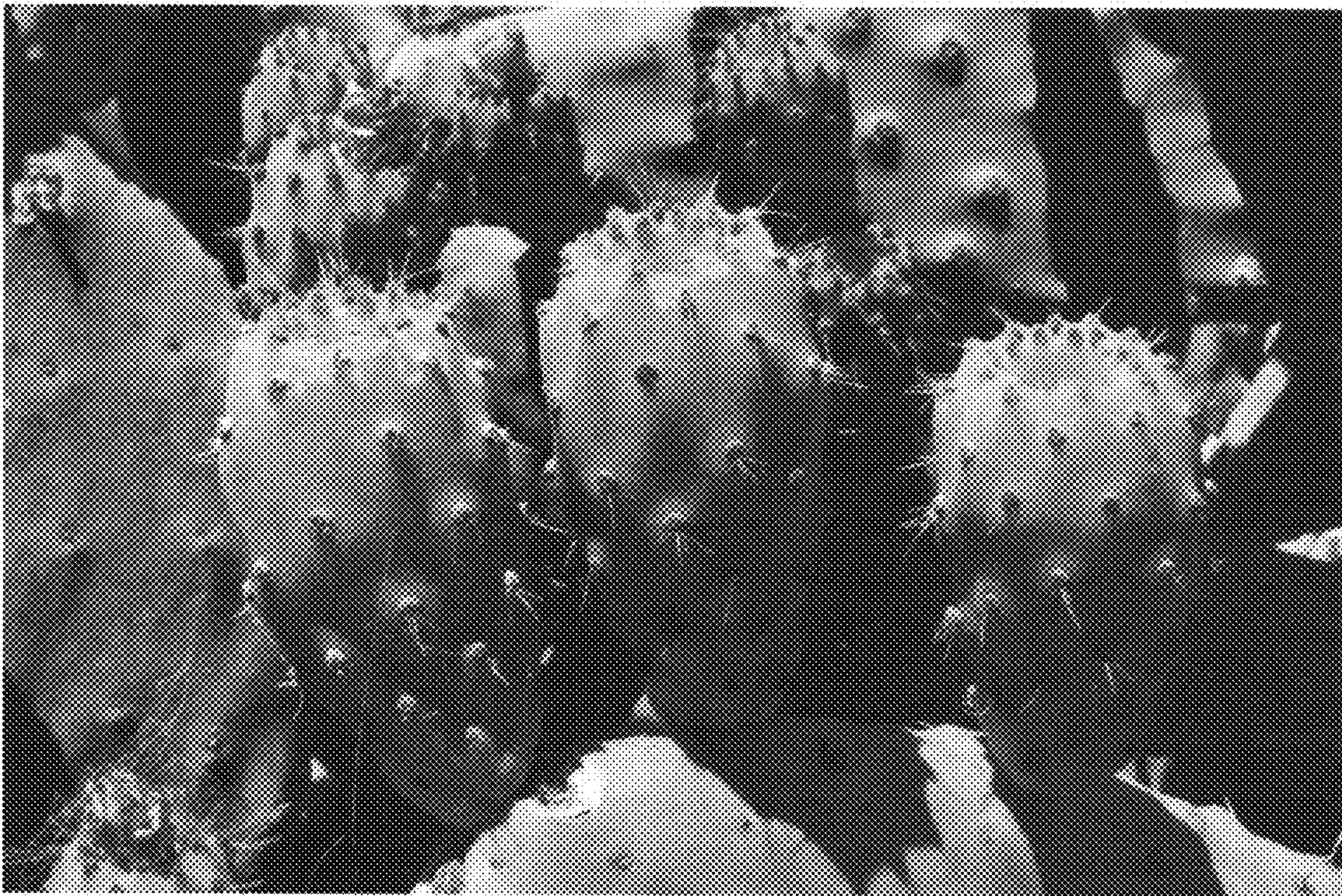


FIG.2

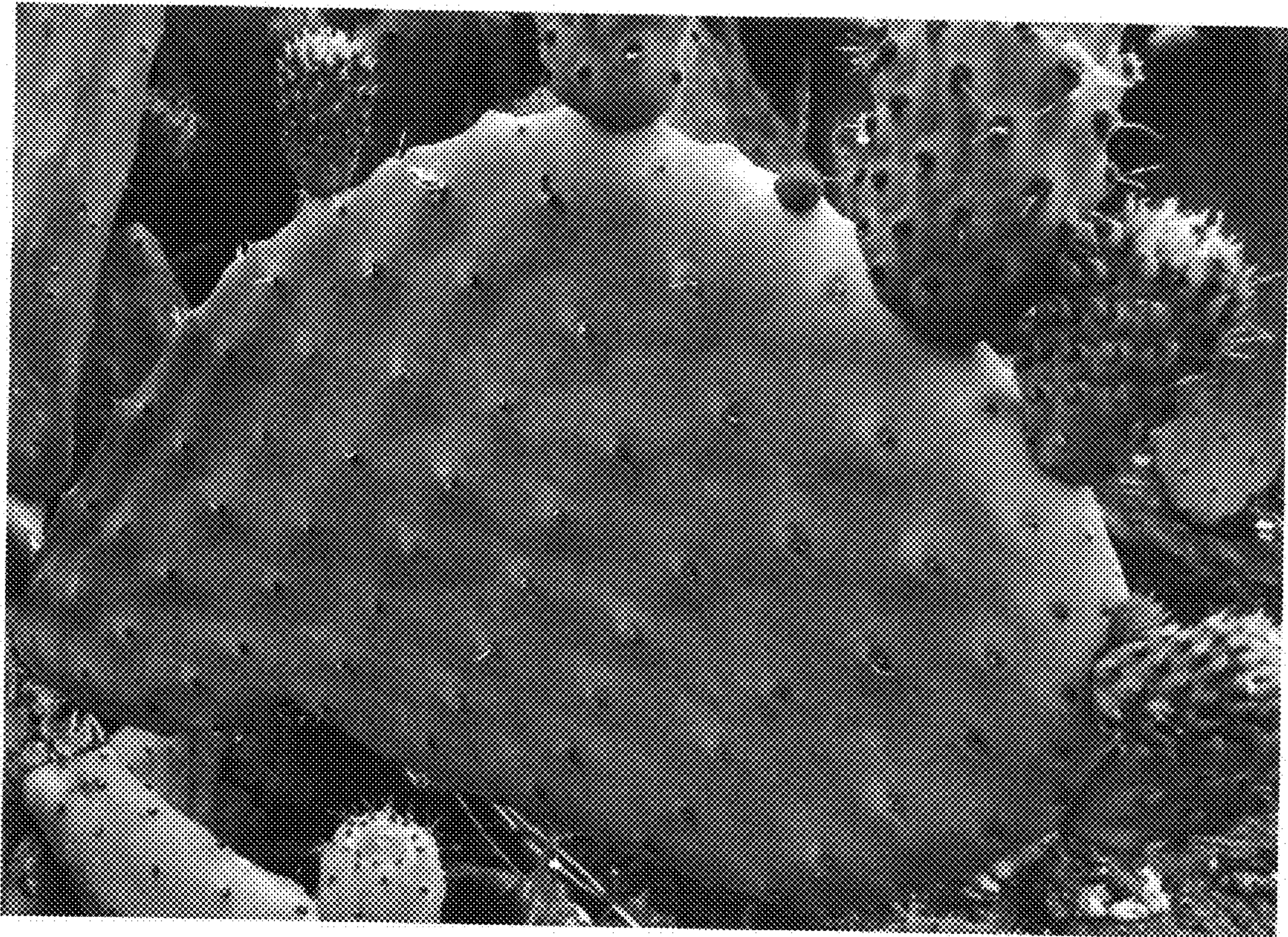


FIG.3

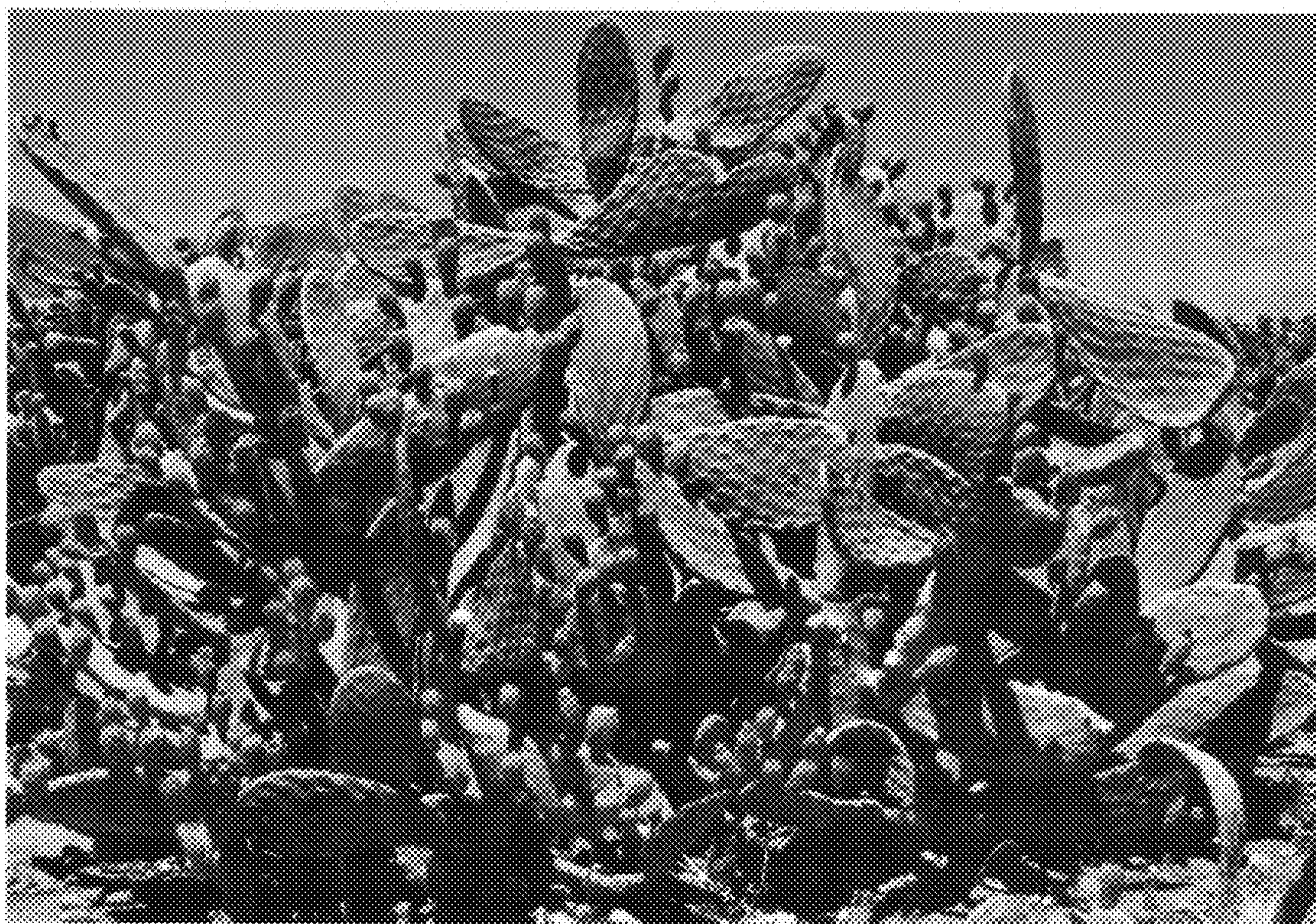


FIG.4

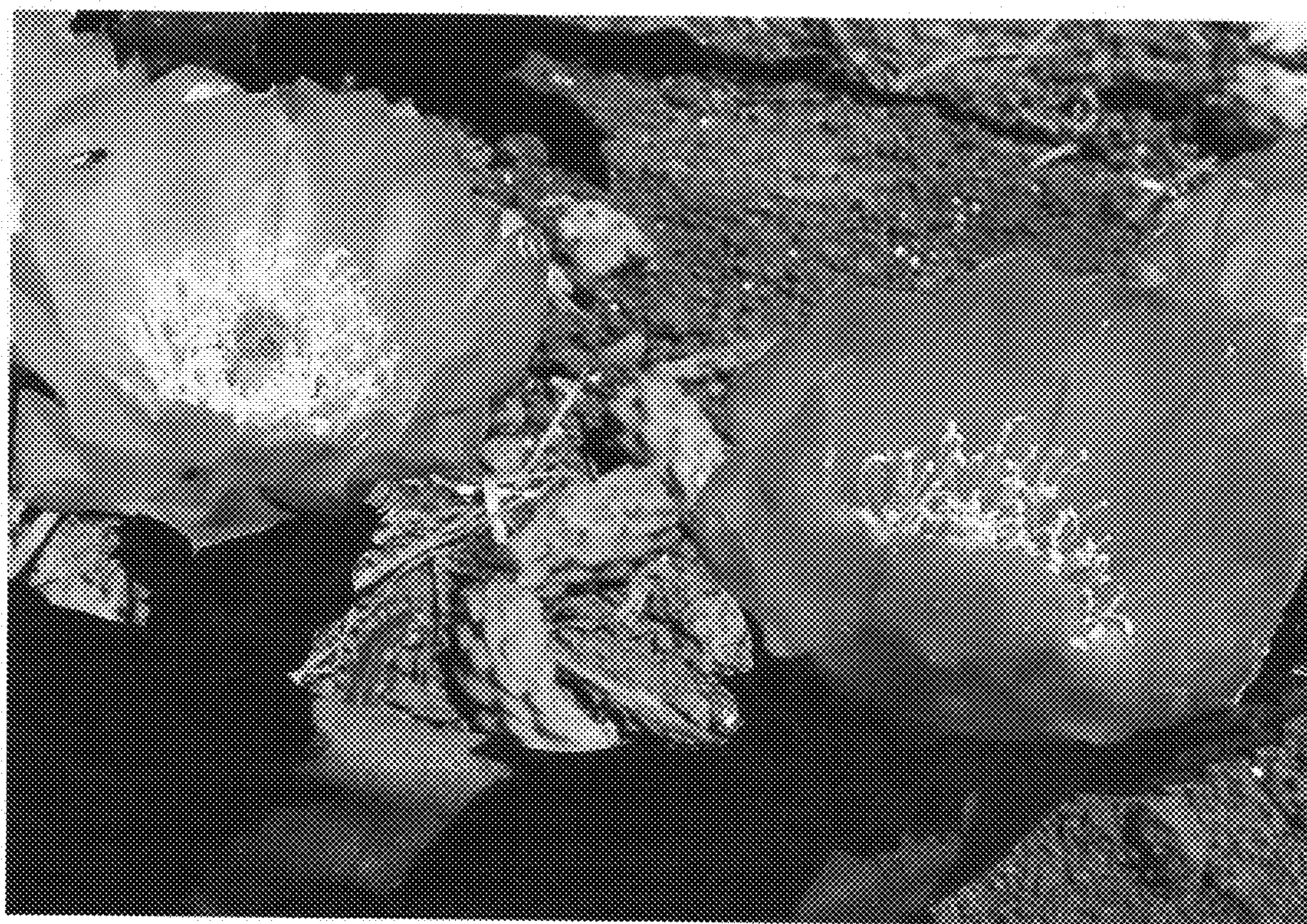


FIG.5