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OPTICAL IMAGES OF QUASARS AND RADIO GALAXIES

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ABSTRACT

We present matched contour plots and gray-scale diagrams of 54 radio quasars or radio galaxies of redshift 0.1–0.6, observed with the Canada-France-Hawaii Telescope. All except four were recorded on the RCA1 CCD chip: four were summed from several photographic exposures behind an image tube. All except nine of the objects form the principal data base of a recent paper by Hutchings, in which most measurements are given. Measurements are presented here for the first time on the nine other objects, most of which have been discussed as radio sources in a 1984 paper by Gower and Hutchings. Detailed comments are given on all objects, and some further measures of the objects and their companions.

Subject headings: galaxies: structure — quasars — radio sources: galaxies

I. INTRODUCTION

Results have been published in a previous paper (Hutchings 1987, hereafter Paper I) of a program of optical imaging of some 50 radio quasars and radio galaxies, in the redshift range 0.1–0.5. In that paper, the measurements were given and used to examine the overall properties of the samples. In this supplementary paper, we show the individual objects and discuss their individual properties. We also include similar individual results and diagrams on several other QSOs and radio galaxies, which have not previously been published but which have been referred to in other papers.

Observations were all obtained at the Canada-France-Hawaii Telescope, usually using *B* and *R* filters. Most of the data were recorded on the RCA1 CCD chip, but some were made with the ITT image tube and photographic plates. Seeing in all cases was measured (FWHM) at between 1″.0 and 1″.5. The data format and reduction techniques are described in Paper I and in Hutchings, Crampton, and Campbell (1984), and will not be given again here. The data presented in the diagrams in this paper (Figs. 1–20) are the finally processed images, smoothed with a ≤ 1.6 pixel (0″.7) Gaussian. In some cases, bad columns have been removed by interpolation across them before smoothing. The diagrams are generally in two forms: contour pots and gray-scale images. These two representations are often complementary in displaying different features of structures which are complex and cover a wide range of intensities. In a few cases of exceptional interest, we display pictures representing color differences, or pictures with simple large-scale models of the main galaxy subtracted. In these latter cases, other blended or superposed objects can be seen more easily. Measurements and morphological classifications of most of the objects are given in Tables 1 and 2 of Paper I. Some objects also have published images in Hutchings *et al.* (1984, hereafter HCCDG). Normally, the lowest contour level displayed is at ~ 26 mag arcsec^{-2}. Gray-level displays go somewhat fainter. The four ITT images reach about 1 mag brighter and may be saturated in their nuclei. Magnitudes of the principal objects are given in Hutchings, Crampton, and Campbell (1984) or in Paper I. The text below gives magnitudes for other objects in the fields. In Table 1 measures are given of objects not published before. As described in Hutchings (1987), there is generally a preferred fit for the luminosity law between exponential and $r^{1/4}$. In the case of the quasars, the central unresolved source is removed before making such a fit.

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II. COMMENTS ON INDIVIDUAL OBJECTS

0017+257.—This radio quasar has swept-back large-scale radio structure, and an extended radio core (Gower and Hutchings 1984). The CCD image reveals a large extended object with a bright nucleus, and four faint companions which may be connected. Some bad columns in the CCD make interpreting the low light levels uncertain, and also lead to the extended appearance of the nucleus. The brightest of the companions (10″ southeast) appears to be connected to the quasar by a curved filament.

0041+119 (Fig. 1).—This is another radio object observed by Gower and Hutchings, and has a large triple radio structure, with possible small-angle precession or wiggle. The optical image shows the quasar to be the southernmost of a close pair of bright objects which could be in mutual orbit. The outer isophotes are irregular, and there are two fainter objects within them. This is one of the few cases where there are two bright galaxies in apparent interaction.

0433+29 (Fig. 1).—A faint red distant galaxy. The outer structure appears swept to the south, with a sharp northern edge. This may resemble the much more clearly seen edge ("shell") seen in Mrk 110 (Hutchings and Craven 1988). The field is crowded with faint small objects to the south; to the north is a bright star. The galaxy structure is irregular, with a bright area to the southwest.

0453+22 (Fig. 2).—The galaxy lies immediately west of a star which is brighter than it, and which overlies some of it. There are also several smaller resolved objects within the

TABLE 1

NEW MEASURES OF SEVEN QUASARS AND TWO RADIO GALAXIES

NAME	z	L_{nuc}/L_{gal} Observed	L_{nuc}/L_{gal} Corrected	m_{gal}	m_{nuc}	$-M_{gal}$	$-M_{nuc}$	SCALE L (kpc)
0017+257	0.28	79	17	18.5	15.5	21.7	24.4	(large)
0041+119	0.23	4.1	1.6	20.0	19.5	19.5	19.8	4.3
1612+262 *R*.....	0.13	10	3	16.8	15.6	21.3	22.4	2.8
1626+554 *R*.....	0.13	3.1	0.4	16.5	17.5	21.7	20.5	3.2
1635+119	0.15	7.7	3.2	18.4	17.1	20.0	21.2	4.8
1641+399 *R*.....	0.59	59	4.5	17.9	16.2	24.3	25.5	(large)
1833+326 *B*.....	0.06	(9.4)	...	16.3	...	20.0	...	4.8
1833+326 *R*.....	...	(4.9)	...	14.2	...	22.1	...	2.9
1845+797 *R*.....	0.06	(7.1)	...	14.0	...	22.3	...	2.0
2328+167 *B*.....	0.28	42	7.7	20.6	18.4	20.5	21.5	7.0
2328+167 *R*.....	...	6.4	1.4	18.9	18.5	21.2	21.3	5.6

NOTE.— $H_0 = 100$ (km s^{-1} Mpc^{-1}); $q_0 = 0$.

projected area of the galaxy. The closest of these (2″ away) is much bluer ($B - R = 1.1$) than the galaxy nucleus, while others are all redder. The outer galaxy structure has an irregular blob to the northwest.

0605+48 (Fig. 2).—This is a faint red galaxy to the northeast of a brighter star. Three fainter galaxies of similar scale length lie about 40″ south, 50″ southeast, and 30″ northeast. It is too small to note any structure.

0607−157.—Earlier data were published on this object by HCCDG. This quasar has an unresolved object 4″ away, and is resolved only in *R* light. It appears to have a low-luminosity host galaxy, with a faint halo. Little can be said about its structure.

0642+21 (Fig. 3).—This galaxy is small, circular, and has slightly irregular contours; particularly in *B* light. In spite of its lack of spiral features, the luminosity profile fits an exponential much better than an $r^{1/4}$ law. It has no obvious companion.

0651+54 (Fig. 3).—This galaxy has an unusual structure, with three maxima. The bright central object appears to be linked to the eastern component; the western component *may* be only an overlap. There is a group of resolved objects of this size and brightness to the east of the object. There is also a plume (tidal tail?) extending to the north of the central galaxy, seen more clearly in *B* light. *B* structure has a large scale length.

0710+43 (Fig. 4).—This galaxy lies at the large redshift of 0.52. It lies in a tight group of faint objects, and has curved connecting luminosity with one about 4″ to the northeast, seen more clearly in *B* light. The galaxy is luminous, of intermediate intrinsic color, and its luminosity profile in *R* light fits an $r^{1/4}$ law.

0735+178 (Fig. 4).—This luminous quasar at high redshift (0.42) is unresolved except at its faintest outer levels. It has connecting curved *R*-band luminosity with a faint galaxy 7″ to the northwest. There appears to be a sparse group of similar faint (~ 22 mag) galaxies in the field. Brighter objects are unresolved stars. Our observation yields a magnitude ~ 0.9 fainter than the Hewitt and Burbidge (1987, hereafter HB) catalog.

0736+017 (Fig. 5).—This quasar lies in a resolved round galaxy with little structure. There is a faint round resolved object 6″ to the southeast, within the host galaxy fuzz. Another lies east-northeast at a distance of 12″. Bright edge-on spirals and companions, possibly at the quasar redshift, lie some 40″ away, to the southwest and southeast. These bright galaxies are similar in luminosity to the quasar host galaxy.

0742+02 (Fig. 6).—This galaxy lies close to (20″) a bright star, and the CCD frames are contaminated by scattered light from the star. This light is modeled and subtracted in the diagrams. The galaxy appears to be elliptical and without obvious structure. It appears to be a member of a cluster of about 30 similar extended objects in the field.

0806−10 (Fig. 6).—This galaxy also lies close to a bright object—in this case a bright galaxy. Here, too, the diagram has the large-galaxy light subtracted. The radio galaxy is elliptical, structureless, but asymmetrical, and has an extended companion object embedded within its light, some 5″ to the east. Three other faint extended objects lies within 20″, and there is a fainter embedded extended object 6″ to the west. It seems probable that an interaction is taking place, from the high concentration of faint objects with the galaxy. The lowest contours are not reliable.

0812−02 (Fig. 5).—This is a large, faint galaxy. The *R*-band image appears to have two spiral arms emerging from the central elliptical bulge. There is also a faint extended feature within the northeast arm, and a secondary nucleus 4″ to the north. Several other faint extended objects lie within 20″. The overall size is large (77 kpc). The *B* image is fainter and shows only the inner bulge and secondary nucleus, although it is irregular in outline. The main nucleus and northeastern feature are bluest, and the southwestern part of the galaxy is redder. The luminosity profile is exponential, and an interaction or merger seems very probable here.

0818+47 (Fig. 6).—This low-redshift galaxy has a very smooth, round shape and fits an $r^{1/4}$ law well. It appears to be an elliptical galaxy. There is a connecting curved luminous bridge to a (R ~ 22 mag) companion object 11″ to the west. The color of both objects is quite red ($B - R = 2.0$). There are several other galaxies of similar size and brightness in the

field, one of which has spiral arms. None appear to be interacting.

0831+55 (Fig. 7).—This is a large galaxy in a field also containing a cluster of more distant galaxies. Most of these are redder than the radio galaxy. The nucleus is blue, as is an elongated faint object to the southwest, which has luminosity scale length similar to that of the radio galaxy. The ratio of red to blue images reveals that there is a color change across the short axis of the galaxy through the nucleus, probably indicating dust. Blue areas to the south of the nucleus may indicate star formation. A faint blue feature to the northeast may be a tidal tail. The asymmetry, large scale length, and tail suggest interaction between the galaxy and the blue elongated galaxy to the south.

0837−120 (Fig. 6).—This quasar is resolved in B and R light. It appears to have connecting luminosity with a barlike object 4″ to the west and a round resolved object 5″ to the east. The western object is redder, and the eastern object bluer, than the quasar. A double-nucleus object 10″ to the northeast is redder and possibly connected. The quasar nebulosity itself has a bulge or extension to the southwest. The field contains a number of small resolved objects (presumably a cluster). The luminosity law is indeterminate in type, but the scale length is large (8 kpc).

0846+100 (Fig. 8).—An image-tube R image of this quasar was just resolved by HCCDG. The CCD B image is unresolved. In both colors, there is a connection to a faint companion 7″ to the east. Another faint companion lies 11″ to the northwest. The quasar image in both colors has a slight isophote elongation to the northwest. The B image shows the quasar magnitude to be 18.6, suggesting that it has brightened from the 19.2 given by Lynds and Wills (1972). The faint companion objects are both near 23.5 mag in B.

0911+053 (Fig. 8).—This quasar is well resolved in B and R. It has a close companion bright galaxy to the southwest which is red and has similar scale length to the quasar host. There is no apparent interaction. The inner quasar galaxy is elongated to the southeast, and its overall shape is extended southeast to northwest. A faint irregular galaxy lies along this southeast axis some 18″ away, and the northwest extension of the quasar may be a curved tidal tail. In any event, the quasar galaxy is irregular in shape. The faint companion to the southeast is blue, with R-magnitude 21.7 and B-magnitude 22.9. The quasar has $R = 16.7$, $B = 16.9$ (Lynds and Wills give 17.4); and the bright companion has $R = 18.6$, $B = 21.6$.

0917+45 (Fig. 8).—This is a large red galaxy which appears to lie in front of a rich cluster of galaxies at higher (~ 0.3?) redshift. There are three fainter objects of similar apparent scale length to the south and east. There is a closer one to the northwest. It is difficult to tell whether there is an interaction in this case. The radio galaxy is blue in the center and red on the outside. The $R - B$ image is very irregular and suggests a connection to the companion to the east.

0936+36 (Fig. 9).—This is a large galaxy which is clearly interacting with a smaller companion to the south. The companion has very bent isophotes, and there is a long blue tidal tail extending to the northeast of the radio galaxy. The main galaxy has a red dust lane across its short axis to the south of the nucleus (see $B - R$ picture). Luminosity profiles fit $r^{1/4}$ laws, with B falling faster than R.

0958+29 (Fig. 10).—This radio galaxy is the northernmost and brightest of a group of three galaxies. There is no obvious interaction among them. However, the active galaxy has four fainter "nuclei" embedded within it, the innermost of which is less than 2″ from the center. These fainter objects are all redder than the central nucleus. There are many such small objects in the field (although not as tightly grouped as these), and it may be a background cluster. Another close-by object to the south is more diffuse (and very blue: $B - R = 0.2$) and could be associated. Apart from its blue nucleus, the main galaxy has low surface brightness, as do its large companions. Large companions are redder ($B - R = 1.7, 1.9$) and about 20 mag in B. The active galaxy has a uniformly bluer color than its companions. It seems likely that there is some sort of tidal interaction occurring here.

1003+35 (Fig. 10).—This is a large, smooth-looking elliptical galaxy. It has no visible companions or irregularities. The central region has a blue bar aligned with the short axis of the galaxy (seen in the $B - R$ image). The radial luminosity follows an $r^{1/4}$ law well out to about 6″, after which there is an extra light in both B and R. The nucleus is blue, and the overall color is also relatively blue: $(B - R)_0 = 0.8$. The outermost isophotes may be somewhat wispy. This may be a galaxy which underwent merging, perhaps some 10^8 years ago.

1004+130 (Fig. 11).—This quasar is not definitely resolved in B. The R image is round and structureless, but the outermost isophotes are wispy and there is an outer faint shell 40 kpc to the northwest, which may be seen in B light as well. The R luminosity law appears to be $r^{1/4}$. No interactions are seen. This is another case which may be postmerger.

1011−282 (Fig. 11).—The R image of this quasar was obtained with the ITT image tube and published by HCCDG. This showed an elliptical object without structure. The B image was obtained through some cloud and is not very deep. However, it is only marginally resolved, and not obviously elliptical. It has faint outer wisps. Both images show a faint extended nebulosity to the southwest. This is another slightly disturbed elliptical galaxy. Gower and Hutchings (1984) discussed the radio morphology.

1020−103 (Fig. 11).—This quasar was also observed in R with the ITT tube, and just resolved, showing little structure. The (new) B image is also just resolved, but it has irregular outer structure, particularly in the form of extensions to the south and southeast. A companion galaxy some 20″ to the northwest appears extended toward the quasar, and there is possible faint connecting luminosity. The luminosity law is not exponential: it may be $r^{1/4}$. There is also a faint extended object 20″ to the northwest. Other objects in the field are more compact and presumably not related.

1030+58.—This distant galaxy has a complex morphology, and lies in an apparent cluster of resolved objects which are probably at the same redshift. There is a very high density of overlapping objects at the galaxy, which is the dominant member of the group. It seems very likely that some of these objects are interacting. Luminosity laws (including the blended

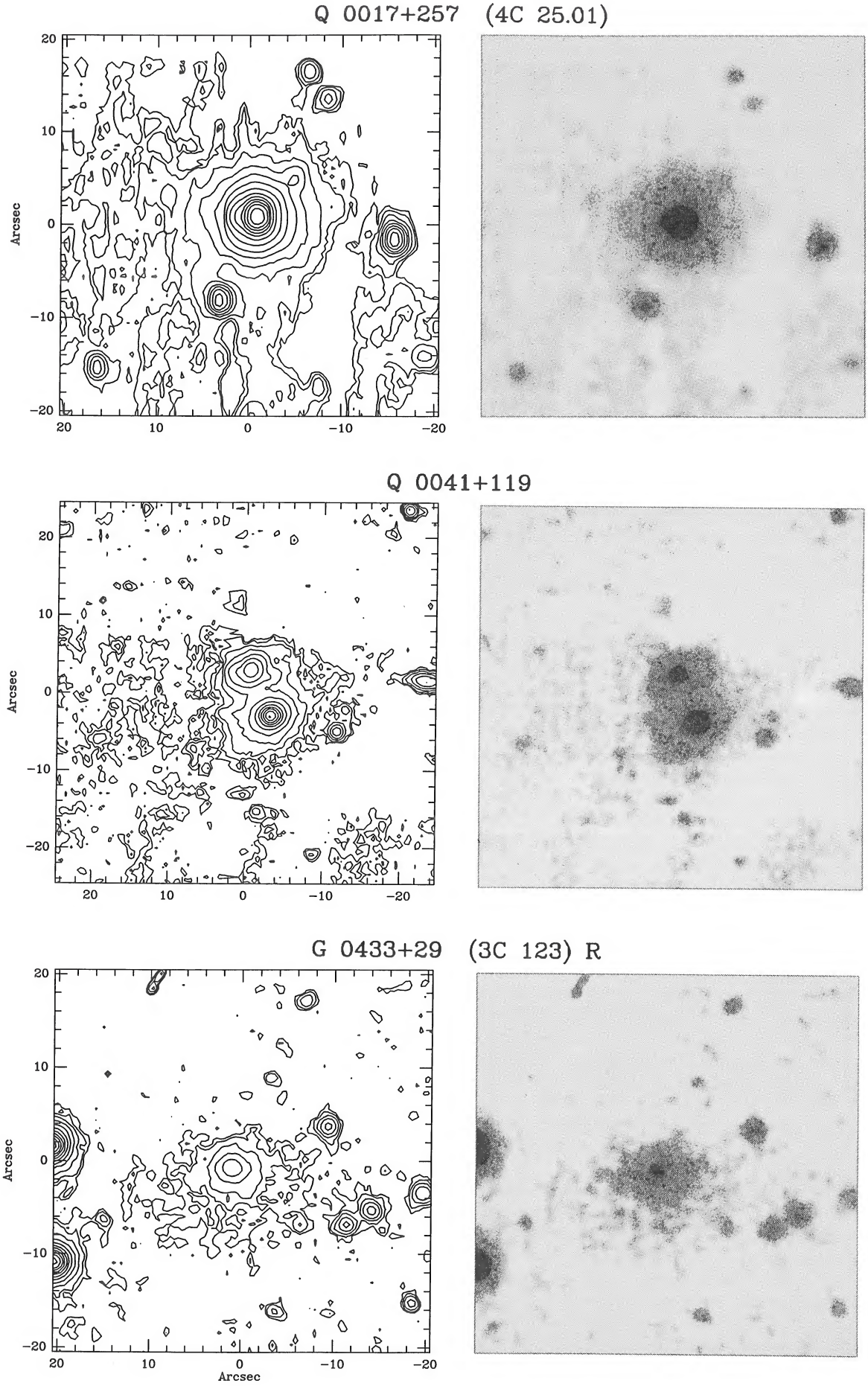

FIG. 1

images) are approximately exponential. There is a blended object 3″ to the southeast which is bluer than the rest.

1048−090 (Fig. 12).—This quasar is just resolved at both wavelengths, and little inner structure can be seen. There is connecting luminosity to a companion 7″ to the southeast, and a curved tail to the northeast in *R* light. The companion has $R \sim 21.5$, $B \sim 22.6$. A fainter companion lies 10″ to the southwest and appears to be blue.

1058+110 (Fig. 12).—This is a high-redshift quasar, which is resolved in both *B* and *R*. It is extended northwest to southeast and apparently connected to a faint companion 5″ to the southeast. Another, brighter, companion lies 5″ southwest. There are several faint objects in the field which could be a group at this redshift. The quasar and a companion 20″ to the west are the brightest objects. The object is too small and crowded by companions to enable a fit to the luminosity law.

1117−248 (Fig. 12).—This high-redshift quasar is just resolved in *R*, but not in a (short) *B* exposure. The quasar has a knot to the southeast and connecting luminosity to a peculiarly shaped extended object (20 mag) to the south. Luminosity scale lengths are similar for the quasar and companion. Other faint objects in the field could be associated.

1122+19 (Fig. 13).—This radio galaxy has an off-center nucleus in an elliptical-looking galaxy, suggesting a tail or tidal distortion. There is a companion of comparable size, luminosity, and color 20″ to the east. The radio galaxy is somewhat bluer and has a larger luminosity scale length, azimuthally averaged.

1140+22 (Fig. 13).—The published optical identification for the radio source is a faint, small galaxy with a barred appearance in *R*, and very blue color. H. Spinrad (1987, private communication) reports a revised redshift of 0.83. Two nearby galaxies to the southeast and southwest about 25″ away are brighter, and there are several fainter galaxies in the field. Luminosity laws are $r^{1/4}$.

1150+497 (Fig. 13).—This quasar resides in the brightest and largest galaxy in the field. It is resolved in *B* and *R*, and the luminosity law fits an exponential fairly well. The nucleus lies off-center, with the galaxy extended mainly to the northeast. In *B* light, there is a faint curved arm to the north, in the direction of a small companion 10″ away—possibly connected. Some clouds prevented color determination.

1158+31 (Fig. 14).—This galaxy is unusually elongated, with outer isophotes distorted by a faint irregular companion 6″ to the northeast. Radial luminosity plots show a shoulder at 2″.5 in both colors. The *B* image extends farther to the south, suggesting a tidal tail away from the apparently interacting companion. The galaxy is the brightest in the field.

1200−051 (Fig. 14).—This quasar is just resolved in both *B* and *R* in its inner regions. The outer isophotes are irregular. There are several faint resolved objects within 20″, and the quasar is apparently connected to one which lies 5″ to the northeast. There is a thin taillike feature on the opposite side of the quasar. The nucleus is at least 1.5 mag brighter than the HB catalog magnitude. Faint companions appear blue, but exact colors were not derived because of variable thin cloud cover.

1203+64.—This high-redshift galaxy is very small in the sky. The *R* image has irregular outer isophotes orthogonal to the inner ones, seen in *B* and *R*, suggesting barred structure. Two regular elliptical companions of comparable size lie 10″ away, to the northeast and west.

1217+023 (Fig. 14).—This quasar lies in a large, round galaxy. Outer isophotes are wispy, and there is a radial color gradient, becoming redder outward. Luminosity plots do not fit either exponential or $r^{1/4}$ laws well. Two other galaxies lie some distance away with ~19 mag, and have steeper luminosity gradients. The outermost parts are shell-like and overlie some faint objects.

1222+216 (Fig. 15).—This high-redshift quasar is just resolved in *B* and *R*, and shows little structure. The nucleus is brighter than the HB catalog value by at least 0.7 mag. Outer isophotes envelope a companion 6″ to the southwest. There are also very faint luminous extensions to the northwest and southeast, brighter in *R* than in *B*. A large irregular galaxy 25″ to the northeast has roughly exponential luminosity falloff. A faint object 9″ to the east coincides with a bright spot in the radio structure.

1223+252 (Fig. 15).—This quasar is well resolved in *B* and *R*, showing an elliptical shape. There is also a luminous extension along the short axis, connecting to an irregular small companion 8″ to the north, and a possible counterjet or tail. Some cloud cover prevented color and magnitude determination.

1239−04 (Fig. 15).—This galaxy is very distant, small, and faint. It is extended east to west, but swept back to the south in *R*. The *B* image is smaller and extended north to south. A nearby object to the northeast is bluer, and not connected in our data. This and another companion to the southeast are at magnitude ~ 24.

1345+12 (Fig. 16).—This low-redshift radio galaxy is a spectacular object, which appears to be a merging of three galaxies. The irregular body of the system contains three nuclei, and there is a complex pattern of three curved tails emerging from a point close to the faintest of these. This object was discussed in a paper by Gilmore and Shaw (1986). The faint nucleus and the inner tail region are blue, as is a detached region opposite (to the north). Luminosity profiles are irregular, with the outermost regions close to $r^{1/4}$. The radio source is unresolved, suggesting that the system is only recently activated (Hutchings, Price, and Gower 1988).

1400+162 (Fig. 16).—The *R* image of this object was published by HCCGD. The *B* image is just resolved, and

FIGS. 1–20.—Diagrams show contour plots and gray-scale pictures of most objects. These two displays allow different types of morphological features to be seen easily. Q or G denotes quasar or radio galaxy, and *B* or *R* the broad-band filter. In all cases, north is up and east is to the left. All data are taken with the RCA1 CCD except 1612+262, 1626+554, 1833+326, and 1845+797, which are the sum of four ITT image-tube plates each. The other five objects in Table 1 had low-level CCD streaking, present only in these images. The lowest contours are all close to 26 mag arcsec^{-2} (ITT data 1 mag brighter), and are a factor of 2 apart in intensity. The quasar or galaxy is always the central one in the field (an exception is 0958+29, where it is the upper galaxy). In some cases, displays are also shown with a smooth model of the galaxy removed, or of color differences. These enable some subtle morphological features to be seen, such as dust lanes, tidal tails, or superposed smaller objects. Where *B* or *R* filters are not indicated, observations were made with medium-band filters near 6000 Å.

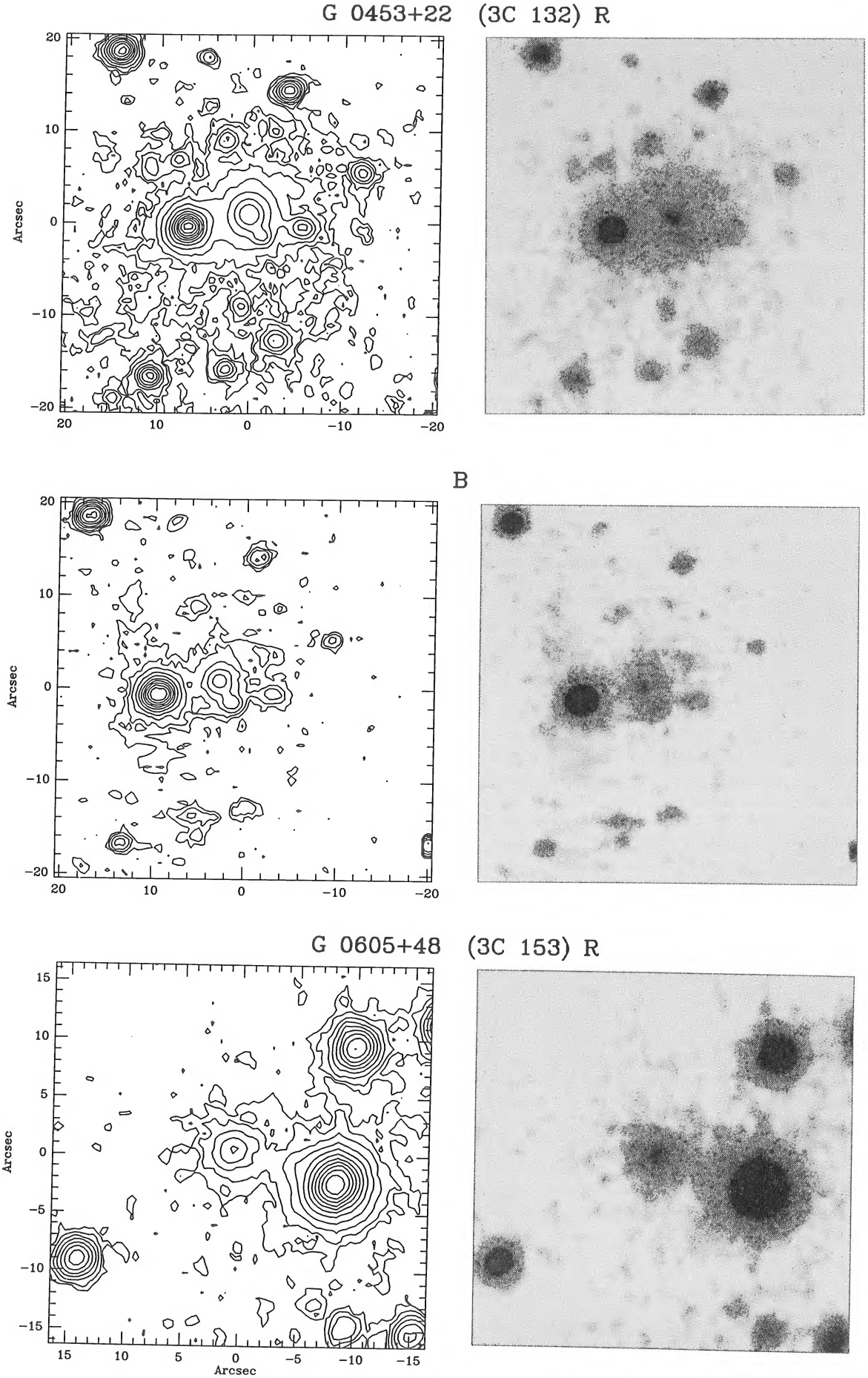

FIG. 2

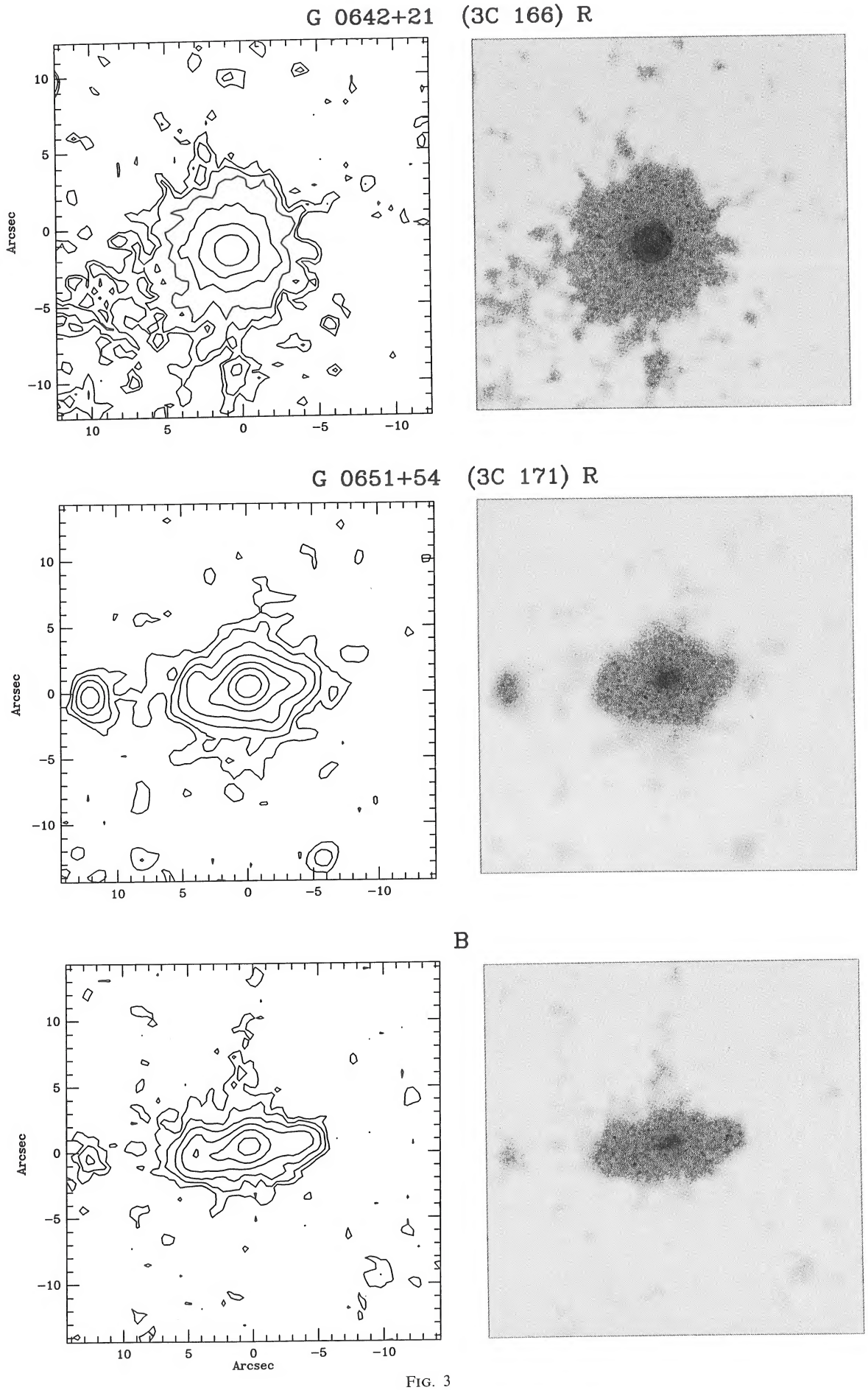

FIG. 3

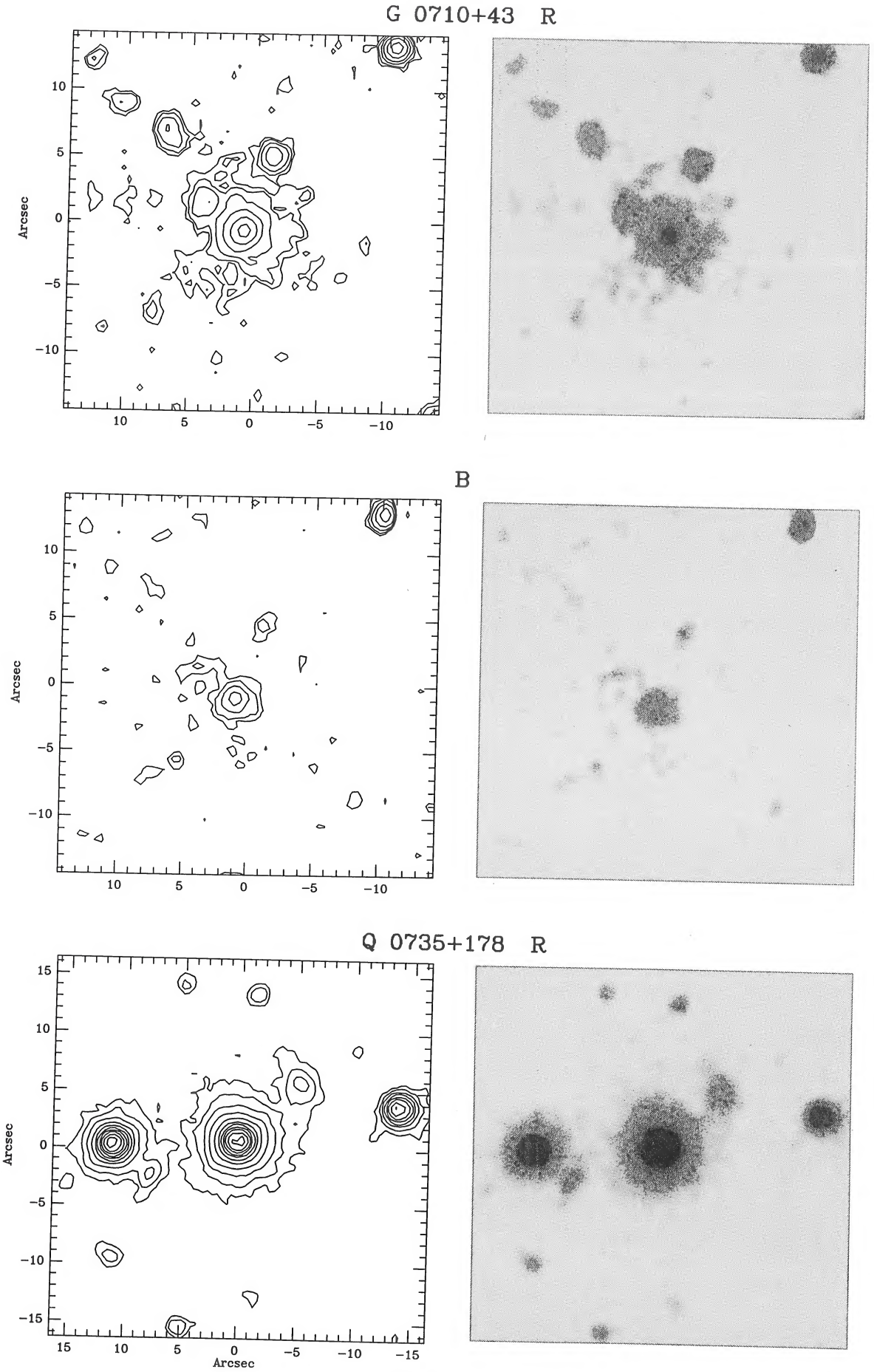

FIG. 4

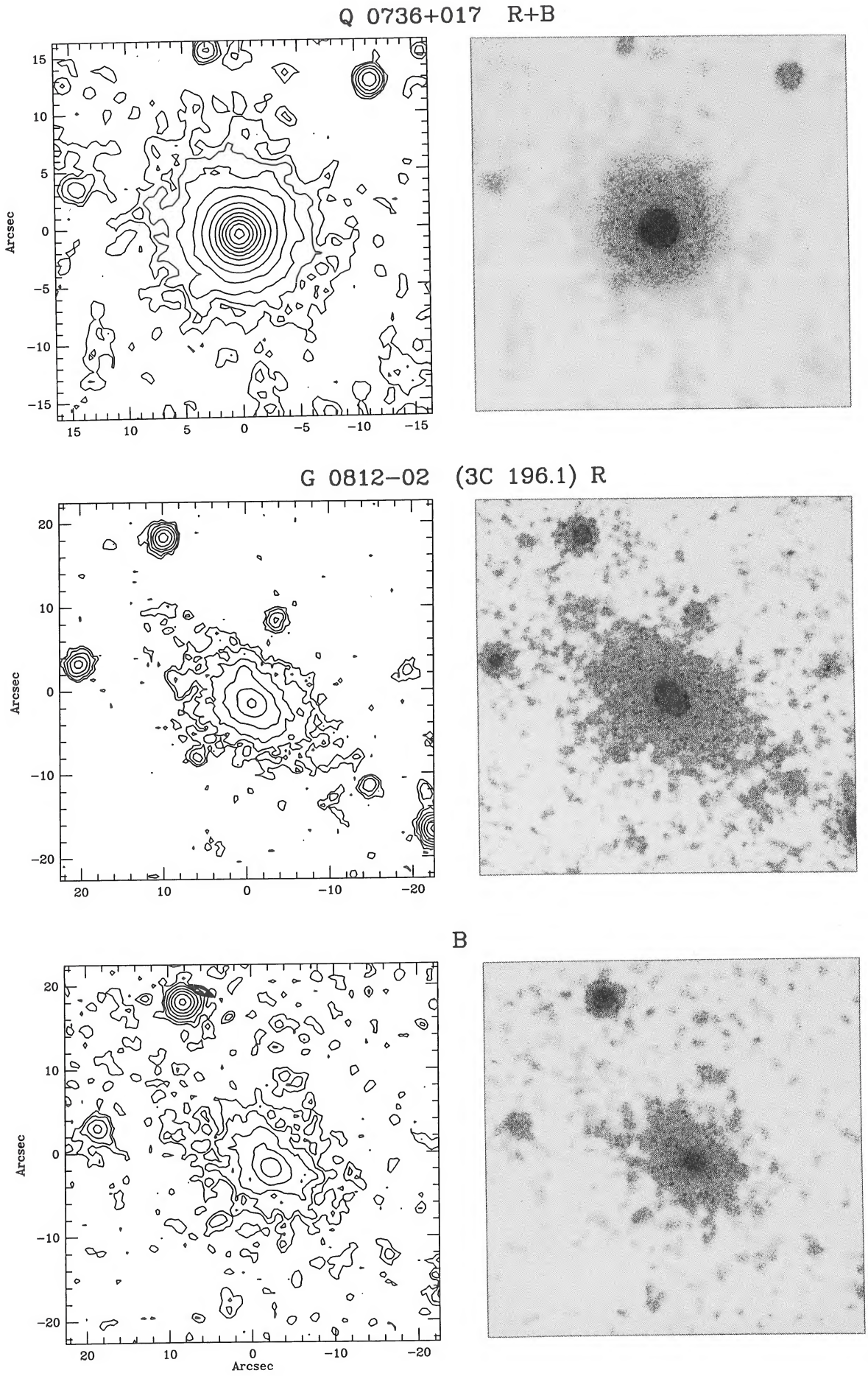

FIG. 5

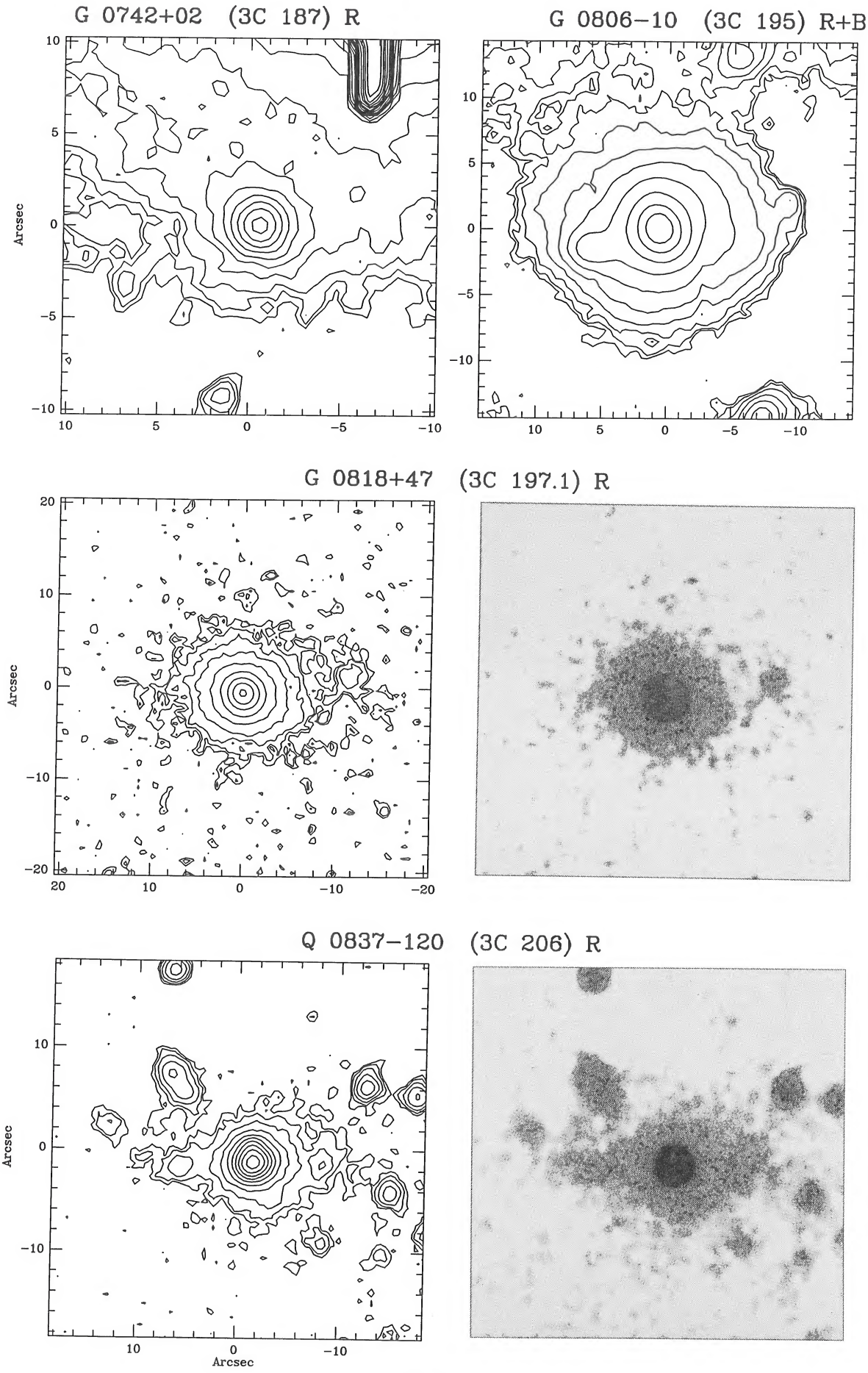

FIG. 6

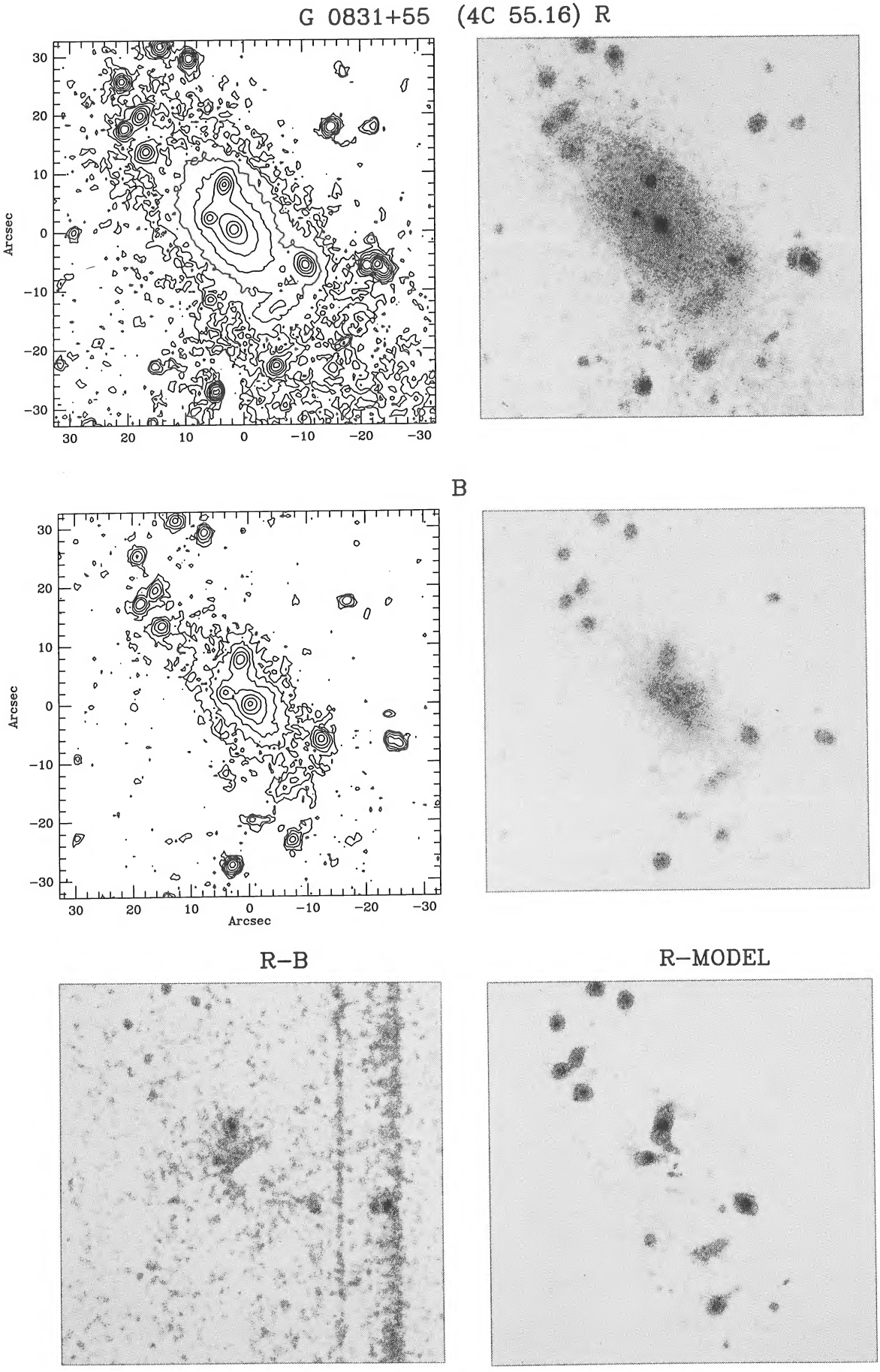

FIG. 7

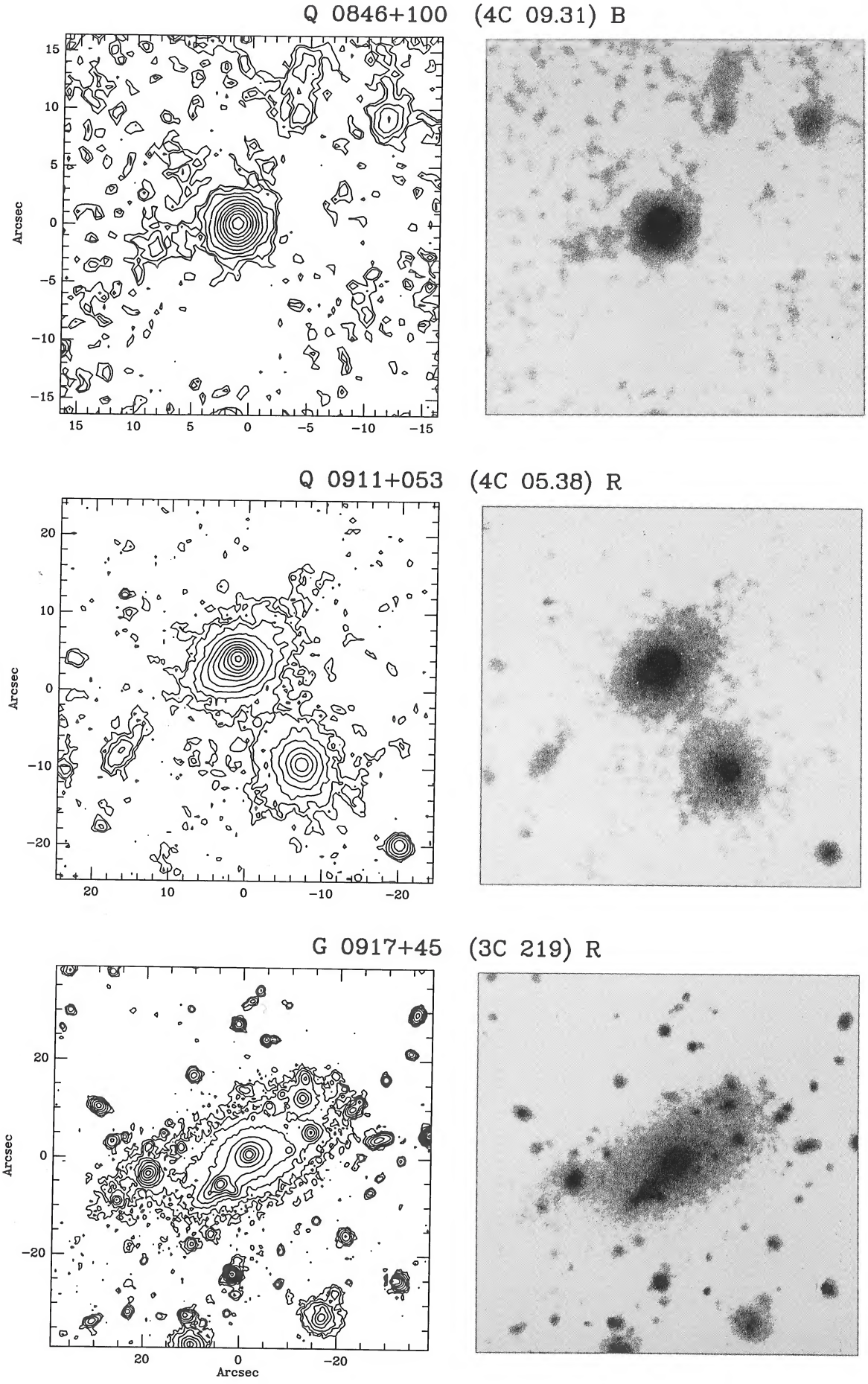

FIG. 8

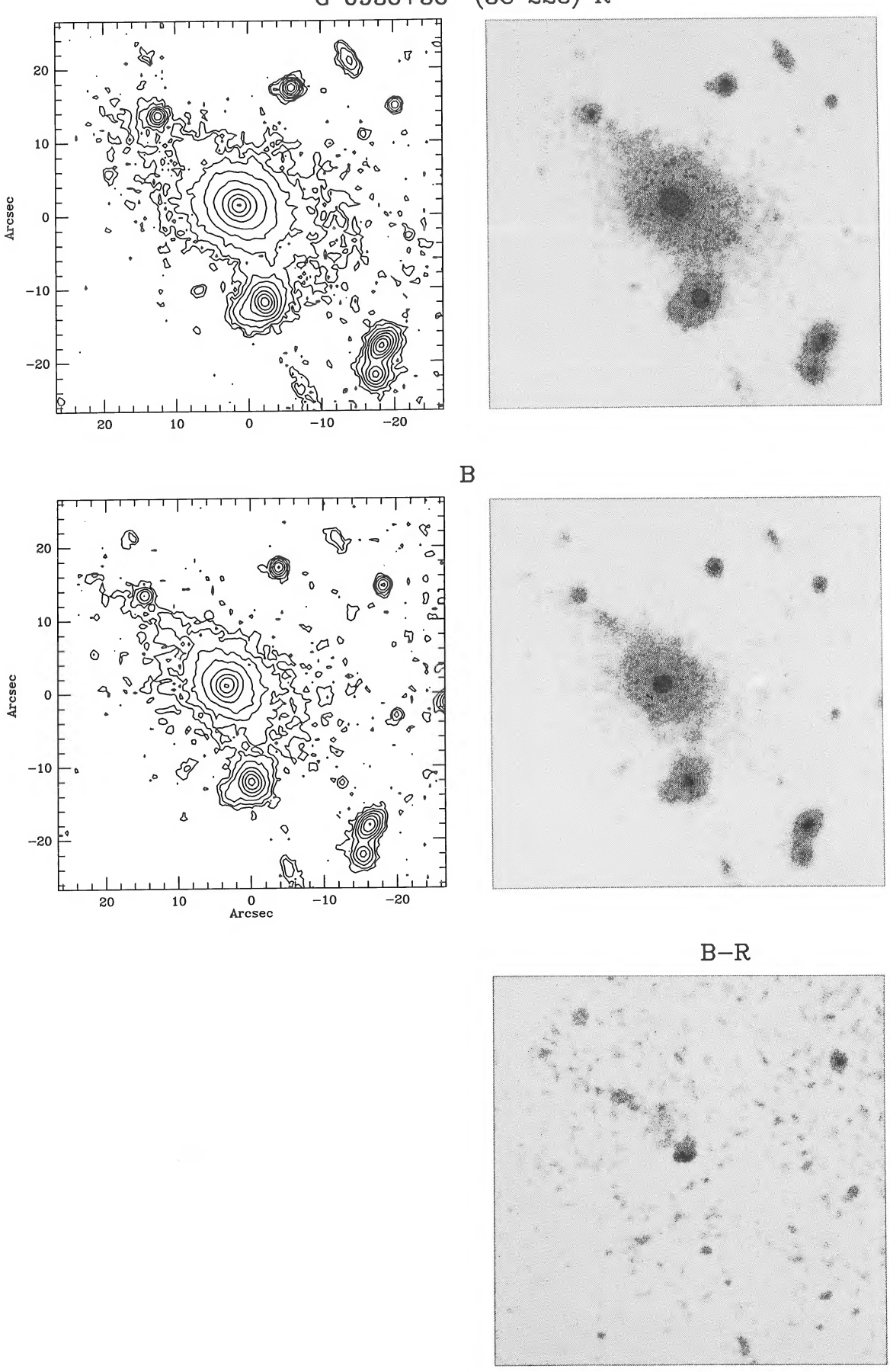

FIG. 9

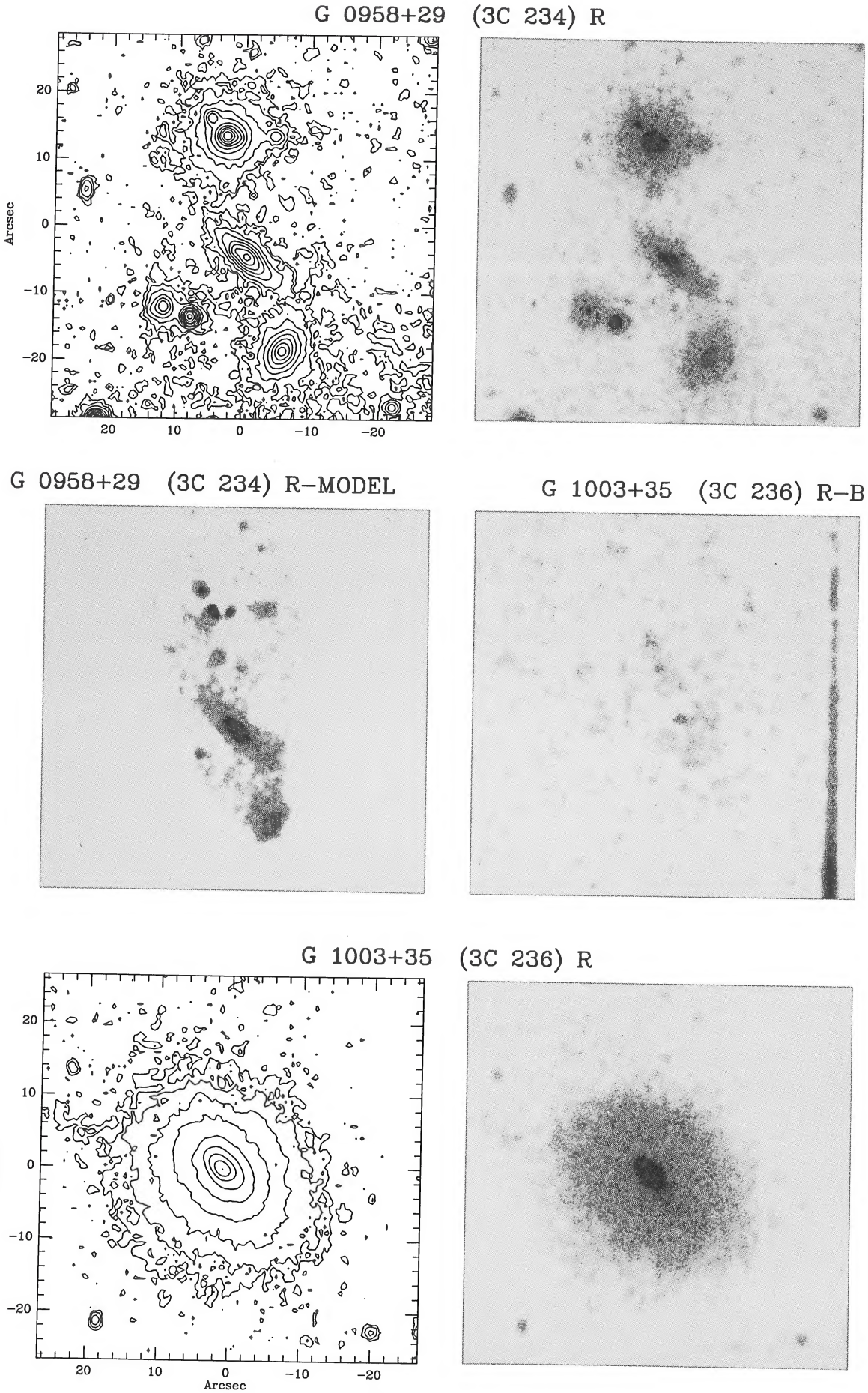

FIG. 10

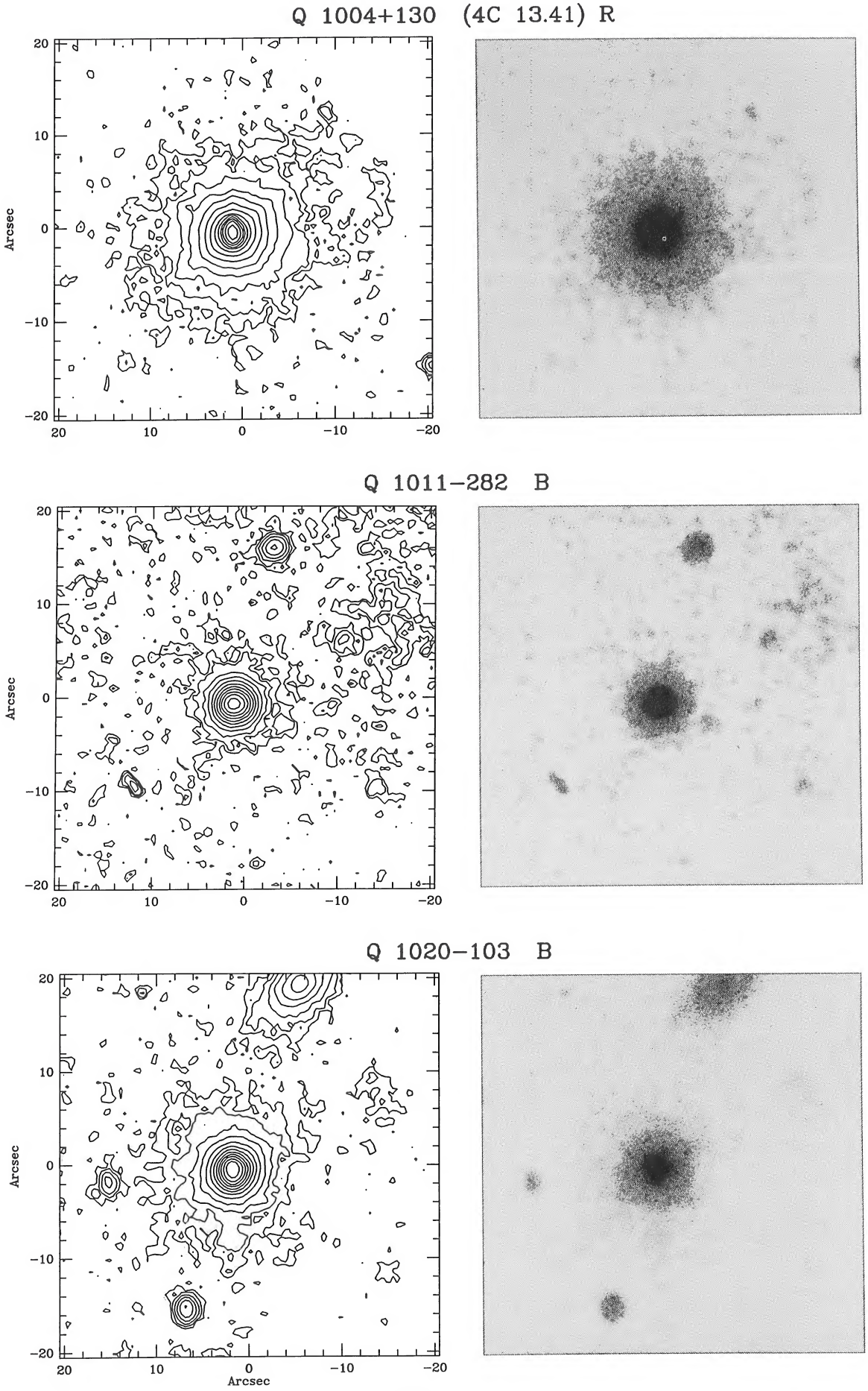

FIG. 11

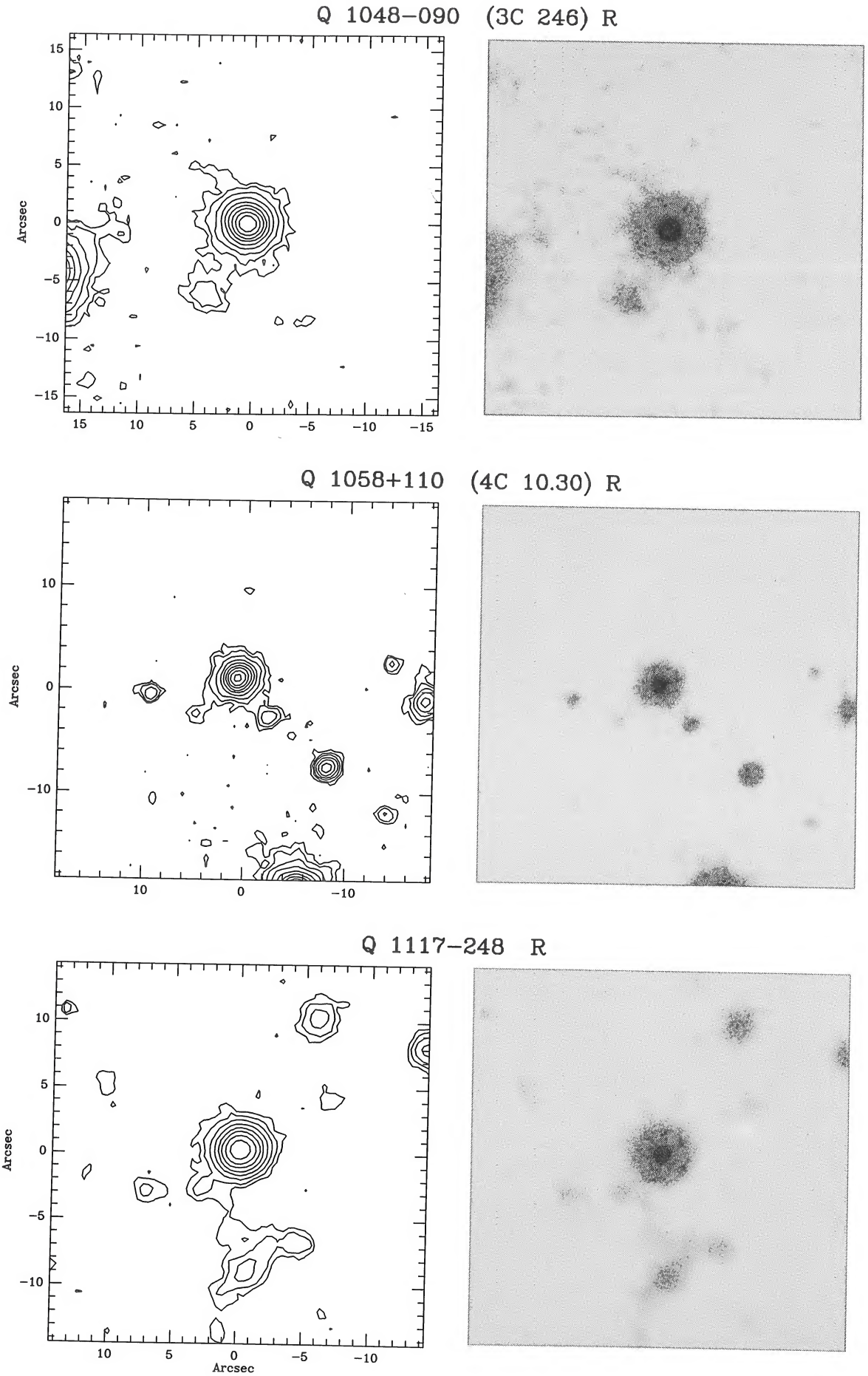

FIG. 12

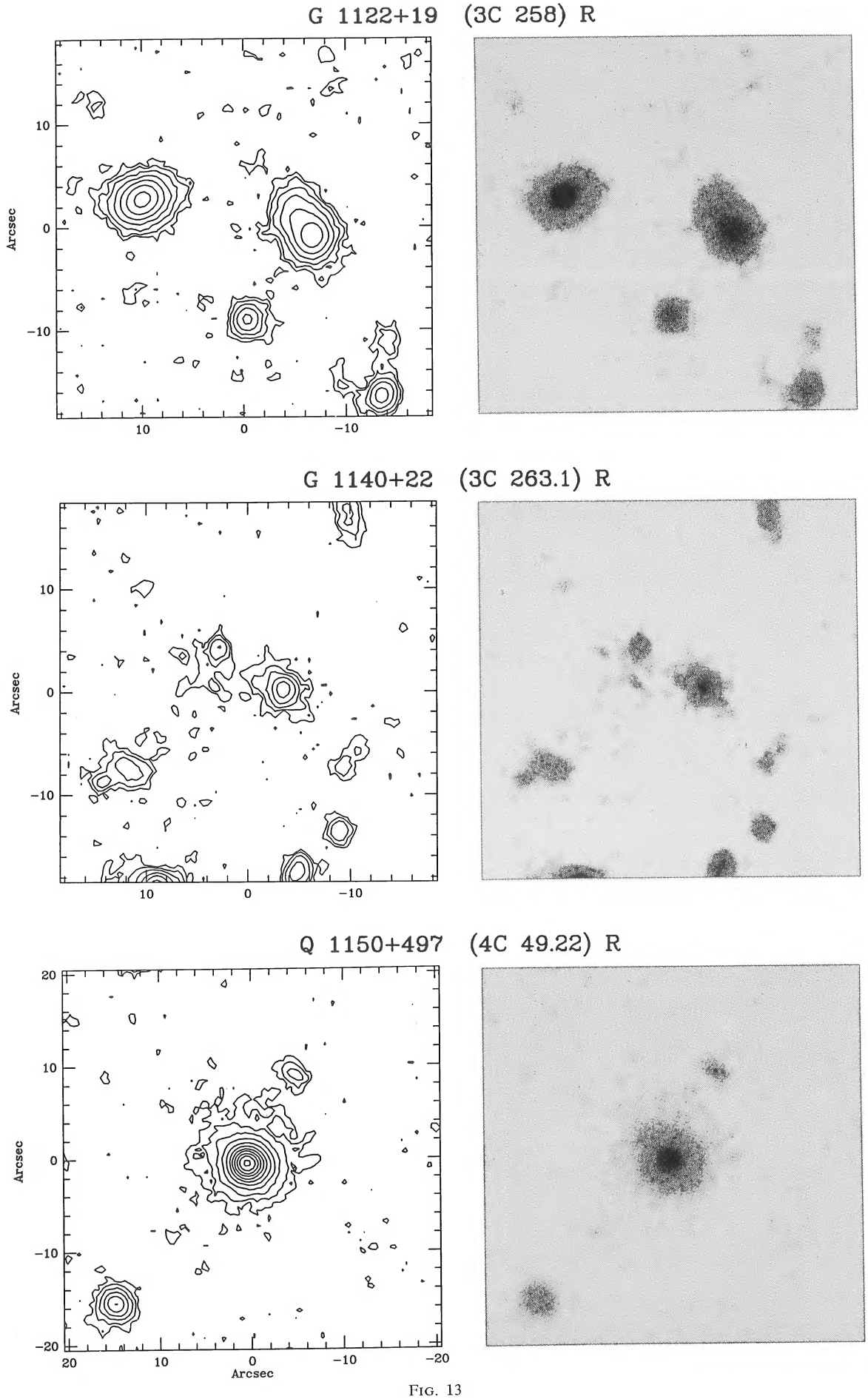

FIG. 13

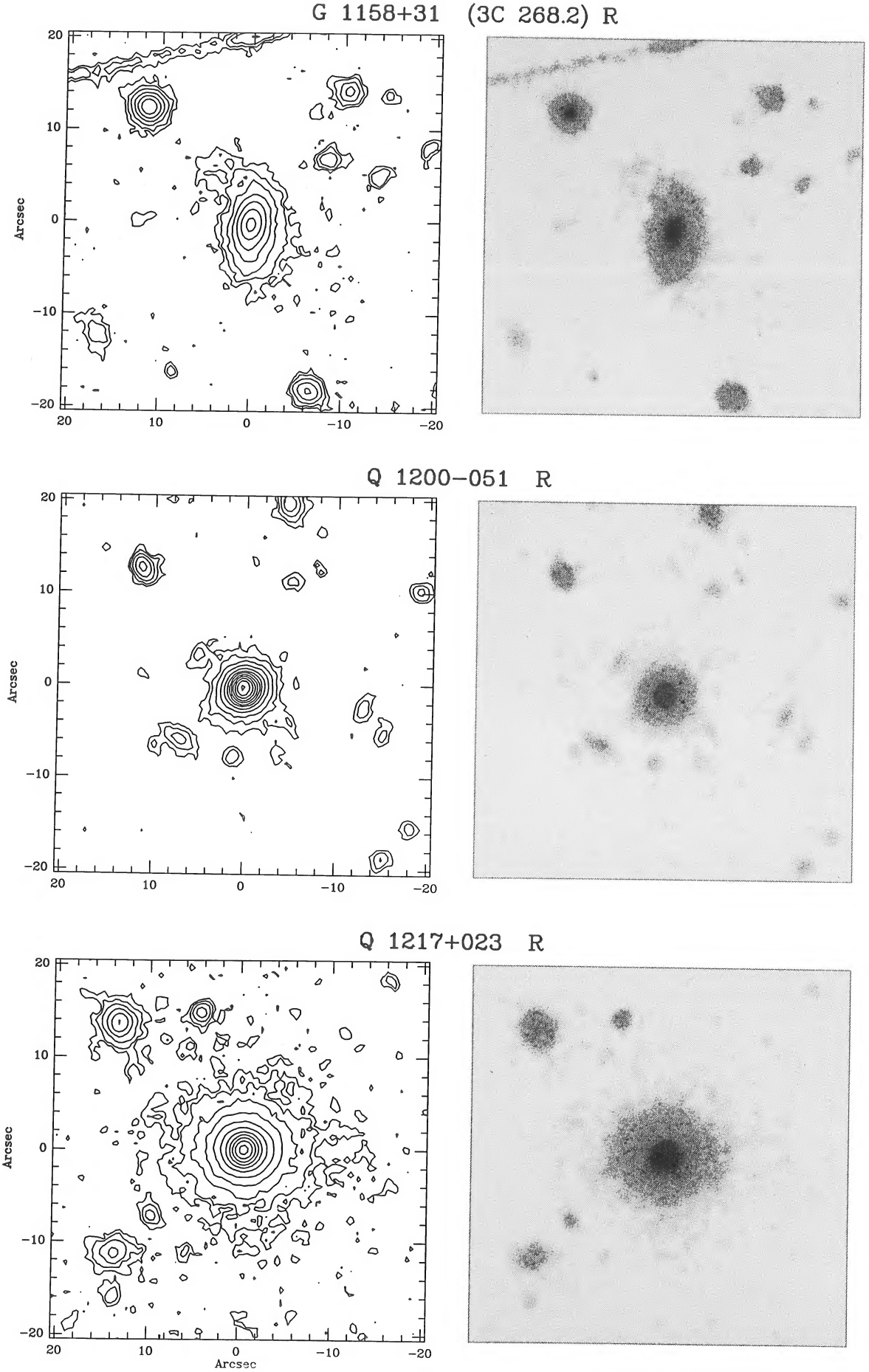

FIG. 14

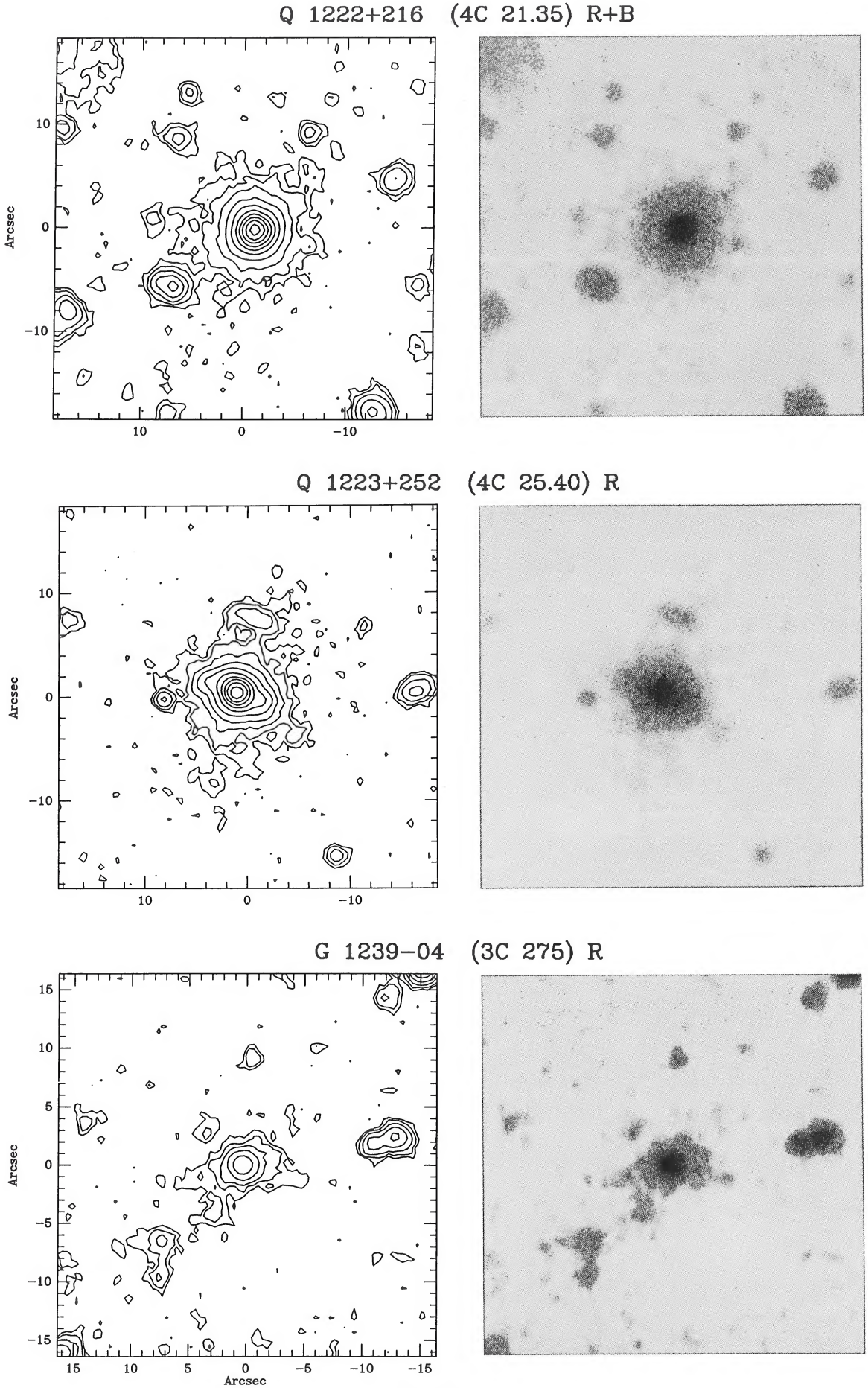

FIG. 15

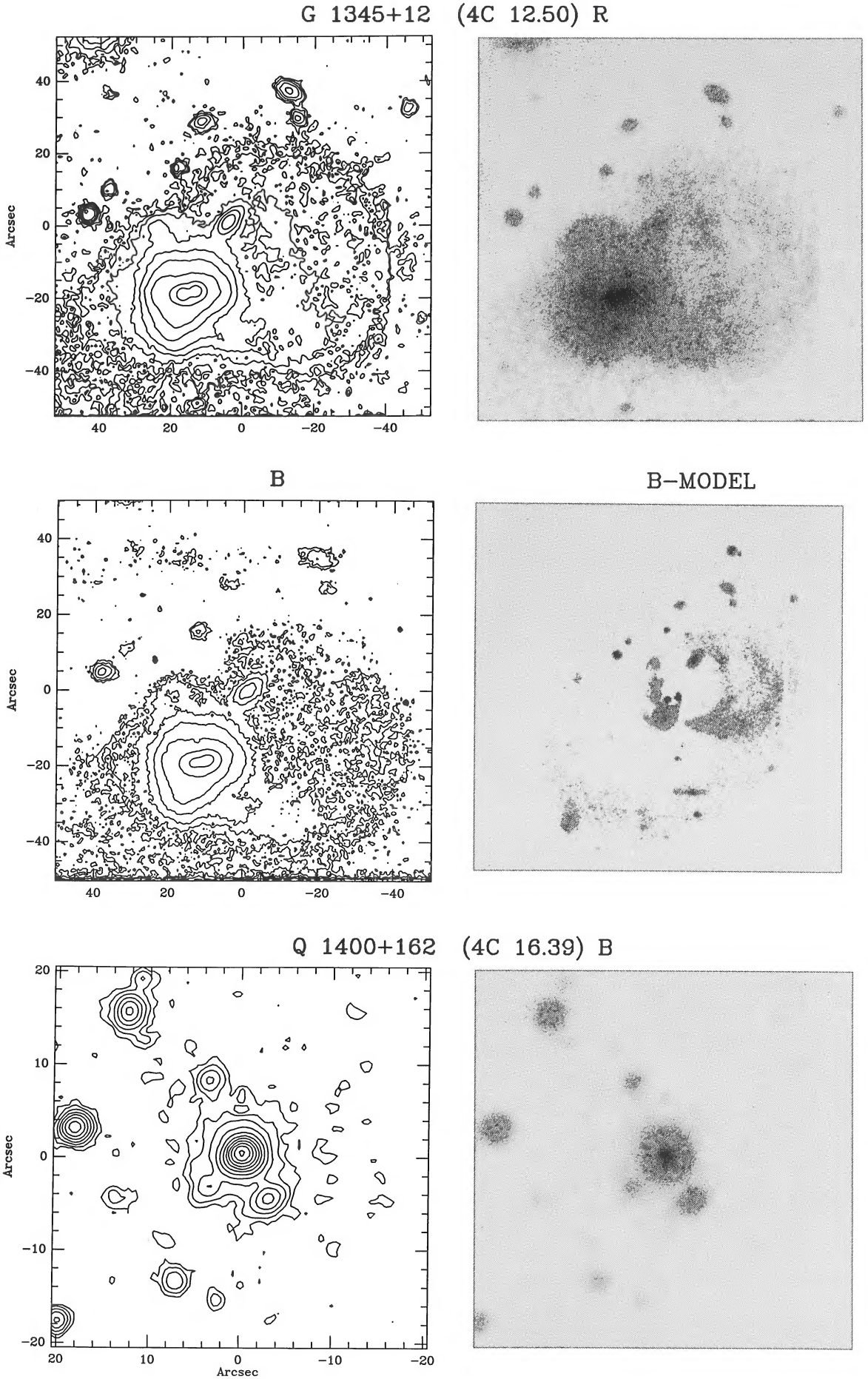

FIG. 16

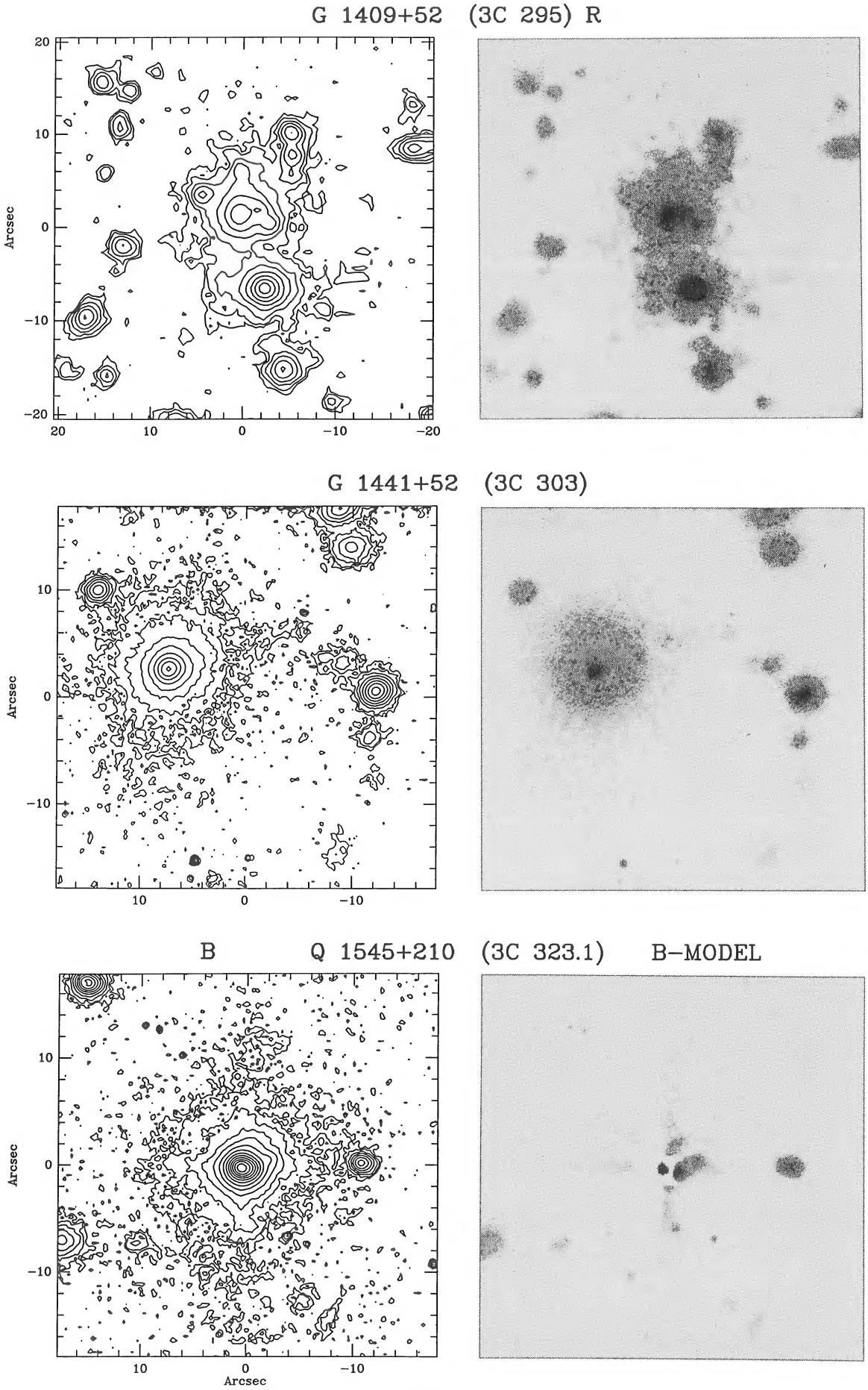

FIG. 17

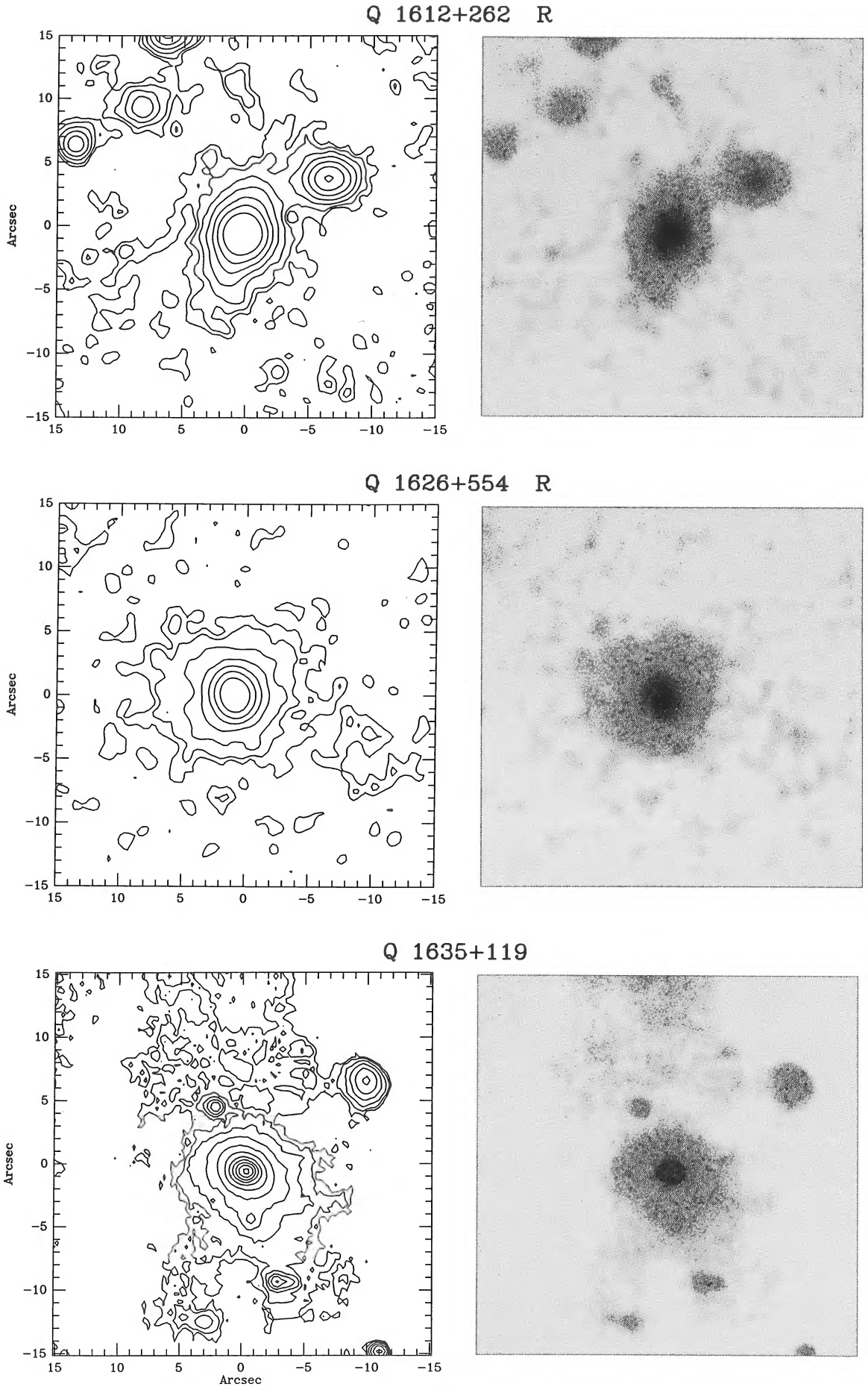

FIG. 18

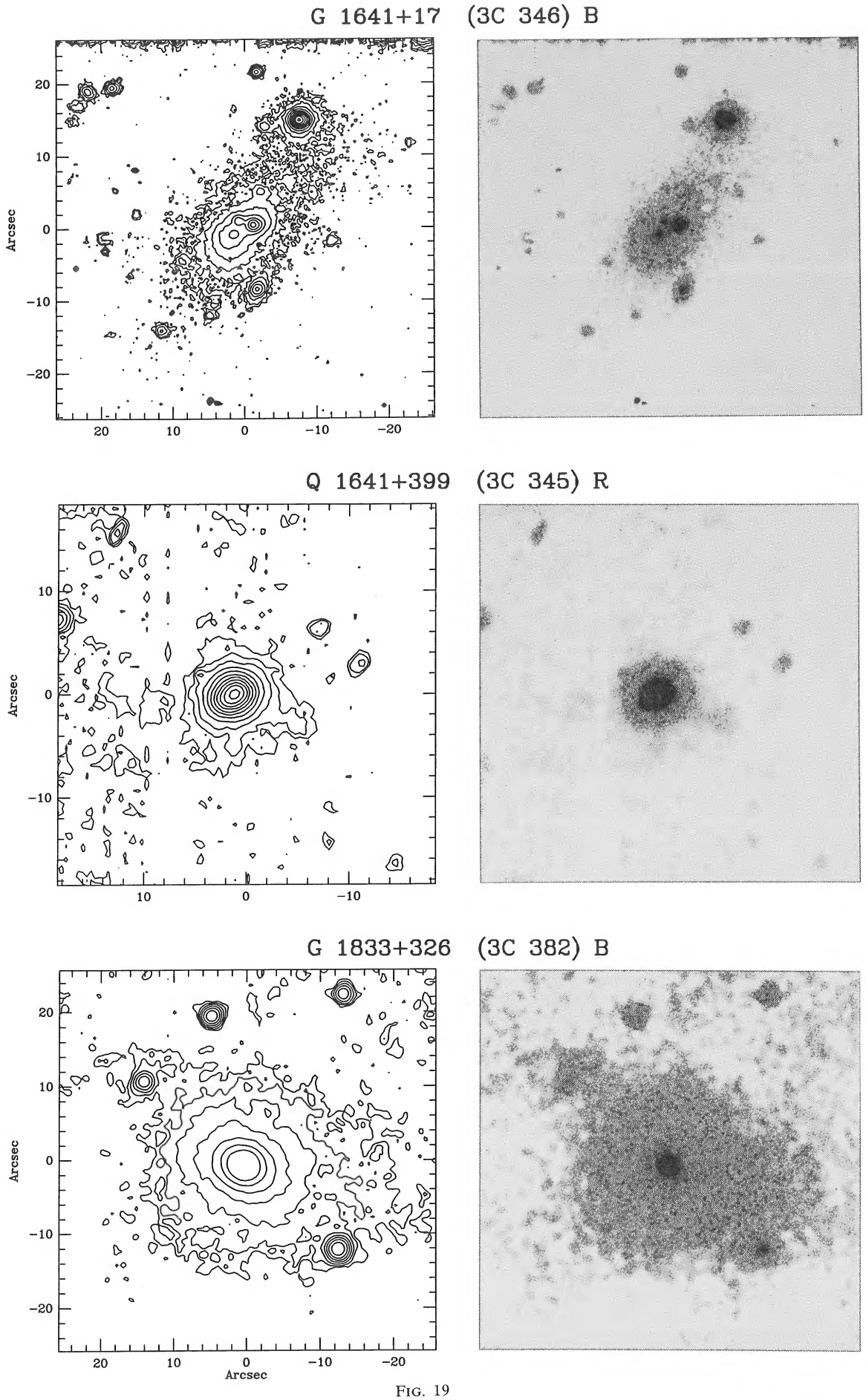

FIG. 19

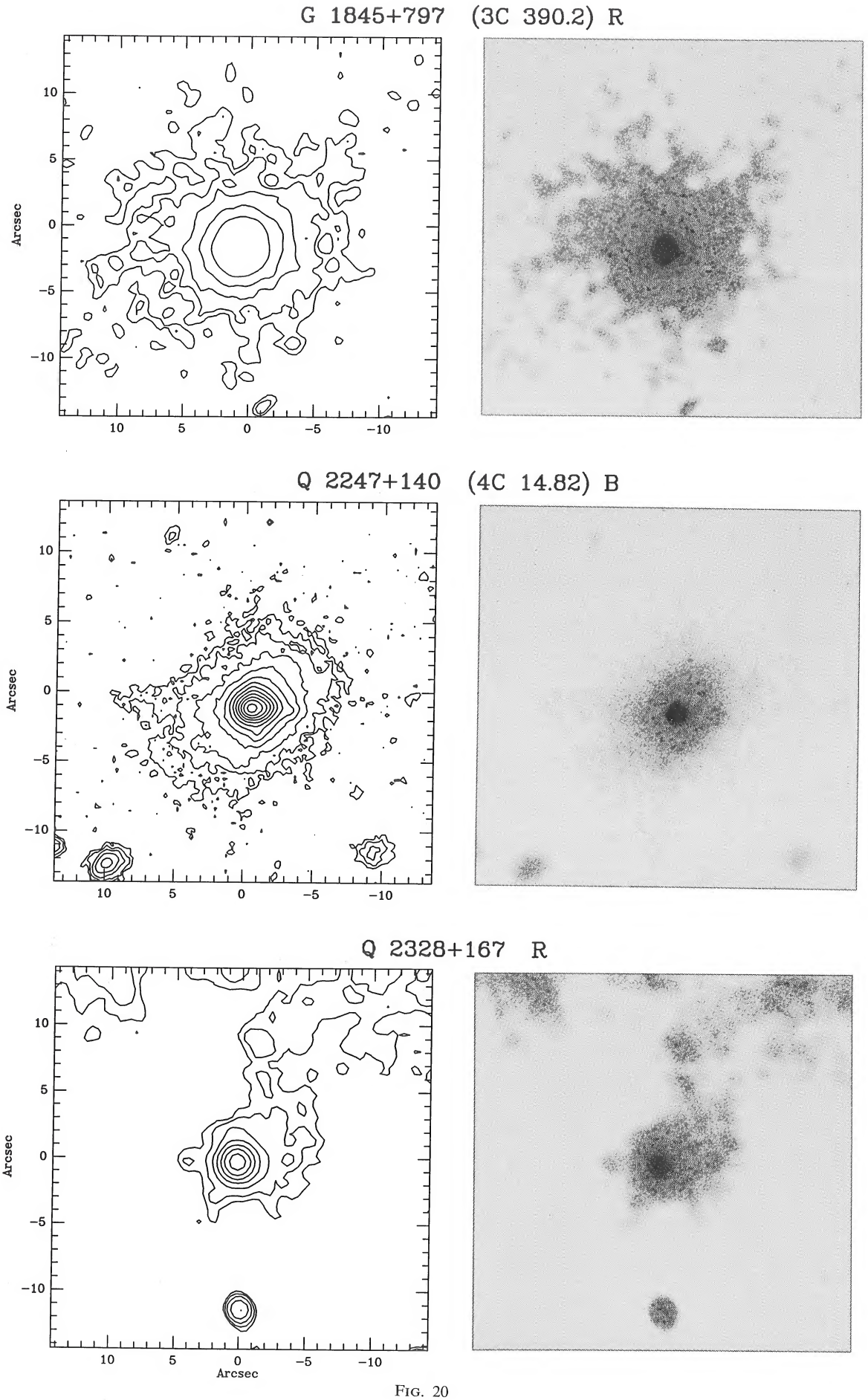

FIG. 20

reveals little structure. The quasar lies close to two fainter companions, the nearer of which (5″ southeast) is blue, but is not clearly connected to either. The *B*-magnitude is about 1 mag fainter than that given in the HB catalog.

1409+52 (Fig. 17).—This high-redshift galaxy is (the northern) one of two bright galaxies in a field of many fainter ones. These could be an associated cluster. The active galaxy is blended with several of these, and lies at the most crowded location in the field. The nearest four objects are at 1.″6, 2.″4, 4.″3, and 4.″7 from the active galaxy nucleus. The blended luminosity law is exponential. Our *R*-magnitude is 1 mag brighter than the cataloged 20.1. It seems very likely that some interaction is occurring here.

1441+52 (Fig. 17).—This galaxy is better known as 3C 303, and has been discussed, e.g., by Lonsdale, Hartley-Davies, and Morison (1983), in connection with the juxtaposition of a high-redshift quasar with the galaxy radio structure. The radio galaxy is large, structureless, and round. However, the nucleus lies off-center and the outer isophotes are irregular, as is the luminosity plot. There is an extension to the west which lies north of the radio jet, and a faint optical feature at the end of the jet. The high-*z* quasar is unresolved. There is no obvious interaction, but the galaxy could be a recent merger. Our data have higher optical resolution than other published pictures.

1538+14.—Only one short *B* exposure of this quasar is available, and the only interesting evidence seen is that the outer isophotes appear to be off-center from the nucleus. There are two companion galaxies some 16″ away.

1545+210 (Fig. 17).—This quasar also has only a relatively short *B* exposure, and the image has diffraction spikes. However, the host galaxy is asymmetrical, and there are two faint knots embedded in it, seen most easily when the main object is modeled and removed. The knots lie 1.″3 northwest and 3″ south, with a luminous curved ridge connecting the latter to the nucleus. The closer knot has a jetlike extension pointing away from the nucleus. This may be another merging system.

1612+262 (Fig. 18).—Data on this quasar are from ITT image-tube plates. The object is easily resolved in *R* light, and was noted as such by Arp (1970). Bahcall, Schmidt and Gunn (1969) noted that it lies within the boundaries of a cataloged cluster of galaxies. The object is smoothly elliptical in shape, with a nearby resolved companion (8″ northwest). There is also a faint curved wisp to the southeast. The lowest contours are not very deep, and it is difficult to comment on interactions here. There is no clear preference between exponential and $r^{1/4}$ fit.

1626+554 (Fig. 18).—Data for this quasar are also ITT plates in *R* light. It is clearly resolved, with a round, irregular shape. Here, too, the image is not very deep, but there appears to be a faint irregular companion to the west. Outer luminosity appears exponential.

1635+119 (Fig. 18).—The CCD images of this quasar have some bad columns. However, it is well resolved, having slightly elliptical amorphous structure. There are several smaller resolved objects within 10″, but no strong signs of interaction. The faint large-scale structure is not reliable because of CCD streaking problems. The luminosity profile is not exponential or $r^{1/4}$.

1641+17 (Fig. 19).—This is a large galaxy with a very offset nucleus, and two other central knots within 2″. There is a large faint extension to the northwest. There is a small galaxy to the south. Outer isophotes follow an $r^{1/4}$ law. The galaxy is very large and very likely in a state of recent merging. Our image is in *B* only: it would be useful to observe it in *R* as well.

1641+399 (Fig. 19).—The red image of this luminous, distant quasar was published by HCCGD. The new *B* image is deeper and shows the presence of a compact (23.3 mag) knot 5″ to the northeast and a connected diffuse object or extension reaching some 10″ in the opposite direction. These objects are blue: there is also the faint red object 10″ to the east, seen in the *R* image. Bad columns in the image prevent us from seeing whether this is also connected.

1833+326 (Fig. 19).—These observations were taken with the ITT image tube in *B* and *R*. The galaxy looks elliptical, with connecting luminosity to a fainter companion some 20″ northeast. Absolute colors are not available, but it is bluer in the nucleus and the outer regions. Another, fainter companion lies a little beyond the first. Outer isophotes in *R* are more irregular than in *B*. The luminosity law fits exponential better than $r^{1/4}$.

1845+797 (Fig. 20).—This radio galaxy was also observed with the ITT image tube. The object is round, without much structure. It has irregular outer contours (partly noise) and no detectable companion. Luminosity laws fit neither exponential nor $r^{1/4}$ well.

2247+140 (Fig. 20).—See *R* images and comments in HCCDG.

2328+167 (Fig. 20).—There are *B* and *R* CCD images of this quasar, and it is resolved in both colors. The low-level signals are affected by CCD streaking. There are small close companions about 4″ to the east and west, and the quasar galaxy appears more extended to the northwest.

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